Policy Analysis

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Executive Summary

Nuclear war evokes images of mass destruction and mutilation -- images so overwhelming that they normally represent the end, not the beginning, of a dialogue. Yet, the time seems ripe -- indeed, some would say critical -- to expand the nature and scope of the domestic dialogue about nuclear war. Based on its perception of a strategic nuclear imbalance, the administration has made a commitment to long-term expansion of U.S. strategic nuclear capabilities, including plans for a modified B-1 bomber, a version of the MX missile, and expansion of Trident submarine production. At the same time, growing public awareness and concern about nuclear proliferation and prospects for a nuclear war are manifested in the current wave of grassroots and congressional action calling for a nuclear weapons freeze and challenging federal crisis relocation plans. Unfortunately, saying that nuclear war is bad and is to be avoided is not enough.

There are significant difficulties in establishing and maintaining a dialogue about nuclear war that would enable policy-makers as well as citizens to analyze realistically the implications of our current and proposed policies, and seek to implement necessary changes. Those images of holocaust and unspeakable damage often close off debate. They are reinforced by the basic strategy of the U.S. and U.S.S.R. -- deterrence, or mutually assured destruction (MAD). The object of this strategy, pursued since the 1960s, is as it states, irrevocable destruction. MAD promises that even after a surprise attack (or first strike) both adversaries would retain weapons sufficient to inflict totally unacceptable damage on the other. Therefore, an adversary would be *deterred* from initiating a nuclear war because of the certainty of devastating retaliation. On the other hand, technological advances producing sophisticated weapons capable of increased accuracy and targeting flexibility have created a set of confusing and expanding hypothetical versions of "controllable" or "limited" nuclear war. We therefore have to determine the credibility of scenarios that claim to be capable of producing attacks with surgically precise accuracy, permitting nations to engage in a new type of subtle, benign nuclear exchange -- more an apparent extension of conventional warfare than a massive holocaust. In other words, "limited" nuclear war, at least in strategic planning terms, has crept into our vocabularies and has become "thinkable," i.e., potentially survivable. As unobtrusively, a companion strategy of "crisis relocation" -- massive evacuation of urban areas in advance of a threatened attack to reduce casualties -- also has become a focus of interest because of its proposed ability to support successful "war fighting."

The range of scenarios -- from the horrifying to the arcane -- has not created a common ground for public discussion. This debate needs to be reconstructed in a manner that is comprehensible to the nation. Unfortunately, the type of information normally presented is for only limited use to the public, or even to policy-makers.

The issues are generally presented in terms of comparative nuclear strength -- rarely in terms of overall purpose, and especially, intended consequences. Thus, the discussion invariably focuses on relative numbers -- warheads and gross destructive power (megatonnage) -- and sometimes comparative technology, weapon accuracy, and survivability. While these gross measures of strength are legitimate and important aspects of the strategic debate, strategic decisions are essentially political decisions. As such, they should reflect not only their proposed effects on an adversary's perception of national strength, but also a realistic understanding of whether these strategies will produce effects that are acceptable to the nation and its leaders.

The thesis of this paper is that the effects of nuclear war on a complex, technical/industrial society are not evaluated adequately in the development of strategic policies. If the full range of economic, social, and political effects, as well as casualty projections, of fighting various types of proposed nuclear war were to be examined realistically, our strategic goals and weapons requirements would change, in some cases significantly. To put it bluntly, the true damage of nuclear war to society has been greatly understated. This leads to certain basic questions:

-- How many weapons must survive a first strike to retain capacity sufficient to deliver a crippling counterattack to an adversary?

-- Are weapons requirements for effective deterrence seriously overstated or misperceived?

-- Are "limited" nuclear war and its companion strategy, crisis relocation, thought to be viable nuclear strategies when they are not?

To try to answer these questions, we will look at what might happen to the United States or any other complex technological/industrial society after each of two hypothetical attacks -- a "limited" or "counterforce" nuclear attack aimed at military targets and an "economic" or "countervalue" attack aimed at urban areas. The civil defense strategy of crisis relocation is also analyzed. While casualties and physical destruction will be the starting point, we will concentrate on the impact on the economic and political structures and social support mechanisms of the attacked society. While the study focuses on the U.S., there is ample reason to believe the U.S.S.R. or any other industrialized nation would suffer similar, if not worse, consequences from a nuclear attack.

Part I

Limited Nuclear War -- Is It a Viable Strategy?

In 1974, Secretary of Defense James Schlesinger formally acknowledged the adoption of limited nuclear war (counter-force) as a part of United States strategic doctrine.[1] "Limited" nuclear war is conceived of as a nuclear attack on one or more elements of a nation's land-based strategic arsenal: Intercontinental ballistic missiles (ICBMs), strategic bombers, or nuclear-powered ballistic missile submarine support bases. Other variations on the concept include possible attacks on other critical military, industrial (war production), or command and control centers. Individually, or in combination, these options could be used either as a means of paralyzing effective military response or to demonstrate the attacker's resolve and ability to employ the ultimate weapon. The adoption of this strategy rests on two assumptions.

The first is that it is possible to limit and structure a nuclear attack that will seriously damage ICBMs or other strategic targets without causing substantial direct or indirect damage to the civilian population. In other words, societal (and thus political) impacts would be so benign that the attacked nation would perceive it as "acceptable" and would not automatically trigger escalation toward a full-scale nuclear response.

The second, and inextricably related, assumption is that following a limited nuclear attack, effective political mechanisms would exist to constrain and terminate the nuclear exchange, preventing escalation to a full-scale nuclear conflict. Thus, it presupposes the physical survival of an effective chain of command as well as a central government that has sufficient credibility, legitimacy, and authority. Within the context of the goals of limited nuclear war, then, the central issue to be considered is not physical survival, but rather the domestic (and international) political acceptability of the damage inflicted by the attack. Essentially the question is whether after surveying the extent of the

perceived damage, the national leadership of the country attacked would be able to pursue this so-called "rational" policy of restraint.

The effects discussed below are based on a representative hypothetical attack in which the targets would be the U.S. ICBM arsenal and Strategic Air Command bases. The United States has approximately 1000 ICBMs, which are based in the states of South Dakota, North Dakota, Missouri, Kansas, Arkansas, Montana, Wyoming, and Arizona. The 46 Strategic Air Command bases are spread throughout the nation.

For each ICBM target, it is assumed that two weapons, each one megaton, would be dropped at ground level. (For purposes of comparison, these weapons would then have approximately 80 times the force of the bombs dropped on Hiroshima and Nagasaki.) The resulting fallout from the ICBM attacks would cover substantial parts of the Farm Belt, the Midwest, and some of the South and Southeast. The bomber or submarine bases would be attacked by three and one, one-megaton weapons, respectively, exploded to maximize blast damage, rather than fallout.

Casualties

An initial Department of Defense projection in 1974 estimated less than one million fatalities in the original version of a "limited" attack scenario.[2] The Office of Technology Assessment (OTA) reviewed attack scenarios and produced estimates of 7 to 15 million deaths.[3] Other projections estimate 10 to 20 million injuries, most resulting from radiation exposure due to fallout.[4] For comparison, during World War II the Soviet Union lost 20 million people, but over a period of four to five years; all U.S. combat fatalities in World War II were only 290,000.

Medical

What would this level of destruction mean? If in the most heavily contaminated and damaged regions, all the doctors survived and hospitals were usable, there would be one doctor for every 50 or 100 injured, and between 10 and 30 patients per available hospital bed. Even if the entire national health care system was used, the patient-doctor ratio would be between 25 and 50 to 1 and patients per hospital bed between 10 and 20 to 1. Care for patients suffering from other medical problems, such as heart attack and cancer, would be significantly degraded for an extended time because of the competing and continuing demands of those injured by fallout, the loss of physicians and hospitals (because of contamination) in specific regions, and potential reductions in the manufacture and distribution of medical supplies (about 30% of all drugs are manufactured in the regions most affected by fallout). For a more specific example, to treat a single patient exposed to substantial levels of radiation (200 Radiation Equivalent Man -- REMS -- or more) would require massive medical resources -- intensive care, bone marrow transplants, blood transfusions and antibiotics. In this type of attack hundreds of thousands -- perhaps millions -- would require complex bone marrow transplants to assure survival. Because of reduced resistance to infectious diseases, all clinical cases (a radiation dose exceeding 50 REMS) would need continuous protection against infection, involving high doses of antibiotics, etc. Treating large numbers would rapidly drain existing supplies and professional energy. As antibiotics supplies dwindled and immunization proved ineffective in this radiation-weakened group, a huge reservoir of potential disease carriers would develop. Diseases such as polio might reappear. Other key elements of medical care support systems, such as medical insurance and records, would be disrupted and in chaos after evacuation.

Food Production

Fallout would also significantly damage the U.S. food-producing system. The states in the Midwest, Farm Belt, and South/Southwest would be most affected by fallout. They produce 40 to 80% of the U.S. grains, such as wheat, rye, corn, and soybeans, and contain 40% of the cattle and 60% of the nation's hogs. Overall, these states produce about half of the U.S. food energy (calories). With virtually no fallout protection, cattle, hogs, and other animals would be particularly vulnerable since relatively low radiation doses can cause injury or death, similar to levels injuring humans.

Besides direct destruction of crops or livestock, many farmers would be killed, injured, or permanently disabled, leaving the food production system without the skilled manpower needed to quickly renew its productivity. In addition, even if the skilled farmers are available, food producing areas would be contaminated; soil radiation levels would be higher than what is considered "acceptable" in peacetime for growing crops. There would also be residual levels of radiation representing unacceptable occupational (worker) and general population exposures. Thus, in vast

areas of such states as Montana, North and South Dakota, Nebraska, Missouri, and Illinois, such land denial is certain to occur; crops would be lost and farms unusable for months, or even years, where there are radioactive "hot" spots. All these factors combined will result in severe disruption to the most significant and productive parts of the U.S. agricultural system for a period extending far beyond the attack.

Since it is not unusual to have food travel 1000 miles or more from farm to market, a breakdown of the distribution system is likely to cause imbalances of food supply among regions. (The Northeast, for example, produces only 15% of its needs.) Such a geographical imbalance could result in major conflict among regions. The reality is that with huge areas contaminated with radioactivity, tens -- perhaps a hundred -- million or more people evacuating their homes, regional hoarding likely, and social disorganization widespread, the distribution system would be ineffective for months. Prices also would rise dramatically, and major government intervention and controls would be likely results.

The Economic System

Casualties, evacuation, and land denial would create severe national and local economic dislocations. Approximately one-third of the U.S.'s manufacturing capacity lies within the geographic areas most affected by fallout.[5] A major evacuation would leave the regional economy in a shambles. Because of economic interdependence, the problem of "bottlenecking" -- serious disruption of the national economy -- would be likely. Bottlenecking is the disruptive effect that losses in a key industry (e.g., steel) have on other dependent economic activities (automobiles and machine tool production). Even modest reductions in capacity of basic, pivotal industries can have severe, widespread effects on the economy. Despite the possibility of product substitution (e.g., plastics for steel) or high inventories of selected products, the short- and mid-term ramifications of a disruption of even 25 to 50% of the affected region's manufacturing activities (equivalent to 8 to 15% of national economic activities) would be a serious blow to the national economy. This disruption could easily last several months, and in a post-attack stalemate with the possibility of future attack requiring prolonged urban evacuation, it would become worse.

There are other likely consequences that are less obvious. The banking system would face a particularly severe burden, for example -- potential bankruptcies; defaults on basic time payments, such as mortgages and major appliances; and major shifts of monies by individuals during evacuation. In contaminated areas individuals or businesses would be unable to gain access to money, especially in local banks, for long periods. In general, it would be virtually impossible for banks, either regionally or nationally, to pursue "normal" lending and borrowing policies. Payments such as rents and salaries to businesses or individuals would also have to be deferred.

Business insurance would certainly not cover this type of catastrophe. On a scale unknown in U.S. experience, there would probably be a massive outcry for the federal government to provide regional disaster loans to prevent bankruptcy and help resettle workers and their families from severely contaminated areas. The injured and evacuated population would create enormous social service demands (medical care, welfare, emergency housing, etc.) requiring huge sums of money to be spent rapidly. Unprecedented government intervention would probably be demanded to save industries from bankruptcies, allocate goods, and determine industrial priorities. Since individual, industrial, and even regional economic stability would depend on which industries and plants were decontaminated and/or received needed financial support first, implementing these governmental policies would be politically explosive.

Evacuation and Relocation

Fallout would be so intense that massive evacuation of the affected areas in the Midwest, South, and Farm Belt would be required; relocation would last for weeks, months, and in some cases, even years. At least 30 to 40 million people would be forced to leave. However, in a stalemated situation -- as "limited" nuclear war is likely to be initially -- well over 100 million people, mostly from major urban areas, would either leave spontaneously or be required to leave by government directive. The implications, particularly for the economy, are dramatic. As Fred Ikle, current Undersecretary of Defense for Policy, concluded 25 years ago, "not only nonessential persons but most of the workers will remain evacuated as long after the first nuclear attack as further attacks appear likely."[6] Certainly this would be the case in a limited nuclear war.

If evacuation were to result in a prolonged relocation, divisive social conflicts, as well as economic and social dislocation, would be likely. Under much more favorable conditions in Great Britain during World War II,

relationships between evacuees and their hosts degenerated quickly under the influence of prolonged stress, uncertainty, substantial class and urban-rural differences, and inadequate social service resources. This experience was not unique. Japan and Germany in World War II, and even the Netherlands in peacetime, experienced these type of conflicts. Under a limited war scenario in the United States, to absorb the evacuated population the number of people living in a single house or apartment in the host areas would have to increase six times (from three people to eighteen). It is not hard to imagine the conflict and stress that type for crowding would create.[7] Thus these problems are likely to be much more intractable under the "limited" war scenarios because of insufficient social services and the massive numbers of people involved. In threatened but unaffected metropolitan areas, decisions about who will be evacuated and when could become politically explosive -- fraught with fears of one group or another becoming the expendable victims. This is not to mention the problem of deciding when and how to evacuate special populations -- prisoners, patients in acute and chronic care facilities, etc.

Psychological Effects

From a psychological point of view, limited nuclear war probably is the worst of all worlds. The imagery of nuclear war, the pervasiveness of casualties, the possibility of massive media coverage and the intense fear of radioactivity that has been manifested in the United States, would spread widely the nuclear war survivor syndrome -- the powerful sense of personal vulnerability, helplessness, guilt, isolation and fear -- seen to varying degrees in the Hiroshima and Nagasaki survivors. If there is any doubt about the effects of the fear of radioactivity, the psychological effects and "loss of trust" described by the President's Commission, and subsequent studies of the accident at Three Mile Island, should provide ample evidence.[8] This would be true of the fallout from an ICBM attack even without the additional impacts of a geographically dispersed SAC-based attack, since fallout would create throughout the nation the image of nuclear threat and vulnerability. The disorienting and debilitating nature of this type of psychological syndrome would threaten an individual's social and economic functioning.

International Consequences

Not only is the domestic economy highly integrated and interdependent, so is the international system. Consequences of a limited nuclear war would be felt beyond the U.S. Reductions in industrial and food production would trigger a severely imbalanced import/export trade. This would in turn under-cut the dollar's stability and the international monetary system.

The United States plays a key role as a world food producer, exporting food to many nations, such as Japan. The U.S. produces 50% of the wheat and 70% of the corn used for grain, and 80% of the soybeans traded in the world. As a result of a severely damaged food production and distribution system, exports would be severely limited, if they are permitted at all. Thus, a significant number of countries may find themselves inadvertent victims of this attack, with their own stability threatened.

Summary -- Life After a Limited Nuclear Attack

Life would be severely disrupted. The medical care system would be overburdened providing intensive treatment to fallout victims, resulting in degraded regular, acute, chronic or preventive care. Support systems such as insurance and medical records would likely be in chaos, or at best in serious disarray, with some drugs in short supply. Food production and distribution systems, as well as the banking system, would be severely disrupted.

Judging from previous experience, survivors are likely to feel threatened and disoriented. Massive urban evacuation and prolonged relocation could provoke social tension, severely taxing limited social services. Choices to be made regarding evacuation and future aid to rebuild the post-attack economy could become politically explosive.

Effects would extend beyond the U.S. Industrial and food exports would decrease, or cease, tilting the balance of payments, destabilizing the dollar, and ultimately affecting other currencies. Countries dependent on the United States for food would probably experience shortages and face domestic political problems as a result. The international situation would likely be unstable.

Is Limited Nuclear War a Viable Strategy?

Would these effects be acceptable? Would-events in the post-attack situation be controllable? Remember the critical criterion for acceptability, and thus control, is the perception that a benign military-oriented attack has taken place.

Since the point of comparison would be the pre-attack world, not a full-scale nuclear war, it is unlikely that a limited nuclear attack would be perceived as benign. Instead, the effects are likely to be perceived as catastrophic and threatening. As a result, the attacked nation may be even more resistant to negotiating a resolution of whatever crisis triggered the attack.

In reality, the subtle differentiation made by military strategists between counterforce (military) and countervalue (economic/human) attacks may be politically, as well as militarily, meaningless.

Attacks Against Economic Targets: How Much Is Enough?

The test of any effective strategic nuclear deterrent is its ability to answer any "surprise" attack with a counter-attack so powerful and destructive that an adversary would face such great damage to its society as to be "unacceptable." Hence, an apparently successful first strike would be pyrrhic victory at best. Comparing the consequences to society of different levels of nuclear attack, we now consider how much of an arsenal is needed to achieve this goal.

The nature of defining "How much is enough?" has changed with the dramatic increase in warheads attributed to the appearance of multiple independent reentry vehicles (MIRVs) and the parallel development of increased accuracy and reliability of land- and sea-based missiles.

It is now possible to target selectively for maximum damage key components of the U.S. or Soviet economic and urban infrastructure, using only a small proportion of the current nuclear arsenal -- for either a first strike or counterattack. The combination of technological advances in weaponry plus the highly integrated nature of technical/industrial societies results in potentially devastating damage from a relatively small attack. To demonstrate this potential, the attacks hypothesized for this consideration use only a fraction of existing nuclear weapons. As already noted, this scenario takes place in the U.S., but there is ample evidence that the Soviet Union would be just as vulnerable -- or even more so -- to such a disciplined attack.

In our hypothetical scenario, 34 major categories of industry were assumed as targets. Standard Industrial Classification (SIC) codes were used to identify these major categories. The study established the geographical distribution, capacity and location, by plant, of these major industries. The 71 largest metropolitan areas for 1980 were assumed to be the major initial targets, since they contain the largest concentration of the 34 critical industries.

The attacks (designated A-1 the largest to A-4 the smallest) range in size from 800 weapons, with a total destructive power equivalent to about 500 weapons, to 400 weapons totaling 150 equivalent megatons. For comparison, the Soviet SS-18s (which represent 308 out of approximately 1600 of the USSR's ICBMs) are estimated to have over 2,400 warheads, each with the destructive power of at least one megaton.

These attacks had two elements: 100(A-4), 200(A-3), 300(A-2) and 500(A-1) one megaton weapons used against the 71 U.S. chief urban centers containing 60% of U.S. manufacturing capability; and a second part in which 200-300 smaller 100 kiloton weapons were employed specifically to destroy eight key elements of the economy such as petroleum refining, iron and steel works, nonferrous metals (aluminum, zinc, copper, lead), drugs, electrical distribution products, and engines and turbines, which would reduce these industries to only 2 to 3% of their pre-attack capacity.[9] No fallout is produced in these attacks. Selective use of weapons producing fallout would increase the effects described below.

The largest or "reference" attack -- A-1 -- uses 500 one megaton warheads and 200-300 smaller 100 kiloton warheads. It is based on data developed in a 1970 study entitled Potential Vulnerabilities Affecting National Survival prepared for the Army s Office of Civil Defense.[10] The PVANS study assumed a nuclear attack intended to cripple the national economy recovery capabilities of the United States. Its purpose was to determine the number and variety of weapons needed to accomplish this objective.

Casualties and Economic Effects

Depending on the size of the attack, casualties would range from 20 to 45% of the U.S. population (40 to 90 million people) including 20 to 30 million injured. From 25 to 65% of the economy would be destroyed.[11] The gross economic figures seriously understate the problem since even using the smallest attack A-4 (100 one megaton, 200-300 one hundred kiloton weapons), specifically targeted key industries are likely to be well over 50% destroyed -- some as high as 80 to 90%. To put these numbers in perspective, a Stanford Research Institute (SRI) study for the Office of Civil Defense (the Federal Emergency Management Agency's predecessor) estimated that to recover from nuclear attacks in the range discussed here would take well over a decade. We believe these estimates are based upon unrealistically optimistic assumptions -- or as the authors themselves state, the "upper limits on potential recovery. Projected recovery rates should prove over optimistic when compared with rates actually realized in a real case."[12] If recovery is possible, and that is an open question, a more reasonable estimate would be several decades -- perhaps 40 or 50 years. Of course the attacks described above are not full-scale exchanges; under those circumstances the number of warheads and megatons directed at urban/industrial targets could easily reach 2000, 3000, or more, as well as substantial fallout from ground bursts not included as part of attacks A-1 to A-4. In the case of a large-scale attack the damage would be even more severe and widespread than in the discussion to follow; combining the effects of Parts I and II might provide the minimum damage expected with a full-scale attack.

Despite the effects of so-called urban sprawl and industrial migration, industry and population remain concentrated in a relatively small number of urban areas which present particularly vulnerable targets to nuclear weapons. Nearly 60% of the U.S. population lives on only 1% of the total land area of the United States. This is a result of the fact that approximately 85% of the population of large metropolitan areas lives on only 10% of the total urban land area. The population within these metropolitan regions is concentrated in very high-density areas, rendering the U.S. even more vulnerable to an "economic" attack. For example, the implications of urban concentration are illustrated by the smallest attack, A-4. It would cause the destruction of about 20 to 30% of total manufacturing capacity and 44 to 55% of the manufacturing capacity in the 71 largest metropolitan areas. In cities as diverse as New York, Chicago, Los Angeles, and Akron, Ohio, A-4 would destroy approximately 50% or more of their manufacturing capacity. When the number of one megaton weapons in the attack on these cities is increased five-fold (500%), as in A-1, casualties and industrial damage increase only by approximately 200%.

Therefore, devastating economic destruction, disruption, and social disorganization would be caused even by the smaller attacks, since in terms of the destructive effects of nuclear weapons, population and industry are not really dispersed. In the Soviet Union, industry and population are concentrated even more densely than in the United States.

Impact on Regions

Not only would major metropolitan areas be heavily damaged, whole regions would be seriously incapacitated. This is true in part because major urban centers tend to be relatively close to one another, such as in the Northeast Corridor, along the southern rim of the Great Lakes, and in Southern California. The primary area of destruction would be the Northeast/East-Central tier of states from Massachusetts to Minnesota. The one-megaton weapon component of the larger attacks (A-3, A-4) would destroy 50% or more of the industrial capacity of every state in the area, except Wisconsin and Indiana, which would suffer between 40 to 50% Manufacturing Value Added (MVA) destruction.[13] Thus, the nation's largest block of industrial states is unlikely to continue to exist as a significant functioning unit because of the loss of population, industrial plants, and economic systems.

Several other states or industrial regions are likely to suffer similar destruction and disruption, making their contribution to the survival or recovery of the surrounding territory highly problematic. Key parts of the Sunbelt, sections of Texas, Louisiana, Oklahoma, Missouri, and Florida; and the area covered by California, Arizona, Utah, and Colorado would be severely damaged.

These regional patterns of destruction suggest that there will not be large, undamaged areas able to provide adequate refuge and support for the surviving urban population or to foster a rapid economic recovery. Although extensive rural or semi-rural territory will remain undamaged, it is largely devoid of the industrial infrastructure needed for substantial economic recovery.

Selected Industries

Since industrial societies are so well integrated, the strategy of virtually obliterating selected critical industries (2 to 3% survival) appears to be a way of assuring devastating, long-term disruption. As already discussed in the section on limited nuclear war, "bottlenecks" are created that eliminate key industries on which a large number of other industries directly and indirectly depend. For example, attacking petroleum refining directly affects the petrochemical industry; indirectly it would affect the heating of workers' homes, fuel and electricity for factories, and fuel for farm machinery and for transportation of goods. The power of this type of economic bottlenecking is well established. For example, the SRI study of post-attack recovery made calculations that assumed that energy, specifically the petroleum refining industry, was the sole target of a nuclear attack. It found that while potentially 85% of the Gross National Product (GNP) would survive, only one-quarter of the surviving GNP -- that is, only one-fifth of the pre-attack economy -- would be able to operate in the first two post-attack years.[14] Thus an effective attack would lead to an economy in which even surviving capacity would be drastically under-utilized.

Only one critical sector was the target in that situation. The implications of a more systematic effort affecting several industries should be clear. Additional evidence supporting the effectiveness of this bottlenecking strategy is found in a study prepared for the U.S. Arms Control and Disarmament Agency. In this study, which was not designed to create the largest amount of economic damage and disruption, modest 10% reductions in the capacity of a single basic industrial sector caused an overall 30 to 40% reduction in over 100 defense-related sectors. As it turns out, defense-related sectors included industries with broader influence on the entire economy, such as manufacturing trucks, airplanes and machine tools. The study concluded, "Since the economic and institutional activities necessary to sustain a war-making capability are highly interactive, relatively low levels of MVA (manufacturing) destruction can lead to significant reduction in the ability to support a war effort."[15]

A nuclear war would fragment the U.S. economic system; its integration as an effective system would be seriously in question. Economic attacks would not only damage the industrial base (factories, etc.), they would also thin the ranks of the technical and managerial personnel. Moreover, they would disrupt and destroy supporting financial structures, throwing into question the value and utility of money, as well as the value and ownership of goods and property; records of financial transactions would be destroyed, and the lending and borrowing system (banks and the Federal Reserve) would collapse with the disappearance of assets and the non-payment of debts.

Also associated with extensive industrial damage is injury to the basic physical support systems. In particular, the urban infrastructure in attacked areas -- transportation, utilities, housing, fuel and food distribution systems, sanitation systems, and medical care services -- would emerge either badly damaged or of very limited use in supporting industrial workers. To rebuild these systems or to duplicate them elsewhere would be a lengthy but necessary process, diverting resources from the economic expansion necessary to achieve rapid full recovery.

The casualties (dead and injured) resulting from this type of attack would be incomprehensible, even if some reduction due to strategies of civil defense (evacuation) were possible. While the monumental loss of skilled workers, managers and economic leadership has already been noted, the key to the reality of the postnuclear attack period is the staggering burden of 20 to 30 million injured, many of whom would never again be fully productive. Who would care for them? Who would provide the support? What would be the cost to society in delayed recovery and social stability? These are almost unanswerable questions, but one thing is clear: The physical resources left after a "limited" nuclear attack will not exist after an economic attack.

Food

The U.S. food system (production, processing, distribution) is both highly integrated and dispersed. Since food may travel 1000 miles or more from production to consumer, the system depends very heavily on effective transportation and organization. For example, almost one-third of the population lives in counties that produce less than a two-week supply of their grain needs, and half the population lives in counties with two months or less production capability. Approximately two-thirds of the nation's food (as measured by calories) is produced in the North Central tier of states from Indiana to Colorado, which themselves contain only about one-quarter of the population. Moreover, this system is highly dependent on petroleum (farm equipment), electricity (particularly dairy), and fertilizers and pesticides. If, for

example, dairy farms lost electricity, many cows could not be milked adequately. Without proper milking a cow would simply dry up in less than a week until it calved nine months later. Finally, almost 90% of U.S. processing capacity (canning, baking and packaging) would be in regions destroyed or severely damaged by the attack.

The severe limitation of energy supplies, particularly the large-scale loss (97 to 98%) of petroleum refining capacity; the loss of key chemicals (such as pesticides and fertilizers); and the regional and national economic and social disorganization resulting from any size attack, would deeply affect the nation's food supplies. The results of attacks A-1 through A-4 on the nation's food distribution, processing, and production systems would be as follows: First, sufficient basic production capacity in most food categories in the mid-range would survive because the Farm Belt is not directly attacked and fallout is not generated. There are real limitations on the use of this capacity, however, due to inadequate fuel for running farm machinery and transportation; disruption of electricity production through loss of fuel supplies and key workers; shortages of fertilizer and pesticides to maintain productivity because of the severe losses in petroleum refining and heavy damage to the related chemical industry; uncontrolled population migration and social disorganization, and possibly radioactive fallout. Second, because of widespread urban destruction the transport and distribution system would be severely disrupted, raising the possibility of a sufficient food supply but no effective means to distribute it. Regional maldistribution exacerbated by hoarding contains the seeds of profoundly disruptive political as well as survival problems. For example, in theory, over 200 days of grain supply could be available; for the surviving population, however, there is no certainty that food would be permitted to leave the producing areas by local residents. Third, food-processing industry losses of potentially 80 to 90% would lead to insufficient capacity, even if supplies of raw foodstuffs were adequate, and cause spoilage and shortages.

Therefore, while mechanization, automation, and widespread use of chemical fertilizers and pesticides have made American food production comparatively very efficient, they have also created a situation in which large urban populations distant from their suppliers are totally dependent for food supplies on a system that is highly vulnerable to nuclear attack.

Finally, as we noted in the discussion of limited nuclear war, many other nations that depend on U.S. food production will be affected. A disruption or partial destruction of U.S. agriculture will have implications throughout the world food market, dramatically cutting supplies and increasing prices. For surviving supplier nations, food could quickly become a major political weapon; for consumers, it could become a focal point of desperate conflict in international affairs. From a humanitarian and political perspective, this vulnerability is a serious concern.

Energy

The availability of energy is a critical element in national survival and economic power. The United States depends on fossil fuels for about 93% of its energy needs, with petroleum accounting for the largest share (49%). In the two largest attacks hypothesized in Life After Nuclear War (A-1 and A-2), 98% of the petroleum refining capacity in the country would be destroyed. Surviving capacity would be inadequate to meet even farm fuel needs. Less refinery capacity -- but still well over 50% -- would be destroyed in attacks A-3 and A-4, but damage and disruptions to pipelines, port facilities, rolling stock, and other associated facilities would reduce the effectiveness of the surviving capacity.

Adequate foreign petroleum supplies may not be available, depending on the post-attack international situation, the availability of tanker capacity, the willingness or ability of the OPEC nations to maintain or increase production, and the willingness of oil-producing nations to provide petroleum to a country without the economic capacity to generate adequate funds for payment. In any case, most imported petroleum arrives in the United States as crude oil, and thus U.S. refinery capacity, plus its port and distribution system, is needed to render it usable.

Natural gas is produced primarily in Texas and Louisiana (74%) and also in Oklahoma, Kansas, and New Mexico. These states consume one-third of their own production; the remainder goes mainly to the Midwest, New England, Mid-Atlantic states and California. Most of this gas is shipped by pipelines, many of which could be damaged if targeted in the hypothetical attacks.

Although coal is the most abundant fossil fuel in the United States, substitution of coal for oil will be very limited in the near and mid-term because of existing constraints and those imposed by nuclear war on fuel conversion and coal mining capacity. Coal is mined by electrical and diesel equipment, and it is transported by trucks and trains which will

be damaged and short of fuel themselves in the post-attack period.

Power generating stations that survive the attacks would also be affected by fuel shortages. As is the case with refining and transporting fossil fuels, efforts to maintain or expand electrical generating capacity will suffer from reduced maintenance capability and lack of equipment and replacement parts. In fact, the loss of skilled personnel is a potentially more significant threat to power plant operation than any physical losses.

Both household and industrial fuel consumption will decrease as a result of losses in manufacturing capacity, population, and housing. It is not possible to predict precisely whether surviving fuel and power resources will match demand, though under the assumed attacks, refining capacity losses exceed losses in industrial capacity. Nor can we know in advance precisely what sort of price system would exist -- whether prices would be controlled by government -- or even the extent to which barter would replace monetary transactions. It does seem clear that maldistribution of surviving fuel stocks and transportation system damage will create local shortages and hamper immediate relief efforts.

And what about recovery? Postwar experience in Europe and Japan indicates that to replace and rebuild the fuel processing and distribution systems, as well as electrical generating and transmission facilities, will be time-consuming. Even if domestic or imported fuel is available in adequate quantities -- an uncertain assumption -- the capacity to convert it efficiently to its end use is likely to be inadequate for several years, thereby retarding economic recovery from the post-attack base. The American economy depends on large quantities of electrical power and fossil-fueled transportation systems; combined with the vulnerability of petroleum refining facilities and significant dependence on foreign petroleum, this suggests that the magnitude of the difficulty of meeting energy needs may be one of the most critical determinants of the nation's long-term ability to recover economically from urban-oriented nuclear attacks.

Pursuing full economic recovery will place enormous demands on the damaged energy system, even if stringest rationing were imposed on individual consumption. It remains doubtful whether the badly damaged economy with its output greatly curtailed would be able to generate the enormous sums of capital and other resources required to refurbish the national energy system and to purchase foreign petroleum (assuming it is available). After a limited nuclear attack, people's time preferences would increase dramatically, and savings and investment would nearly grind to a halt, even if the institutions to channel savings into rebuilding productive capacity should happen to survive. It is not a far-fetched prospect that the victim of an urban-oriented thermonuclear attack would find itself in the position analogous to many of today's least developed countries -- in a vicious circle where essential consumption prevents accumulation of the surplus resources required to expand productivity and output.

Medical Effects

The potential losses in medical resources are dramatic, particularly because United States medical resources, especially specialists, are so heavily concentrated in urban areas: 68% of the physicians, including about 70% of the specialist, over 60% of the surgeons, and 64% of the dentists, are located in the 71 urban areas attacked. These urban areas contain only 55% of the total population. Likewise, the areas exposed to both the attack against 71 urban areas and the adjunct attack against selected industries contain 61% of the total U.S. population, but 71% of U.S. physicians and 68% of its dentists. Thus, physicians and dentists would be comparatively more vulnerable than the general populace in an urban/economic attack. Also concentrated in the urban areas are many of the most advanced hospitals and almost 80% of the hospital-based physicians.

The combination of physician losses and injuries on the order of 20-30 million would produce patient-physicians ratios of 100-600 to 1. In the early period, when the wounded and dying cannot be distinguished, ratios would be 1000 to 1, depending on the movement of physicians into and/or patients out of damaged areas. For perspective, an average physician sees perhaps 25 patients a day with only 20% having serious problems, usually not emergencies. Surviving hospitals would face ratios of 30 to 40 injured per bed. There would be hundreds of thousands of burn victims; most large burn units -- found only in major hospitals -- have about 10 beds, And few major urban hospitals would be left.

Under these attacks, medical care for the injured will be further complicated by the virtual elimination of the pharmaceutical industry, one of the eight critical industries targeted for maximum destruction. Even simple protection

against infection will be difficult without antibiotics and other prophylactics. Urban stocks of these medicines will be largely destroyed and new supplies unavailable. Chronically ill individuals (heart disease, diabetes, etc.) who depend on drugs to sustain physical activity or life itself will also be affected.

Providing high quality medical care requires high capital investment and long training periods; thus post-attack medical care norms may continue to be dramatically below current standards for a considerable time, with negative implications for labor productivity and other aspects of economic recovery. Significant radioactive fallout or the breaching of immunological barriers in the aftermath of the attack would permit a high incidence of epidemic disease.[16]. The loss of major medical research centers will be devastating to research on improved disease treatment. The heavy burden of chronically ill or permanently injured survivors will continuously tax the reduced medical capabilities and disoriented social service support system, leading to a general deterioration of all medical care.

Because malnutrition lowers resistance to disease, medical problems would be exacerbated if the food supply system proves ineffective. Serious mental health problems will arise from the impact of the attack -- particularly a sense of impotence from watching people die who in a "normal" society would have lived -- or from the stress of the post-attack recovery period.

The implications of all these problems would be a society burdened and preoccupied with human suffering, unable to cope successfully with its demands. The credibility of the remaining leadership and its ability to focus resources for recovery might very well hinge on how it was able to manage the medical effects of nuclear war.

Higher Education

America's economic and military power derives in large measure from its ability to maintain its technological leadership; higher education plays a central role in maintaining this lead. Universities and colleges provide trained personnel to assist in scientific and technological development. They also provide the institutional framework for basic research that becomes the basis of scientific discovery and technological innovation.

In the above attack on the 71 major urban areas, over 50% of the higher education system would be damaged or destroyed. Professional schools are even more vulnerable -- over 70% of the students are concentrated in these urban areas, which contain only 55% of the general student population. Of equal significance, an attempt to measure not only quantity but also the quality of graduate (science and engineering) and professional (medical, law) schools found a disproportionate number -- 70% -- in attacked areas. In other words, in the academic areas we evaluated, quality educational facilities tended to be highly concentrated in the major urban areas. In addition, these universities and professional schools attract or spin off important private research-and-development or consulting firms and high-technology manufacturing firms in close proximity.

Given the massive scale of population losses and casualties after nuclear attacks, it is likely that the concept of the function of the university would also change, assuming a more narrow role as a vocational and professional training ground. The training could be at a very basic level, with many important intellectual pursuits and professions abandoned. The basic scientific and technological infrastructure could be the most seriously injured since even if the capacity remained, the justification for basic research during the post-attack recovery period would likely be questioned, and any diversion of energies in this direction challenged. Complex scientific experiments requiring extraordinary collaboration among scientific groups and expensive, sophisticated equipment would be eliminated or delayed for perhaps decades. The quality of research and the university's vital contribution to technology would diminish drastically in almost any nuclear attack. Thus, the damage to the higher education system would pose serious obstacles to a strong and rapid economic recovery.

Social Consequences

To understand the effects of a nuclear war it is important to distinguish it from common disasters, even World War II. Especially if hostilities continue or their resumption is threatened, all the elements that make a small disaster tractable will be lacking: limited damage, modest casualties, surviving leadership, a diminishing incidence of role conflict (desire to protect one's family rather than to perform emergency work) and large reservoirs of external, easily mobilized skilled workers, material resources, and organizational skills.

The massive and simultaneous destruction of economic and human resources would result in an inability to provide immediate and sufficient human and material aid to damaged areas. There will be no time to adapt and to innovate as nations did in World War II (U.S.S.R. as previously cited is an example). More important, the lack of outside aid would create a sense of individual and communal isolation. Aid symbolizes a reconnection with a larger, normal world. This connection helps provide the impetus for rebuilding the damaged society, creating a sense of vitality and competence to dispel the continuing perception of isolation. It also has an important function for binding together society, restating a common thread of hope and shared aspirations that are the essence of national life. The post-attack situation could be like Japan near the end of World War II.

There could be "a drift toward accomplishing personal and private aims rather than those which are national...farmers...growing little more than is required for their own subsistence,"[17] or more likely, the complete demoralization seen in an earlier tragedy: "Survivors of the Black Death in growing helplessness fell into apathy, leaving ripe wheat uncut and livestock untended...no one had any inclination to concern themselves about the future."[18] More pertinent, a panel of experts in a study of social consequence of nuclear war for the Office of Civil Defense concluded: "One month after the attack, less than half the potential labor force could be expected to work without immediately beneficial compensation, and that, of these, one in five would be able to function only at a level greatly degraded from his normal abilities."[19]

The experience of nuclear war is likely to have devastating psychological effects, especially for Americans, whose homes and institutions have essentially escaped the ravages of recent wars. The very short period required to carry out highly destructive nuclear attacks would intensify the emotional impact, particularly those reactions associated with denial of the true extent of the damage or fostering flight from and resistance to reentering damaged areas.

Robert J. Lifton, in his study of Hiroshima survivors, described the psychological effect as "a sudden and absolute shift from normal existence to an overwhelming encounter with death."[20] The reaction, as reported by a witness to the disaster, Father Siemes: "Among the passersby, there are many who are uninjured. In a purposeless, insensate manner, distraught by the magnitude of the disaster, most of them rush by and none conceives the thought of organizing help on his own initiative. They are concerned only with the welfare of their own families."[21] In some cases even families were abandoned. The result of this experience was, as Fred Ikle described it 25 years ago, a deep aversion to returning to the cities to rebuild the economy. "And thus a very different situation will exist from that envisaged in most civil defense plans (in the 1950s)."[22] The economic implications of this type of withdrawal would be serious.

A high incidence of abnormal behavior, ranging from the nonfunctional to the antisocial, could be anticipated. Specific psychological effects would include disorientation, fear, doubt, apathy, and antipathy toward authorities. The effects on Hiroshima/Nagasaki survivors provide ample evidence to support these concerns.

Families would be broken up by death, severe injury, disease, evacuation, or military and labor conscription. The young, elderly, and handicapped would suffer disproportionately since they depend most on society's material and institutional resources. For example, the young and elderly showed significant increases in accidental death attributed to neglect in Great Britain in World War II.

The loss of material and institutional resources in urban-industrial attacks would make survival in the post-attack period difficult for individuals and groups alike, compounding the psychological stresses of the attack itself. Satisfying even the simplest survival requirements -- food, shelter, and clothing -- would become major tasks.

Significant interpersonal, intergroup, and inter-regional conflicts would probably arise. Ethnic, racial, regional, and economic conflicts present in the pre-attack society, while minimized in the period immediately after an attack, would be heightened after only a limited time by the extent of the deprivation and the resulting tensions. New antagonisms would develop between hosts and evacuees or refugees over the possession and use of surviving resources.

These phenomena were observed both in Britain and in Japan during World War II. The Allnutt study predicted these conflicts would be so serious that they "would necessitate the imposition of martial law or other authoritarian system in many localities, and the widespread use of troops to maintain order." r 231

Continuing hostilities or prolonged threat of renewed war would engender even more profound changes in the social fabric. Major, possibly permanent, changes in social values and institutions could be expected as society sought to adjust to a radically altered environment dominated by the question of physical survival.

Economic destruction, loss of political leadership (especially at the local level), and the need to mobilize resources for relief and recovery would present extraordinary demands on weakened political institutions. In the interest of implementing survival programs, legal norms and practices would have to be suspended for prolonged periods in many areas. The character of political institutions and authority would almost certainly change, especially if hostilities or the threat of hostilities persisted. Both old and new political structures would be likely to suffer from greatly reduced credibility. Decentralization of political power and more authoritarian methods of political, social, and economic control would be probable responses to post-attack conditions.

The substance of these problems is acknowledged with an ironic optimism by the panel assembled for the Allnutt study:

Major institutions and organizations were seen as fragmenting in most cases and collapsing in others, but the seriousness of this result would be relieved somewhat by the irrelevancy of many of them to the early stages of recovery, and by the ability of social structures to spring back into action where physical conditions permit. The Federal Government would make serious mistakes and suffer a loss of power and prestige, but not a loss of faith so serious as to favor the possibility of revolt. Financial institutions would be modified greatly, and barter would be a widespread reaction to inflation, but money was not seen as going out of style, nor was a barter economy foreseen. Legal, judicial, and enforcement systems would similarly undergo great strains, being overwhelmed entirely in some areas, but again, due process, though delayed, would not be lost in principle. Industries and commercial organizations were expected to fragment into autonomous, local entities until communications and transportation systems were repaired, but the goals of such corporations would not be greatly changed.[24]

We are not similarly convinced that such massive dislocations would not create more significant changes in both the underlying goals and functions of economic, social and political institutions in the post-attack society.

Summary

The economic attacks postulated above employ only a small fraction of the existing nuclear arsenal. It is clear that even a small, selectively targeted nuclear attack can paralyze a nation and that recovery would be problematic at best. We have presented a brief, grim description of economic and human damage, as well as the vulnerability of key support structures for society's short- and long-term goals. Yet even that picture could not adequately describe life after nuclear war. What it lacks is a sense of the uncertainty and ambiguity that would exist in the effective use of surviving physical and human resources and in reestablishing social bonds

Conclusions

To see the problem of nuclear war in its proper context, we must first return briefly to the concept of "unacceptable" damage. Although two levels of damage -- biological survival of individuals and the functioning of regions -- often appear in public discussion of nuclear war, neither makes much sense in terms of the normal expectations of organized technical/industrial society. Not only must individuals survive, but so must the institutions necessary to maintain a social order. Do the weapons surviving constitute a viable military force and by what process would they be employed? The surviving weapons cannot order the economy, rebuild productive industrial capacity or grow or distribute food. Thus, simple biological survival of some members of the population or survival at a regional level could not be an acceptable outcome for a nation as a whole, and still less for its government.

One test of acceptability would be to maintain the minimum economic, political, and social capacity required for full recovery of the nation within a reasonable period of time. A higher standard would be the continued ability to play an effective independent role, politically, economically, diplomatically, and militarily. This ability would be measured in relation to the analogous surviving capability of the attacking nation(s) as well as to the capability of undamaged or less damaged nations which did not participate directly in the nuclear exchange. Would it be acceptable in a post-nuclear war world to become a client state such as Japan and Germany were after World War II? The question then

becomes, what constitutes an acceptable post-attack national status -- what kind of entity remains to fend for itself in the post-attack world? This may not be easy to answer. It is conceivable that on a superficial level, there may still be substantial military and strategic capability equal to or more potent than other nations. The social structure, however, would be in disarray or on the verge of collapse or political leadership unable to "control" the evolution of events. It is this perspective that underlies our conclusions.

The U.S. nuclear deterrent is adequate now and almost certainly through this century. This is true because weapons technology permits relatively small but sophisticated attacks that can deliver stunning damage to the industrial functioning of an adversary, or alternately to its key military infrastructure. The numbers of weapons needed to assure unacceptable damage to an adversary are indeed so small that it is difficult to conceive of any situation where U.S. forces would be inadequate. Even a surviving force of only 10% of U.S. ICBMs, or 100 missiles (assuming a functional command and control system) would possess devastating and potentially fatal power. Moreover, a surviving bomber and in vulnerable submarine nuclear force alone would be sufficient.

Therefore, the "window of vulnerability" projected for U.S. ICBMs in the 1980s is more a matter of perception and emphasis than of compelling reality. We make this assertion because the key underlying assumption of this short-term vulnerability issue is that "limited," controlled nuclear war is credible. That is, it is accepted that if ICBMs are successfully attacked, the U.S. will be paralyzed -- unable or unwilling to retaliate for fear of further destruction of its urban areas. If, as we conclude, limited nuclear war is not a credible strategy, then the sophisticated scenarios for land-based missile vulnerabilities become significant only because they might be believed, encouraging action on a false, high-risk assumption.

To insure nuclear stability there must be a long-range commitment to maintaining the survivability of a mixed force, so that no single vulnerability can threaten the entire nuclear capability force and the command and control structure. In this longer term context, the vulnerability of land-based ICBMs is worrisome because other vulnerabilities could arise, particularly with regard to sea-based missiles. Yet given the huge nuclear capability available, improvements to assure continued survival are certainly not incompatible with a phased mutual reduction of total strategic nuclear weaponry.

What is more, the concept of "limited" nuclear war is illusory and thus dangerous. It propagates a notion that no Soviet and no U.S. planner should be encouraged to accept as a basis for policy-making -- that is, that damage from a military attack would be benign or "acceptable." As we have shown, damage to the fabric of civilian society from any effective attack against ICBMs and/or substantial numbers of military targets would create an imperative to retaliate and escalate. Thus the possibility of a controlled, rational "limited" nuclear war would be undermined. The perception of threat and vulnerability generated by this damage would eliminate the political option of control. Moreover, a number of commentators have raised the serious possibility that in a technical sense, the command and control structure would be so physically vulnerable that even purely mechanical communication requirements for controlling a nuclear response will not be available.[25] The combination of these two elements makes the viability of a "limited" nuclear war strategy highly doubtful.

Finally, civil defense, particularly crisis relocation (evacuation), has been presented as a complementary element in nuclear strategy. It is ineffective at best. Its purpose is to minimize human destruction and thus purports to strengthen the basis for the possibility of successfully enduring a "limited" or even urban-oriented nuclear attack. This argument is tenuous. First, it is hard to believe that in a period of extreme tension, a full-scale urban evacuation by the U.S. or Soviet Union would be perceived as anything but a signal of intent to pursue a nuclear strike. Since an effective evacuation takes at a minimum four to five days to complete, certain actions are likely to be taken by the other side. Among the possibilities: a threat to attack if the evacuation is not stopped; an attack during the evacuation phase when the population is most exposed; and of course, the adoption of a strategy of "launch on warning," creating a hair trigger in a clearly dangerous situation. Ironically, a launch on warning would defeat the whole purpose of a first-strike strategy.

Even with a successful evacuation, destruction from a well-designed second strike against a major portion of urban economic and physical infrastructure (factories, housing, electricity generation, hospitals, etc.) would not necessarily leave a nation better off than no evacuation at all. A surviving population with no basic support systems is a

prescription for human suffering, gross political instability, and eventually death on an incomprehensive scale. Even an evacuation without an attack would seriously damage the U.S. economy. And, as Fred Ikle succinctly put it, "The war will not end miraculously after the people have been moved into the nearest fields, and further problems of evacuation will then arise."[25]

Taken together, the concepts of "limited" nuclear war and crisis relocation represent a kind of sophisticated exercise in self-deception; a Pollyanna-like vision of the world that crumbles when confronted with dispassionate, realistic analysis of the limits of resiliency or flexibility of an society damaged by nuclear war.

Therefore, it is time to rethink the purposes of our nuclear strategy and their implications. Particularly worrisome are the demands for more sophisticated strategic weapons and the direct and inadvertent growth of the technological capabilities to satisfy these demands. It is the potential for technological sophistication and the apparent control these technologies offer that permits military planners to construct scenarios that make nuclear war appear "benign" when analyzed superficially.

Unfortunately, there is no magical prescription to solve these problems. But it is clear that much of the debate about numbers of weapons and vulnerability has little to do with the real problem: We must establish a basis for the control of nuclear weapons, particularly sophisticated technology, and the appropriate strategic weapons mix to maintain a stable defense. This is the challenge confronting Congress, the executive branch, and the American people.

[1] Analyses of Effects of Limited Nuclear Warfare, Senate Foreign Relations Subcommittee on Arms Control, International Organizations and Security Agreements (Washington, D.C.: Government Printing Office, September, 1975), p. 101.

[2] Ibid., p. 113.

[3] The Effects of Nuclear War, Office of Technology Assessment (OTA), U.S. Congress (Washington, D.C.: Government Printing Office, May 1979), p. 86.

[4] Arthur M. Katz, Life After Nuclear War (Cambridge, Mass.: Ballinger Publishing Co., 1982), p. 45.

[5] Ibid., p. 48.

[6] Fred C. Ikle, The Social Impact of Bomb Destruction (Norman: University of Oklahoma Press, 1958), p. 108.

[7] C. M. Haaland, C. V. Chester and E. P. Winger, Survival of the Relocated Population of the U.S. After a Nuclear Attack, ORNL-5401 (Oak Ridge National Laboratory, June 1976), p. 72.

[8] For example, see: Report of the President's Commission on the Accident at Three Mile Island (Washington, D.C., October 1979); and Cynthia B. Flynn and J. A. Chalmers, The Social and Economic Effects of the Accident at Three Mile Island: Findings to Date NUREG-CR-1215 (Washington, D.C.: Government Printing Office, January 1980).

[9] Descriptions of Nuclear Attacks

A-1 (reference attack) Basic 500 1-Mt weapons plus Adjunct 200-300 100-Kt weapons A-2 Basic 300 1-Mt weapons plus Adjunct 200-300 100-Kt weapons A-3 Basic 200 1-Mt weapons plus Adjunct 200-300 100-Kt weapons A-4 Basic 100 1-Mt weapons plus Adjunct 200-300 100-Kt weapons [10] R. L. Goen, R. B. Bothun, and F. E. Walker, Potential Vulnerabilities Affecting National Survival, Stanford Research Institute for the Office of Civil Defense, Department of the Army, contract DAHC 20-69-C-0186, September 1370.

[11] U.S. Vulnerability to Nuclear Attack

Attacks	Percentage of Total U.S.	Percentage of Urban Casualties	Percentage of Total U.S. Industry	Percentage of SMSA Industries	Total Megaton Equivalents	Total Weapons Required

	Casualties		Destroyed	Destroyed	(e)	(f)
A-1	35-45	50-65	60-65	80+	544-566	700-800
A-2	30-40	45-60	45-60	75-80+	344-366	500-600
A-3	25-35	40-50	35-45	55-70	244-266	400-500
A-4	20-30	30-45	25-35	45-55	144-166	300-400

Source Arthur Katz, Economic and Social Consequences of Nuclear Attacks on the United States, Committee on Banking, Housing, and Urban Affairs, U.S. Senate (Washington, D.C.: Government Printing Office, 1979), p 9

[12] F. W. Dresch and S. Baum, Analysis of the U.S. and U.S.S.R. Potential for Economic Recovery Following a Nuclear Attack, Stanford Research Institute, Strategic Studies Center (Menlo Park, Calif., January 1973), p. I-16.

[13] Gross National Product (GNP) is the total of personal consumption expenditures (what individuals spend for goods and services), gross private domestic investment, government purchases of goods, and services. National Manufacturing Value Added (MVA), in contrast, represents only the manufacturing contributions to the U.S. economy. Thus, MVA is smaller -- about 30% of the size of the GNP.

[14] Dresch, et al., p. II-7.

[15] Jack Sassen and Kenneth Willis, Data Base and Damage Criteria for Measurement of Arms Limitation Effects on War Supporting Industry ACDA/WEC-242, Metis Corporation (Alexandria, Va., June 1974), p. 44.

[16] H. L. Abrams and W. E. von Kaenel, "Special Report: Medical Problems of Survivors of Nuclear War," New England Journal of Medicine, November 12, 1981, p. 1229

[17] Alexander H. Leighton, Human Relations in a Changing World (New York: E. P. Dutton an Co., 1949), p. 251.

[18] Barbara Tuchman, A Distant Mirror (New York: Alfred A. Knopf, 1978), pp. 98-99.

[19] Bruce C. Allnutt, A Study of Consensus on Social and Psychological Factors Related to Recovery from HSR-RR-71/3-D1, prepared for the Office of Civil Defense, Department of the Army (McLean, Va.: Human Sciences Research, Inc., May 1971), p. S-4.

[20] Robert J. Lifton, Death in Life (New York: Vantage Books, 1969), p. 31

[21] Father Siemes, "Hiroshima -- August 6, 1945," Bulletin of Atomic Scientists 1 (May 1946): 2-6.

[22] Ikle, p. 107.

[23] Allnutt, pp. S-3 and S-4.

[24] Ibid., p. S-3.

[25] Desmond Ball, Can Nuclear War Be Controlled?, Adelphi Papers, 169 (London: The International Institute for Strategic Studies, 1981).

[26] Ikle, p. 84.