Chapter IV

THREE ATTACK CASES

Chapter IV.—THREE ATTACK CASES

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Chapter IV

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OVERVIEW

The following pages present descriptions of three '*cases" of nuclear attacks. (The tutorial on nuclear effects–chapter H-was the first of our four cases.) As mentioned in the *Executive Summary,* these cases do not necessarily represent "probable" kinds of nuclear attacks; they were chosen rather to shed light on the way in which different types of attacks could have differing effects on the civilian population, economy, and society. Moreover, each case is considered in isolation—events that could lead up to such an attack are deliberately ignored (because their prediction is impossible), and it is assumed (although that assumption is questionable at best) that the attack described is not followed by further nuclear attacks.

Each case considers first a Soviet attack on the United States, and then a U.S. attack on the Soviet Union. These attacks are similar in that they attack similar target sets, but different in detail because both the weapons available to the attacker and the geography of the victim are different. It should be emphasized that this discussion is not suggesting that in the real world an attack would be followed by a mirror-image retaliation; rather, it is looking at similar attacks so as to highlight the asymmetries in the ways in which the United States and the Soviet Union are vulnerable. To save space, it is assumed that the reader will read the Soviet attack on the United States in each case before turning to the U.S. attack on the Soviet Union, and repetition has been minimized.

The analyses that follow are much more like sketches than detailed portraits. Precise prediction of the future of the United States or the Soviet Union is impossible even without taking into account something as unprecedented as a nuclear attack. A detailed study would say more about the assumptions used than about the impact of nuclear war. What is possible, and what this report tries to do, is to indicate the kinds of effects that would probably be most significant, and to comment on the major uncertainties.

The following pages discuss the impact on civil i an societies of:

- A limited attack on industrial targets. For this case the hypothesis was an attack that would be limited to 10 strategic nuclear delivery vehicles (S NDVs) (i. e., 10 missiles or bombers, in this case Soviet SS-18 intercontinental ballistic missiles (I CBMs), and U.S. Poseidon submarine-launched ballistic missiles (SLBMs), and Minuteman Ill ICBMs), and that would be directed at the oil refining industry. Oil refining was chosen as the hypothetical target because it is vital, vulnerable, and concentrated in both countries. It is assumed that the attack would be planned without any effort either to minimize or to maximize civilian casualties.
- A large counterforce attack. The possibilities considered included both an attack on ICBM silos only (a case that has gained some notoriety as a result of assertions by some that the United States may become vulnerable to such an attack) and an attack on silos, missile submarine bases, and bomber bases (which some characterize

as the least irrational way to wage a strategic nuclear war). The analysis draws on several previous studies that made 'varying assumptions about attack design, weapon size, targets attacked, and vulnerability of the population; the ways in which variations in these assumptions affect the calculations of estimated fatalities are discussed.

- A large attack against a range of military and economic targets. This attack is intended to approximate "the ultimate deterrent''—the climax of an escalation process. The description of the results of this attack draws upon several previous studies that made differing assumptions about the number of weapons used and the precise choice of targets, but such variations are useful in indicating the range of possibilities. However, deliberate efforts to kill as many people as possible are not assumed, which would lead to more immediate deaths (perhaps 10 million to 20 million more) than targeting economic and military facilities.

CASE 2: A SOVIET ATTACK ON U.S. OIL REFINERIES

This case is representative of a kind of nuclear attack that, as far as we know, has not been studied elsewhere in recent years–a "limited" attack on economic targets. This section investigates what might happen if the Soviet Union attempted to inflict as much economic damage as possible with an attack limited to 10 SNDVs, in this case 10 SS-18 ICBMs carrying multiple independently targetable reentry vehicles (MlRVs). An OTA contractor designed such an attack, operating on instructions to limit the attack to 10 missiles, to create hypothetical economic damage that would take a very long time to repair, and to design the attack without any effort either to maximize or to minimize human casualties. (The contractor's report is available separately.) The Department of Defense then calculated the immediate results of this hypothetical attack, using the same data base, methodology, and assumptions as they use for their own studies. *

Given the limitation of 10 ICBMs, the most vulnerable element of the U.S. economy was judged to be the energy supply system. As table 6 indicates, the number of components in the U.S. energy system forces the selection of a system subset that is critical, vulnerable to a small attack, and would require a long time to repair or replace.

OTA and the contractor jointly determined that petroleum refining facilities most nearly met these criteria. The United States has about 300 major refineries. Moreover, refineries are relatively vulnerable to damage from nuclear blasts. The key production components are the distillation units, cracking units, cooling towers, power house, and boiler plant. Fractionating towers, the most vulnerable components of the distillation and cracking units, collapse and overturn at relatively low winds and overpressures. Storage tanks can be I if ted from their foundations by similar effects, suffering severe damage and loss of contents and raising the probabilities of secondary fires and explosions.

MlRVed missiles are used to maximize damage per missile. The attack uses eight l-megaton (Mt) warheads on each of 10 SS-18 ICBMs, which is believed to be a reasonable choice given the hypothetical objective of the attack. Like all MIRVed missiles, the SS-18 has limitations of "footprint"–the area within which the warheads from a single missile can be aimed. Thus, the Soviets could strike not any 80 refineries but only 8 targets in each of 10 footprints of roughly 125,000 mi^2 [32,375,000

***The Office of Technology Assessment wishes to thank the Defense Civil Preparedness Agency for their timely and responsive help in calculations related to this case, the Command and Control Technical Center performed similar calculations regarding a similar U S attack on the Soviet Union**

Table 6.—Energy Production and Distribution Components

Category	Prime sources	Numbers	Processing	Numbers	Distribution
Oil	Wells	Thousands	Refineries	Tens/hundreds (tend to be clustered)	Pipelines/rail/truck/barge/ship
	Ports (imports)	Tens			
	Pipelines (imports)				
Gas	Wells	Thousands	Gas plants	Tens/hundreds	Pipelines/rail/truck/barge/ship
	Oil refineries	Hundreds			
	Ports (imports)	Tens	Deliquification plants	Tens	
	Pipelines (imports)	Tens			
Coal	Mines	Hundreds	Usually at mines	Hundreds	Rail/truck/barge/coal slurry pipelines
Electric power production	Hydroelectric	Tens	Same as prime source		Powerlines/power grids
	Thermal	Hundreds			
	Nuclear power	Tens			
	Power grids (imports)	Units			

SOURCES: *Vulnerability of Total Petroleum Systems* (Washington, D.C.: Department of the Interior, Office of Oil and Gas), May 1973, prepared for the Defense Civil Preparedness Agency.
National Energy Outlook 1976 (Washington, D.C.: Federal Energy Administration, February 1976

hectares], The SS-18's footprint size, and the tendency of U.S. refineries to be located in clusters near major cities, however, make the SS-18 appropriate. The footprints are shown in figure 13. Table 7 lists U.S. refineries by capacity; and table 8 lists the percentage of U.S. refining capacity destroyed for each footprint.

The attack uses eighty l-Mt weapons; it strikes the 77 refineries having the largest capacity, and uses the 3 remaining warheads as second weapons on the largest refineries in the appropriate missile footprints, In performing these calculations, each weapon that detonates over a refinery is assumed to destroy its target. This assumption is reasonable in view of the vulnerability of refineries and the fact that a l-Mt weapon produces 5-psi overpressure out to about 4.3 miles [6.9 km]. Thus, damage to refineries is mainly a function of numbers of weapons, not their yield or accuracy; collateral damage, however, is affected by all three factors. it is also assumed that every warhead detonates over its target. In the real world, some weapons would not explode or would be off course. The Soviets could, however, compensate for failures of launch vehicles by readying more than 10 ICBMs for the attack and programming missiles to replace any failures in the initial 10. Finally, all weapons are assumed detonated at an altitude that would maximize the area receiving an overpressure of at least 5 psi. This overpressure was selected as reasonable to destroy refineries. Consequences of using ground bursts are noted where relevant.

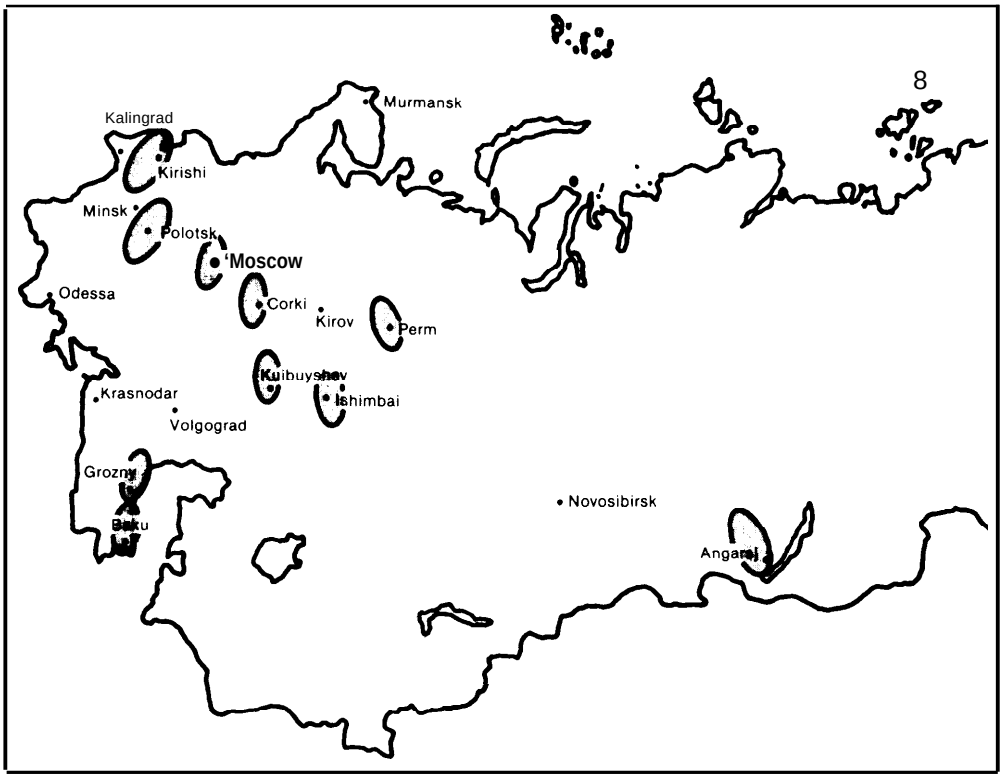
The First Hour: Immediate Effects

The attack succeeds. The 80 weapons destroy 64 percent of U.S. petroleum refining capacity.

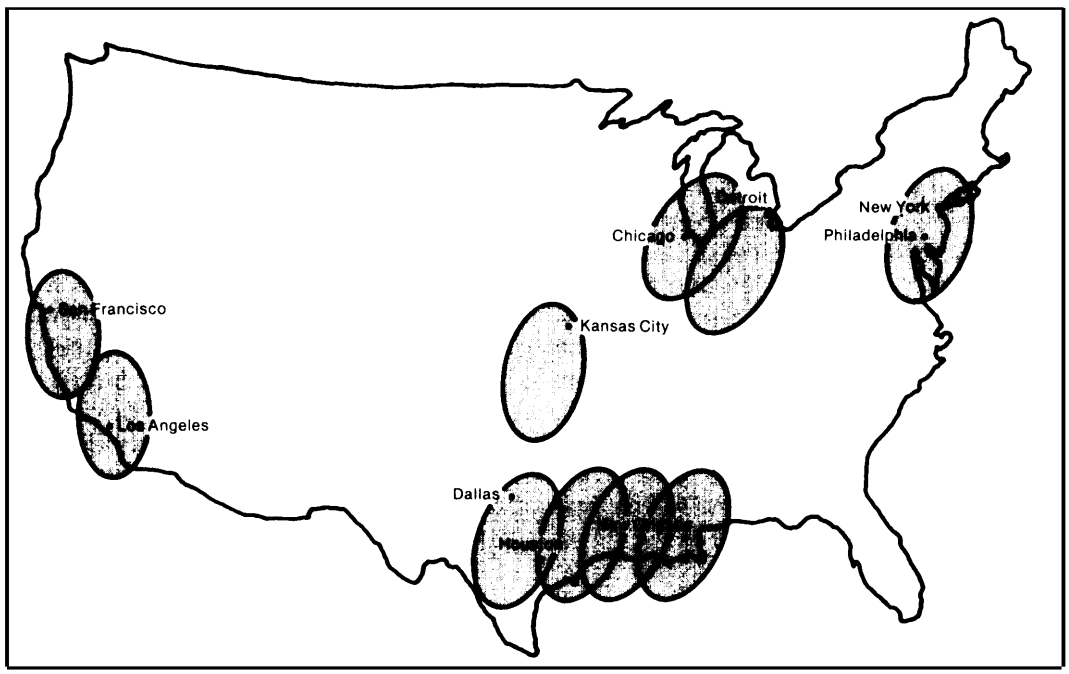
The attack causes much collateral (i. e., unintended) damage. Its only goal was to maximize economic recovery time. While it does not seek to kill people, it does not seek to avoid doing so. Because of the high-yield weapons and the proximity of the refineries to large cities, the attack kills over 5 million people if all weapons are air burst. Because no fireball would touch the ground, this attack would produce little fallout. If all weapons were ground burst, 2,883,000 fatalities and 312,000 fallout fatalities are calculated for a total of 3,195,000. Table 8 lists fatalities by footprint.

The Defense Civil Preparedness Agency (DC PA) provided fatality estimates for this attack. DCPA used the following assumptions re-

Figure 13



Approximate footprint coverage of U.S. attack



Approximate footprint coverage of Soviet attack

Table 7.–U.S. Refinery Locations and Refining Capacity by Rank Order

Rank order	Location	Percent capacity	Cumulative percent capacity	Rank order	Location	Percent capacity	Cumulative percent capacity
1	Baytown, Tex.	**3.6**	3,6	34		0 7	47,9
2	Baton Rouge, La.	**2.9**	6.4	35		0 7	48,6
3	El Segundo, Calif.	**2.3**	8.7	36		0 7	49.3
4	Whiting, Ind.	**2,1**	10.8	37		0 7	50.0
5	Port Arthur, Tex.	**2.1**	12,9	38		0.7	506
6	Richmond, Calif.	2,0	14,9	39		0 7	51.3
7	Texas City, Tex.	2,0	16,9	40		0.6	51.9
8	Beaumont, Tex.	1,9	18,8	41		0 6	52,5
9	Port Arthur, Tex.	1 9	20.7	42		0 6	531
10	Houston, Tex.	1.8	22.5	43		0.6	537
11	Linden, N.J.	1.6	24,1	44		0 6	543
12	Deer Park, Tex.	1.6	25.7	45		0 6	549
13	Wood River, Ill.	1,5	27,3	46		0 5	554
14	Pasagoula, Miss.	1.6	28,9	47		0.5	559
15	Norco, La.	1.3	30.1	48		0.5	56,5
16	Philadelphia, Pa.	1,2	31.3	49		0.5	57.0
17	Garyville, La.	1.1	32.4	50		0 5	57.5
18	Belle Chasse, La.	1.1	33.5	51		0 5	58.0
19	Robinson, Tex.	1.1	34.6	52		0 5	585
20	Corpus Christi, Tex.	1.0	357	53		0 5	59,0
21	Philadelphia, Pa.	1 0	36.7	54		0 5	595
22	Joliett, Ill.	1 0	37.7	55		0 5	600
23	Carson, Calif.	1 0	38.7	56		0.5	60.4
24	Lima, Ohio.	0.9	39.6	57		0.5	609
25	Perth Amboy, N.J.	0.9	40,6	58		0 4	613
26	Marcus Hook, Pa.	0 9	41,5	59		0 4	61 7
27	Marcus Hook, Pa.	0 9	424	60		0.4	622
28	Corpus Christi, Tex.	0.9	433	61		41	66.3
29	Lemont, Tex.	0 8	44,1	62		1,6	679
30	Convent, La.	0.8	449	63		0 5	68.4
31	Delaware City, Del.	0 8	457	64		0 3	68.7
32	Cattletsburg, Ky.	0.8	46,5	65		313	1000
33	Ponca City, Okla.	0 7	47.2				

[a] Sum of all refineries m the indicated geographic area
[b] Foreign trade zone only
[c] Includes summary data from all refineries with capacity less than 75000 bbl/day 224 refineries included
SOURCE National Petroleum Refiners Association

Table 8. –Summary of U.S.S.R. Attack on the United States

Footprint number	Geographic area	EMT[a]	Percent national refining capacity	Percent national storage capacity	Air burst prompt fatalities (x 1,000)
1	Texas	8	14.9	NA[b]	472
2	Indiana, Illinois, Ohio	8	8.1	NA	365
3	New Jersey, Pennsylvania, Delaware	8	7.9	NA	845
4	California	8	7.8	NA	1,252
5	Louisiana, Texas, Mississippi	8	7.5	NA	377
6	Texas	8	4.5	NA	377
7	Illinois, Indiana, Michigan	8	3.6	NA	484
8	Louisiana	8	3.6	NA	278
9	Oklahoma, Kansas	8	3.3	NA	365
10	California	8	2.5	NA	357
	Totals ., ., .,	80	63.7	NA	5,031

[a] EMT=Equivalent megatons
[b] NA = Not applicable

Photo credit: EXXON Corporation

Baytown refinery, Baytown, Tex.

garding the protective postures of the population in its calculations:

1. Ten percent of the population in large cities (above 50,000) spontaneously evacuated beforehand due to rising tensions and crisis development;
2. Home basements are used as fallout shelters as are such public shelters as subways;
3. People are distributed among fallout shelters of varying protection in proportion to the number of shelter spaces at each level of protection rather than occupying the best spaces first;
4. The remaining people are in buildings that offer the same blast protection as a single-story home (2 to 3 psi); radiation protection factors were commensurate with the type of structures occupied.

These assumptions affect the results for reasons noted in chapter III. Other uncertainties affect the casualties and damage. These include fires, panic, inaccurate reentry vehicles (RVs) detonating away from intended targets, time of day, season, local weather, etc. Such uncertainties were not incorporated into the calculations, but have consequences noted in chapters I I and I I 1.

The attack also causes much collateral economic damage. Because many U.S. refineries are located near cities and because the Soviets are assumed to use relatively large weapons, the attack would destroy many buildings and other structures typical of any large city. The attack would also destroy many economic facilities associated with refineries, such as railroads, pipelines, and petroleum storage tanks. While the attack would leave many U.S. ports unscathed, it would damage many that are equipped to handle oil, greatly reducing U.S. petroleum importing capability. Similarly, many petrochemical plants use feedstocks from refineries, so most plants producing complex petrochemicals are located near refineries; indeed, 60 percent of petrochemicals produced in the United States are made in Texas gulf coast plants.[1] Many of these plants would be destroyed by the attack, and many of therest would be for lack of feed stocks. III the attack aimed only at refineries would cause much damage to the entire petroleum industry, and to other assets as well.

All economic damage was not calculated from this attack, because no existing data base would support reasonably accurate calculations. Instead, the issue is approached by using Philadelphia to illustrate the effects of the attack on large cities. Philadelphia contains two major refineries that supply much of the Northeast corridor's refined petroleum. In the attack, each was struck with a l-Mt weapon. For reference, figure 14 is a map of Philadelphia. Since other major U.S. cities are near targeted refineries, similar damage could be expected for Houston, Los Angeles, and Chicago.

Fatalities and Injuries

The Defense Civil Preparedness Agency (DCPA) provided not only the number of people killed within each of the 2-minute grid cells in the Philadelphia region but also the original number of people within each cell. These results are summarized in the following table for distances of 2 and 5 miles [3 and 8 km] from the detonations:

Deaths From Philadelphia Attack

Distance from detonation	Original population	Number killed	Percent killed
2 ml	155,000	135,000	87
5 ml	5,785,000	410,000	52

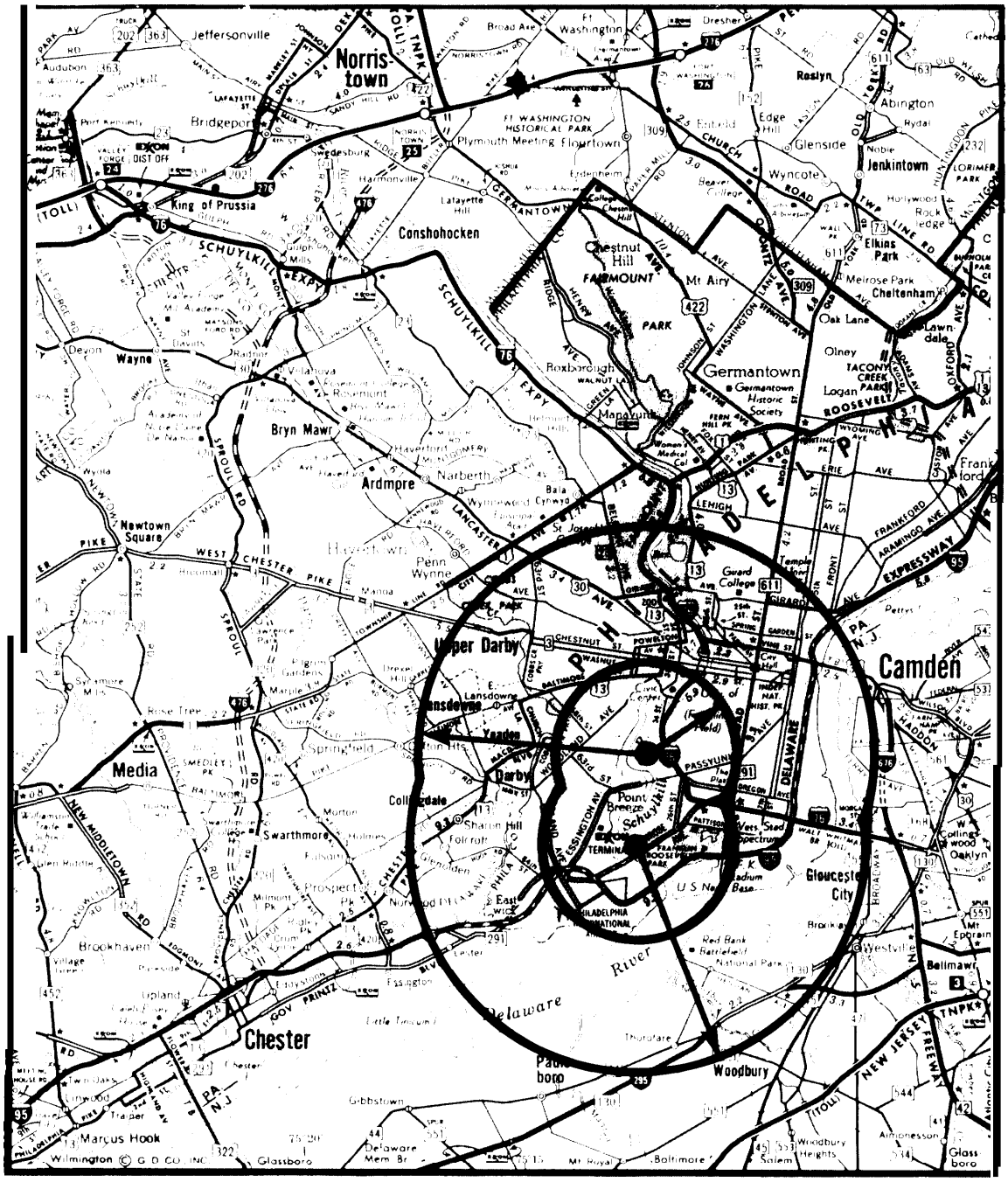
Detailed examination of the large-scale map also indicates the magnitude of the problems and the resources available to cope with them. These are briefly discussed by category.

Petroleum

Local production, storage, and distribution of petroleum are destroyed. 1 n addition to the two refineries, nearly all of the oil storage tanks are in the immediate target area. Presumably, reserve supplies can be brought to Philadelphia from other areas unless– as is likely– they are also attacked. While early overland shipment by rail or tank truck into north and northeast Philadelphia should be possible, water transport up the Delaware River may not

[1] Bill Curry, "Gulf Plants Combed for Carcinogens," *Washington Post*, Feb 19, 1979, page A3

Figure 14.— Philadelphia and Surrounding Counties



The two large dots represent the ground zeros of the two l-Mt Soviet weapons. Within 2 miles of these around zeros, there are approximately 155,000 people of which 135,000 were calculated to have been killed. Within 5 miles, there are 785,000 people of which 410,000 would have died.

be. This busy, narrow channel passes within about 1.3 miles [2.1 km] of one of the targets and could become blocked at least temporarily by a grounded heavily laden iron ore ship (bound upriver for the Fairless Works) or by sunken ships or barges.

Electric Power

There are four major electric powerplants in or near Philadelphia. Table 9 summarizes capacity, average usage (1976), and expected damage to these four installations.

While the usage figures in table 9 are average and do not reflect peak demand, it should be noted that a large percentage of this demand will disappear with destruction of the industrial areas along the Schuylkill River and of a large portion of the downtown business district. Thus, the plant in the Richmond section of Philadelphia, Pa., may be able to handle the emergency load. Assuming early recovery of the Delaware plant, there probably will be adequate emergency electric power for the surviving portion of the distribution system.

Transportation

Air.– The major facilities of the Philadelphia International Airport are located about 1.5 nautical miles [2.8 km] from the nearest burst. These can be assumed to be severely damaged. The runways are 1.5 to 2.5 nautical miles [2.8 to 4.6 km] from the nearest burst and should experience little or no long-term damage. Alternate airfields in the northeast and near Camden, N. J., should be unaffected.

Rail.– The main Conrail lines from Washington to New York and New England pass about a mile from the nearest burst. It can be expected that these will be sufficiently damaged to cause at least short-term interruption. Local rail connections to the port area pass within a few hundred yards of one of the refineries. This service suffers long-term disruption. An important consequence is the loss of rail connections to the massive food distribution center and the produce terminal in the southeast corner of the city.

Road.– Several major northeast-southwest highways are severed at the refineries and at bridge crossings over the Schuylkill River. While this poses serious problems for the immediate area, there are alternate routes through New Jersey and via the western suburbs of the city.

Ship.– Barring the possible blockage of the channel by grounded or sunken ships in the narrow reach near the naval shipyard, ship traffic to and from the port should experience only short-term interruption.

Casualty Handling

Perhaps the most serious immediate and continuing problem is the destruction of many of Philadelphia's hospitals. Hospitals, assuming a typical construction of multistory steel or

Table 9.—Electric Powerplants in Philadelphia

Name	Capacity (kW)	Average usage kW (1976)	Distance from blast	
Schuylkill	249,000 steam + 36,750 internal combustion (I.C.)	111,630	1.3	Electrical equipment destroyed. Plant heavily damaged.
Southwark	356,000 steam + 66,750 I.C.	71,605	2.6	Electrical equipment damaged or destroyed. Plant moderately damaged.
Delaware	250,000 steam + 68,750 I.C.	162,799	4.9	Electrical equipment moderately damaged. Plant intact.
Richmond	275,000 steam + 63,400 I.C.	29,247	6.6	Probably undamaged.
Totals	1,130,000 kW (steam) + 235,650 I.C.	375,281		

SOURCE: *Electrical World Directory of Electrical Utilities* (New York, N.Y.: McGraw Hill Inc., 1977)

reinforced concrete, would have a SO-percent probability of destruction at about 2.13 miles (1 .85 nautical miles [3.4 km]). A detailed 1967 map indicates eight major hospitals within this area; all are destroyed or severely damaged. Another nine hospitals are located from 2 to 3 miles [3 to 4 km] from the refineries. While most of the injured would be in this area, their access to these hospitals would be curtailed by rubble, fire, and so on. Thus, most of the seriously injured would have to be taken to more distant hospitals in north and northeast Philadelphia, which would quickly become overtaxed.

Military

Two important military facilities are located near the intended targets. The Defense Supply Agency complex is located within 0.5 miles [0.8 km] of one of the refineries and is completely destroyed. The U.S. Naval Shipyard is 1.0 to 1.8 miles [1.6 to 2.9 km] from the nearest target and can be expected to suffer severe damage. The large drydocks in this shipyard are within a mile of the refinery.

Other

Several educational, cultural, and historical facilities are in or near the area of heavy destruction. These include Independence Hall, the University of Pennsylvania, Drexel institute of Technology, Philadelphia Museum of Art, City Hall, the Convention Hall and Civic Center, Veterans Stadium, Kennedy Stadium, and the Spectrum.

Reaction: The First Week

During this period people would be in a state of shock, with their lives disrupted and further drastic changes inevitable. Many would have loved ones killed and homes destroyed. Factories and offices in the target areas would be destroyed, throwing people out of work. People would face many immediate tasks: care of the injured, burial of the dead, search and rescue, and fire fighting.

Fires at petroleum refineries, storage tanks, and petrochemical factories would rage for hours or days, adding to the damage caused by blast. Some oil tanks would rupture and the oil would leak onto rivers or harbors, where it would ignite and spread fire. Fires at refineries could not be extinguished because of intense heat, local fallout, an inadequate supply of chemicals to use on petroleum fires, and roads blocked by rubble and evacuees. Petrochemical plants, already damaged by blast, would be further damaged by fire and would leak toxic chemicals. As discussed in chapter 11, firestorms or conflagrations might begin, in this case supported by thousands of tons of gas-01 inc. Anyway, the plants would likely be damaged beyond repair. Finally, with fires threatening to burn, poison, or asphyxiate people in shelters, rescue crews would attach top priority to rescuing survivors.

Once it was clear that further attacks were unlikely, the undamaged areas of the country would supply aid. However, the available medical aid would be totally inadequate to treat burns this attack would cause. The radius of third-degree burns (5.2 nautical miles [9.6 km] for a l-Mt weapon air burst) is far greater than for any other life-threatenin$_g$ injury, and huge fires would cause more burns. But, even in peacetime, the entire United States has facilities to treat only a few thousand burn cases adequately at any one time.

If the attack used ground bursts exclusively, it would cause fewer prompt fatalities (2.9 million instead of 5.0 million for the air burst case), but much fallout. Given the extensive fallout sheltering described above, 312,000 people would die of fallout. Fallout casualties, however, would depend strongly on wind directions: would gulf coast fallout blow toward Atlanta, Miami, Cuba, or Venezuela? Would New Jersey fallout land on New York City on its way out to sea? The problems of shelterers are discussed under “Case 3: A Counterforce Attack Against the United States, ” in this chapter.

Beyond the physical damage, people would realize that a central assumption of their lives–that nuclear war could not occur—was wrong. Even people beyond target areas would know immediately that secondary effects

would irrevocably change their way of life; survivors traveling to undamaged areas would drive this point home. Most would fear further attacks, and would seek protection by evacuating or seeking shelter. While recovery plans could be made and damage assessed, little reconstruction could be done with many people away or in shelters. Thus, the reaction period would not end until most people acted as if they believed the war was over.

Recovery

Once people believed that the war was over, the Nation would face the task of restoring the economy. The human consequences would be severe, but most deaths would have occurred within 30 days of the attack. Economic disruption and the economic recovery process would last much longer.

Restoring an adequate supply of refined petroleum would take years. It is unlikely that any of the attacked refineries could be repaired, although enough infrastructure might survive to make it cost effective to clear and decontaminate the rubble and rebuild on the old sites, The attack would kill many people skilled in building or operating refineries. The attack would also destroy many ports with special facilities for handling large quantities of crude oil and refined petroleum, While intensive use of plant and equipment can substantially increase output for many industries, it can increase a typical refinery's output by only 4 percent. Thus, the attack would leave the United States with about a third of its prewar refining capacity and with little of its prewar oil importing capacity; this situation would persist until new refineries and ports could be built.

The survival of a third of the Nation's refining capacity does not mean that everyone would get a third of the petroleum they did before the war. The Government would surely impose rationing. Critical industries and services would have top priority— military forces, agriculture, railroads, police, firefighting, and so on. Heating oil could be supplied, but at austere levels. Uses of petroleum for which there were substitutes would receive little or no petroleum. For example, railroads could substitute for airlines, trucks, and buses on intercity routes; mass transit would probably substitute for private automobiles and taxis in local transportation.

The demise of the petroleum industry would shatter the American economy, as the attack intended. A huge number of jobs depend on refined petroleum: manufacture, sales, repair, and insurance of cars, trucks, buses, aircraft, and ships; industries that make materials used in vehicle manufacture, such as steel, glass, rubber, aluminum, and plastics; highway construct ion; much of the vacation industry; petrochemicals; heating oil; some electric power generation; airlines and some railroads; agriculture; and so on. Thus, many workers would be thrown out of work, and many industries would be forced to close.

The limited direct economic damage, already multiplied by thousands of secondary effects just enumerated, would be multiplied again by tertiary effects. Economic patterns that rest on the petroleum economy would be disrupted. Much of the American way of life is dependent on automobiles, from fast-food restaurants and shopping malls to suburban housing construction and industries located on major highways whose workers commute by car. The many people thrown out of work would have less money to consume things made by others. Service industries of all kinds would be especially hard hit.

These economic changes would lead to social changes that would have further economic consequences. Gasoline rationing would at best severely curtail use of private cars; mass transit would be used to its capacity, which would appear inadequate. Demand for real estate would plummet in some areas, especially suburbs, and skyrocket in others, notably cities, as people moved nearer to work and stores. Such mass movement, even within cities but especially between them, would upset the demographics underlyin$_g$ taxes, schools, and city services. With many people out of work, demand for unemployment com-

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pensation would rise at the same time taxes were falling. Vacation patterns would shift; cuts in air and car travel would force people to travel by train, which would lead people to vacation closer to home. The situation following the attack could lead the dollar to tumble, but whether or not that occurred, the curtailment of commercial air travel would prevent most people from traveling abroad. The economic system on which production depends would be radically different. To be sure, most workers and equipment would survive unscathed, and economic recovery would eventually take place.

Production depends, however, not only on the use of physical resources, but also on a wide range of understandings between producers and consumers. These underpinnings would be destroyed by the attack just as surely as if they were targeted. Prices would be uncertain, and various kinds of barter (trading favors as well as goods) would supplement the use of money. Credit and finance could not function normally in the absence of information about the markets for continuing production. Contracts would have uncertain meaning. Many businesses would go bankrupt as patterns of supply and demand changed overnight. Courts would be seriously overburdened with the task of trying to arbitrate among all of these competing claims. Corporations and individuals would be reluctant to make commitments or investments.

Given this disruption, the effort to resume production would require grappling with some basic organizational questions. To which tasks would surviving resources be applied? How would people be put back to work? What mix of goods would they produce? Which industries should be expanded, and which curtailed? Which decisions would Government make, and which would be left to the market?

This organizational task is unprecedented, but in principle it could be performed, Presumably the United States would follow the precedent of the mobilization for World Wars I and 11, in which extensive Government planning supplemented private enterprise, and key assets and key people from the private sector were borrowed by the Government for the duration of the emergency. Certain tasks, such as caring for the injured, decontamination, high-priority reconstruction, and serving as an employer of last resort (to say nothing of meeting military requirements), would obviously be handled by the Government. The difficulty would be in planning and facilitating the transformation of the private sector. The combination of unusable factories and service facilities with unemployed workers could easily create a situation analogous to that experienced in the United States between 1929-33.

Long-Term Effects

Postattack society would be permanently and irrevocably changed. People would live in different places, work at different jobs, and travel in different ways. They would buy different things and take different kinds of vacations. The Nation would tend to apply the lessons of the past to future policy by seeking to reduce its vulnerabilities to the last attack. Energy conservation, where not required by regulations, would be encouraged by prices, taxes, and subsidies. Railroads and mass transit would supplant travel by cars and planes; rail and ships would substitute for planes and trucks in hauling freight. Automobile production would drop sharply and would emphasize energy-efficient models; bicycles and motorcycles would be popular. While housing construction would not necessarily end in the suburbs, new homes there would probably be built closer together so that mass transit could serve them. Construction in cities would boom. All houses would be better insulated; more would use solar energy as fuel costs soared.

Farms would be able to obtain adequate supplies of petroleum and its derivatives. Agriculture uses only 4 or 5 percent of the Nation's petroleum, and its products are necessary. While gasoline and petrochemical-based fertilizers and pesticides would be much more expensive, they comprise only a small fraction of farm expenses and would be essential for large-scale efficient agriculture. Moreover

much fertilizer is made from natural gas rather than petroleum, so its price would not rise as dramatically as that of gasoline, Petroleum-related cost increases would be passed on to the consumer. The character of agriculture could change, however. I n particular, the livestock industry might be sharply curtailed. At every stage, livestock raising, slaughter, and distribution require much more energy than do crops. For example, rapid transportation and extensive refrigeration are required. Meat would become very much more costly in relation to other foods than it is now, and so would become a luxury. If livestock production dropped, a major source of demand for corn, soybeans, and other fodder would decline, possibly slowing price increases for other farm products.

Although refineries and oil importing facilities would be rebuilt, U.S. refining capacity after recovery would probably be less than pre-attack capacity. Increased prices for gasoline and heating oil would shift demand to other sources of energy, raising their prices and encouraging an acceleration of their development.

Patterns of industrial production would shift dramatically because of these changes, forcing massive shifts in demand for ski I Is and resources. Many people and factories would be oriented to the production of things no longer in demand; it would take many years for the economy to adjust to the sudden, massive changes imposed by the attack.

The attack would affect public health. Chapter V discusses the long-term effects of sublethal levels of radiation. Petrochemical plants damaged by the attack would leak carcinogenous petrochemicals, but numbers of cancer cases from this source, the time of their appearance, and the duration of the threat cannot be predicted. To the extent that contamination or destruction of housing, or economic collapse, force people to live in substandard housing, illness would increase. Not all changes, however, would be for the worse. Some new patterns of living would promote public health. There would be fewer auto, aircraft, and boating accidents. More people would walk or bicycle, increasing exercise. Reduced consumption of meat would reduce dietary fats, heart attacks, and strokes. At some point, Government-imposed controls necessitated by the attack could be lifted because societal changes and market forces (price increases, alternative energy sources, residential patterns, and numbers and efficiency of cars) would achieve the goals of controls without coercion. For example, gasoline rationing would certainly be imposed immediately after the attack, and might be lifted in stages as refining capacity was restored, or subsidies to expand and support mass transit could level off or decline as revenues made it self-supporting.

The Nation's adjustment to all these changes would be painful. The problems would be especially severe because of the speed of their onset. Many people say that the United States would be better off if it was less dependent on cars and petroleum. While changing to new patterns of living via nuclear attack would minimize political problems of deciding to change, it would maximize the difficulties of transition. Problems would appear all at once, while any advantages of new patterns of living would come slowly.

CASE 2: A U.S. ATTACK ON SOVIET OIL REFINERIES

This case investigates what might happen if the United States tried to inflict as much economic damage as possible on the Soviet Union with 10 SNDVs without seeking to maximize or minimize casualties. Petroleum refineries were selected as targets because of their small number and long construction time, and because of the severe economic consequences of doing without refined petroleum,

The Soviet refining industry is at least as vulnerable as its U.S. counterpart, though the

vulnerabilities differ slightly. The United States refines more petroleum than does the U. S. S. R., about 17.9 million barrels per day of crude (1978 figures) versus 11.0 million (1980 projection).[2] According to a 1977 source, the U.S.S.R. had 59 refineries, including at least 12 under construction, some of which are very large; the U.S. and its territories have at least 288.[3] All individual refineries in both nations are highly vulnerable to attacks with nuclear weapons. The U.S. attack destroys most of Soviet refining capacity because the U.S.S.R. has few refineries; the Soviet attack destroys most of U.S. refining capacity because U.S. refineries are clustered.

The hypothetical attack targets 24 refineries and 34 petroleum storage sites. Some major refineries are beyond range of Poseidon missiles, so the United States uses 7 Poseidons with a total of sixty-four 40-kiloton (kt) RVs and 3 Minuteman IIIs with a total of nine 170-kt RVs. Because of the dispersal of Soviet refineries and limits of footprint size, each footprint had fewer refineries than available RVs. The additional RVs were first allocated 2 on 1 against large refineries; remaining RVs were targeted against petroleum storage complexes. As in the U.S. case, every weapon is assumed to detonate over and destroy its target. It is assumed that all weapons are air burst, and the consequences of using ground bursts are noted where appropriate.

Immediate Effects: The First Hour

The attack destroys 73 percent of Soviet refining capacity and 16 percent of Soviet storage capacity, as table 10 shows. Collateral economic damage could not be calculated or collateral damage to a large Soviet city assessed because sufficient unclassified data could not be found.

If all weapons are air burst, the attack kills 1,458,000 people assuming everyone to be in single-story buildings, and 836,000 assuming everyone in multistory buildings; the latter assumption comes closer to reality. If all weapons were ground burst, the attack would kill 1,019,000 people, 722,000 promptly and 297,000 by fallout, assuming the worst case, everyone living in single-story buildings.

The estimated injuries from the attack are substantial under all conditions. Under the single-story assumption on housing, the air-

[2] "U S. Refining Capacity" (Washington, D.C National **Petroleum Refiners Association, July** 28, 1978), p 1 (U. S figures), and *International Petroleum Encyclopedia, 1976* **(Tulsa, Okla.: Petroleum Publishing Co , 1977),** p. **323 (Soviet figures).**

[3] *'International Petroleum Encyclopedia, 1976,* op. cit., p. 393 (Soviet figures); and **"U.S. Refining Capacity," op cit.;** *passim,* **(U.S. figures).**

Table 10.—Summary of U.S. Attack on U.S.S.R.

Footprint number	Geographic area (approx. center)	EMT[a]	Percent national refining capacity	Percent national storage capacity	Air burst prompt fatalities (x 1,000) SS[b]	MS[c]
1	Moscow	1.20	10.5	2.1	62	41
2	Baku	0.96	9.8	1.5	224	152
3	Ishimbai	1.20	8.7	2.8	25	12
4	Polotsk	0.92	7.5	0.3	52	32
5	Kuibuyshev	1.20	7.4	3.1	127	83
6	Angarsk	0 92	6.9	0.4	130	54
7	Grozny	0.96	6.7	1.6	56	37
8	Kirishi	0.92	6.2	0.3	493	230
9	Gorki	1.20	5.6	1.5	228	153
10	Perm	0.96	3.6	2.1	61	42
	Totals	10.44	72.9	15.7	1,458	836

[a] EMT = Equivalent megatons.
[b] SS = 100 percent of population in single-story buildings.
[c] MS = 100 percent of population in multistory buildings.

burst attack would produce 3.6 million injuries and a surface-burst attack about a million less. If in multistory buildings, the population would suffer 3.8 million injured from an air-burst attack and 2.5 million for the surface burst. (A protection factor of 5 was assumed against fallout from the surface bursts.)

The attack kills fewer Russians than Americans. The differences in fatalities do not mean that the United States is necessarily more vulnerable than the Soviet Union to nuclear attack; rather, the asymmetries occur from the design of the attack. Soviet refineries are farther from cities than are U.S. refineries and U.S. weapons are smaller, so fewer Russians are within the lethal radii of U.S. weapons. Sensitivity of fatalities and injuries to distance from ground zero is shown in table 11, Had either nation sought to kill people, it would have used different weapons and targeted them differently.

Reaction: The First Week

As in the United States, life for the surviving majority would be totally disrupted. Many would be directly affected by the attack: the injured, those with injured relatives, the homeless, people affected by shortages. Accommodation to a future with a sharply reduced petroleum supply would begin: gasoline and other products might be hoarded, by enterprises if not by individuals. Some less-important industries would probably be closed to save fuel or to allow their workers to shift to the military, agriculture, and essential industry. Until it became clear that the war was over, millions of reservists would be mobilized for military service, placing a heavy demand on the domestic economy to replace them. Because of the mobilization, hours worked and the mix of production would change dramatically and overnight; workers in essential industries might be on 12-hour shifts; other workers not drafted would be pressed into service in essential industries, and quite possibly moved to factories in distant areas. The speed and magnitude of disruption would cause much psychological shock.

How would the Soviet Union cope with the damage? Although a greater percentage of its refining capacity would be destroyed, it would suffer fewer fatalities than would the United States (1.0 million to 1.5 **million** versus **3.2 million to 5.0 million) and** fewer injuries **(2.5** million to **3.8 million versus 3.9 million to 4.9 mil-**

Table 11 .–Approximate Distance (Nautical Miles) of Various Effects From Selected Nuclear Air Bursts (personnel casualties)

Effect		Weapon yield		
		1 Mt	170 kt	40 kt
Overpressure (crushing)	Lethality—			
	Threshold	0.25	0.15	0.1
	Lung damage—			
	Threshold	2.1	1.1	0.7
	Severe	0.8	0.5	0.3
	Broken eardrums—			
	Threshold	3.5	2.0	1.2
	50%	1.0	0.6	0.4
Translation	Personnel in the open—1%	3.3	1.6	0.9
	Personnel near structures—			
	1%	3.8	1.9	1.0
	50%	2.1	1.0	0.6
Thermal	Third-degree burn—100%	5.2	2.6	1.5
	No burns—100%	8.7	4.8	2.8
	Flashblindness*	10	9	8
	Retinal burn*	25	23	20
Radiation	Lethal dose (1,000 rads)	0.9	0.8	0.7
	No immediate harm (100 rads)	1.2	1.1	1.0

*Daytime safe distance

lion) because of the lower yield of U.S. weapons and the location of Soviet refineries away from cities. If all weapons were air burst at optimum height of burst, there would be negligible fallout in both countries; if all weapons were ground burst, the Soviet Union would receive far less fallout because of the lower yield of the weapons. Because the Soviets have built many widely dispersed small dispensaries and first aid centers, rather than smaller numbers of modern full-service hospitals concentrated in cities, more of these facilities would survive than in the United States. In addition, many Russians have received first aid training, and people with injuries that could be treated by paramedics, dispensaries, and first aid would probably be better off than their American counterparts; others would be at least as bad off. Those who required treatment at major hospitals would suffer because of the small number of beds in nearby modern hospitals and the inability of the Soviet transportation system to move them elsewhere. Like the United States, the U.S.S.R. could not cope with large numbers (say, over 100) of severe burn cases. There would be many victims of severe burns in both nations who would die for lack of adequate treatment.

The damage, the emergency conditions, and the risk of further attacks would remind everyone of the special horror that the Soviets faced in World War II. The psychological trauma would be exacerbated in the first week by anticipation of crisis economic conditions. The Soviet Government in past crises has proved to be ruthless and efficient in moving people to parts of the country where labor was needed. Such action would be likely in this crisis as well, along with cutbacks in food, consumer goods, housing construction and maintenance, and transportation. Only regimentation would be likely to increase. Life would be grim, and would remain so for years.

Recovery

What course would Soviet recovery take? Economic viability would not be at issue following this attack, and the Government could be expected to remain firmly in control because of the limited scale of this attack. Assuming that there are no further attacks, most of the deaths would occur within 30 days of the attack. While the course of economic recovery cannot be predicted in detail, it is clear that:

- The attack would hurt. The recovery period would be marked by shortage and sacrifice, with particular problems stemming from agricultural shortfalls.
- Nevertheless, the Soviet economy and political system would survive, and would do so with less drastic changes than the United States would probably experience.
- The asymmetries between the two nations in effects for a given attack are greater for this case than for a very large attack.

The political and economic structure of the U.S.S.R. appears designed to cope with drastic emergencies like this attack. While almost all economic assets would be unscathed, resources would need to be shifted rapidly to produce a different mix of outputs. The attack would totally disrupt existing economic plans. The economic planning apparatus and Government control methods in place in the U.S.S.R. would permit the Government to shift plans and resources, but the speed with which such changes could be made is uncertain. To the extent that revisions in the economic plan were not made or were delayed, people and equipment would sit idle or would be producing according to less-efficient priorities, draining scarce resources from higher priority tasks and hindering recovery. Workers would be shifted to different industries as plants closed; some would be forced to move, share apartments with strangers, or work at new jobs (including manual labor in farms or factories).

Some insight into the economic consequences can be obtained by looking at four sectors of the economy— military, agriculture, transportation, and industry. Each of these sectors would have a strong claim on available petroleum, but their total demand would exceed the supply.

The military would have first call on fuel, especially if the war continued. It has adequate stocks to prosecute a war for several weeks. However, unless this attack led to a decisive Soviet victory or to a major relaxation of tensions, the military would need refined petroleum to rebuild its stocks and to carry out normal training.

Soviet agriculture is precarious even in peacetime because of its inefficiency. Agriculture engages about a third of the work force and consumes a third of Soviet gasoline and diesel fuel. (U.S. agriculture, in contrast, uses 2.7 percent of the work force (in 1978) and a small fraction of U.S. refined petroleum .)4 The Soviet Union imports grain in most years. Nevertheless, the U.S.S.R. has maintained a large cattle industry at considerable expense to provide a consumer good much in demand. Farms use petroleum for tractors and trucks; petroleum and natural gas are feedstocks for fertilizer and pesticides. Agricultural use of petroleum is increasing. One small example is the Soviet use of light aircraft to spread fertilizer; while this task could be done by tractors or by hand, it is much more efficiently done by aircraft.

Cutbacks in petroleum would magnify agricultural inefficiency. Even if the Soviet Union allocated all the petroleum it produced to agriculture, it would not produce enough to sustain agriculture's prewar consumption, and other critical sectors would compete for petroleum. Drawing on inventory would sacrifice later agricultural production for earlier production. Following the attack, the main concern of agriculture would be planting, growing, or harvesting the year's crop; sacrifices and substitutions would be required in other agricultural subsectors to meet this goal with available petroleum. The U.S.S.R. would be likely to divert people from schools, factories, and (depending on the international situation) the military to work the fields, as it does in peacetime, but to a greater extent. The substitution of human labor for mechanical energy would be a poor but perhaps unavoidable trade. The most obvious cutback would be livestock; meat is a luxury, livestock consume much food that could otherwise be used for human consumption, and cattle raising, slaughter, and distribution require much energy. The Soviet Union might slaughter much of its livestock after the attack to free farmers, fields, trucks, and petroleum to produce crops. Russians might have a 3-month orgy of meat followed by two decades without.

Soviet transportation would be pinched. A few top leaders would still have cars; other cars would sit idle for years, monuments to the prewar standard of living. Air transportation would be sharply curtailed, and Soviet supersonic transports would be grounded. Truck transportation would be curtailed, with trucks used almost exclusively for intracity transportation and hauling goods between railroads and loading docks. By elimination, the transportation burden would fall to railroads because of their energy efficiency. Key trunklines are electrified, and might obtain electricity from sources other than petroleum. The Soviets have stored a number of steam locomotives, which would be hauled out, refurbished, and put to use.

The tempo of industrial production would slow. Even as it stands now, the Soviets have barely enough energy and occasional shortages. Electric power would continue, but would probably be cut back 10 to 15 percent,

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4 *Statistical Abstract of* the *United States, 1978* (Washington, D C U S Department of Commerce, Bureau of the Census, 1978), l ists 91,846,000 employed persons age 16 and over in the United States, of whom 2,469,000 were listed as farmworkers, for January-April 1978 (p. 418). *The Statistical Abstract* does not present the amount of petroleum consumed by American agriculture. Several statistics, however, indicate this number to be a small fraction of total U S petroleum consumption Preliminary 1977 data showed all U S prime movers (automotive and nonautomotive) had 26,469,000,000 horsepower, whi le farms accounted for 328,000,000 horsepower, or 1 2 percent (p. 604) In 1976, industrial consumption of petroleum accounted for 18 percent of total U S petroleum consumption (p 764) And a National Academy of Sciences study found that agriculture accounted for 3.5 percent of total national energy consumption in 1968 *Agricultural Production* Efficiency (Washington, D C National Academy of Sciences, National Research Council Committee on Agricultural Production Efficiency, 1975), p 119)

forcing some industries to close and reducing heat and light at other industries and apartments. With transportation cut back, factories would have to wait longer for inputs, lowering productivity.

Some less-essential industries, especially energy- or petroleum-intensive ones, might shut down. Plastics use petroleum derivatives as feedstocks. Aluminum production uses great amounts of energy, though some Soviet aluminum plants, such as at Bratsk in Siberia, use hydroelectric power. Truck production would stop for lack of fuel for existing vehicles, idling the huge Kama River truck plant.

Construction consumes much petroleum, so it would be curtailed except for essential industries, hydroelectric powerplant construction, refining construction, and minimal housing for workers in those occupations.

These changes would disrupt workers' lives. Closing of some plants would idle many workers, forcing them to work in other industries; many could be moved long distances to other plants. Workers would not necessarily be forced to work long hours. While some plants would operate around the clock, others would be closed or cut back to enable the energy they consume to be diverted. At the same time, however, and within limits of substitutability, workers could likewise be diverted from closed to open plants, providing extra labor for factories that remained open extra time.

In sum, the reduction in the standard of living and the amount of disruption would probably be less than in the United States but there might well be more hardship and misery. Russians would have less food, especially protein, than they did before the attack, while American agriculture consumes so little petroleum that its output could probably be maintained, though some variety might be sacrificed. There would be less heat in both nations, but winters are shorter and milder in the United States, and U.S. indoor temperatures in winter could be reduced 50 or 10° F without ill effect. Therefore, heating could probably not be cut as much in the U.S.S.R. as in the United States without jeopardizing health. Cars would be sacrificed at least temporarily in both nations. Soviet industries producing consumer goods would be cut back more sharply than their U, S. counterparts after the attack, and would regain productivity more slowly.

Long-Term Effects

Destroying 73 percent of refining capacity would force the economy onto a crisis footing, curtailing choices and consumer goods, dropping the standard of living from austere to grim, and setting back Soviet economic progress by many years. Recovery might follow the post-World War II pattern, with a slow but steady improvement in the quality of life. But recovery would be slow, The desire to reduce vulnerability to future attacks would undoubtedly divert resources from recovery to such tasks as building some underground refineries. While the United States could possibly recover in a way that would use less petroleum than it did prewar, this course would be difficult for the U.S.S.R. because much of Soviet petroleum goes to necessities. Long-term health and genetic effects would be less than for the United States because of the smaller size of U.S. weapons and the location of Soviet refineries away from people. But the Soviet Government might accept greater radiation exposure for people in order to speed production, increasing such effects.

CASE 3: A COUNTERFORCE ATTACK AGAINST THE UNITED STATES

The case of a Soviet attack on U.S. strategic forces has received extensive public attention in recent years, since some observers believe it is the least irrational way of waging strategic war. For the purposes of this study, the military success of such an attack (i. e., how many U.S. forces would be destroyed) and the resulting U.S. responses are not important. It is sufficient to assume that such an attack is launched, and to examine the consequences for the civilian population, economy, and society. For this purpose, small variations in the attack design (e. g., whether control centers as well as silos are targeted) are immaterial. While there are many possible variations in the design of a counterforce attack, a question of particular interest is whether the attack would be delivered only against ICBM silos, or whether bomber bases and missile submarine bases would also be attacked. Some of the public discussion of such an attack suggests that an attack on ICBM silos alone could cause much less civilian damage than a full-scale counterforce attack because the silos are more isolated from population centers than are bomber bases. It is certainly true that, holding al I the other possible variables constant, an attack that included bomber bases and missile submarine bases would cause more civilian damage than one that did not. Nevertheless, the difference between the ICBM-only attack and a comprehensive counterforce attack was found to be no greater than the difference made by other variables, such as the size of weapons used, the proportion of surface bursts used, and the weather. Both cases are considered in this section; the countersilo attack is a subset of the counterforce attack, and available data is too coarse to support a believable differentiation between the civilian effects of each attack.

Prompt Effects

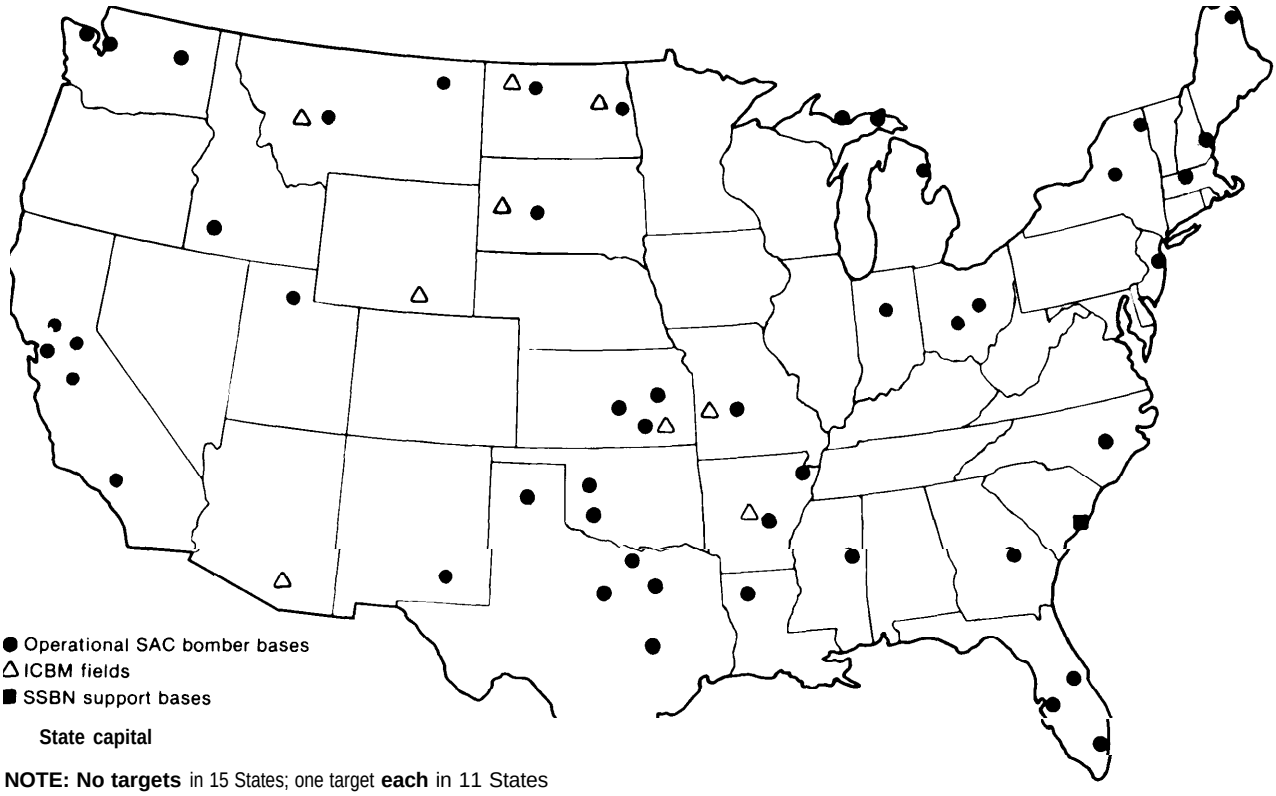
The blast damage from a counterforce attack is concentrated on military installations. Attacks on submarine bases and bomber bases would cause considerable blast damage to nearby populations and urban structures; attacks on silos would cause relatively little civilian blast damage. Unlike ICBM silos, many bomber bases and fleet ballistic missile submarine (SSBN) support facilities are near cities. (See figure 15.) For example, an attack on Griffiss Air Force Base, near Utica and Rome, N. Y., would place nearly **200,000 people at risk from prompt effects; attacking the** SSBN support facility near Charleston, S. C., would place more than 200,000 people at risk; attacking Mather Air Force Base, near Sacramento, Cal if., would place more than 600,000 people at risk. The additional attacks would simultaneously reduce the number of people able to provide aid and increase the number of injured or evacuees re quiring aid. The attacks would make it harder for people able to provide aid to sustain those needing it.

Countersilo attacks would probably detonate some weapons at or near the Earth's surface to maximize the likelihood of destroying ICBM silos. Surface bursts produce intense fallout, causing most of the damage to the civilian population, economy, and society. The principal civilian impact of adding attacks on bomber and SSBN bases is the large increase in urban destruction.

The Period Before Fallout Deposition

Fallout would begin to reach closer populated areas in a few hours; it would reach many others in a few days. As fallout arrives, radiation levels rise sharply and rapidly. People would therefore have to take any protective act ions —shelter or evacuation — before the fallout arrives. This prearrival period would thus be one of intense activity and intense confusion. How would people react? Training could help, but people trained in how to behave under fallout conditions would fare poorly if they could not get to shelters or if shelters were unstocked. To what extent would people

Figure 15.—Counterforce Targets in the United States



NOTE: No targets in 15 States; one target **each** in 11 States

panic, seek other family members, or evacuate spontaneously, and what would be the consequences of such actions?

Evacuation would probably be a poor choice, since it would be difficult or impossible to predict which would be the safe areas and which the hot spots, and since a car in a traffic jam would offer poor shelter indeed. The decision on whether or not to evacuate, however, is complicated because evacuation is a reasonable response for people who would be at risk from blast from further attacks even though evacuation is a poor strategy for people at risk from fallout alone.

Shelter would in theory be available to a majority of people, although the best available shelter might not be good enough in areas where the fallout proved to be very intense. However, the practical difficulties of fallout sheltering could be very great. The time to seek shelter could be very limited (and people would not know how long they had), and people would want to get their families together first. A shelter must have a sufficient protection factor. Fallout particles must be kept out of the shelter, which requires a ventilation system more complicated than an open window or door, and if anybody enters a shelter after fallout has fallen there must be some means of decontaminating the new arrival. Water is necessary; heat may be necessary depending on the time of year; sanitation is a problem. Finally, people could not tell how long it was necessary to stay in the shelter without radiation rate meters.

It is obvious that the time of day, the time of the year, and the degree of emergency preparations during the hours or days before the attack would all affect the level of deaths. Whatever the circumstances, the few hours after the attack would see a frantic effort to seek shelter on the part of most of the American popu-

lation. Then, in densities and locations determined by the attack parameters and the weather, the fallout would descend. Many Americans would be lucky enough to be in areas where the fallout level was low. Many others (between an estimated 2 million and 20 million), would be caught without shelter, or with inadequate shelter, and would die. Still others would suffer from a degree of radiation that would make them sick, or at least lower their life expectancy, but would not kill them. The trials of living in fallout shelters would be intensified by the fact that many people would not know which category they and their families were in.

A comprehensive counterforce attack would impose a greater burden than a countersi 10 attack. Many more people would be injured by prompt effects, and people near bomber and SSBN bases would have only a few minutes warning in which to seek shelter.

Cities in the blast area –those near SSBN or bomber bases–would be heavily damaged. A few cities, such as Charleston, SC., and Little Rock, Ark., could suffer consequences similar to Detroit in Case 1 (chapter 11) or Philadelphia in Case 2 (above in this chapter); most would not. People in blast areas would face hazards as noted in Case 1 — injuries from blast, initial nuclear radiation, and thermal radiation, and from such secondary effects as falling buildings and fires. As in other cases, rescue would be difficult, with streets blocked by rubble, water pressure gone, and emergency vehicles destroyed.

People in areas damaged by blast and in the path of fallout would be in greatest peril. injuries, damage to prospective shelters, damage to transportation, and damage to power and water could make them highly vulnerable. Little Rock, Ark., for example, the site of an ICBM base and a bomber base, would receive both blast damage from a pattern attack (designed to destroy bombers in flight) and intense fallout radiation from the attack on ICBMs.

People in areas neither damaged by blast nor threatened by fallout would believe themselves to be at risk from blast or, at a minimum, from fallout until it was clear that attacks had ended. To these people would fall the burdens of producing necessities and caring for the injured and evacuees. Yet people in these areas, believing themselves to be at risk, would feel compelled to seek shelter or, especially in unattached cities, to evacuate spontaneously. These actions would reduce the flow of aid to damaged areas. Indeed, the economy would probably shut down until people were certain that the war had ended and until most people could get back to work, probably until the end of the shelter period. Even if some people reported to work, production would be difficult with many absentees. There would be large credit, monetary, contractual, and legal problems. If production stopped even for a week, the loss would be tremendous. This attack would disrupt the economy less than Case 2, however, because most productive resources would remain intact.

Casualty Estimates

In seeking to estimate prompt damage from the attacks, fatalities are the most important component of damage and the most calculable. To estimate fatalities, the critical questions are which areas would be damaged by blast, and to what extent? How much fallout would there be, and where would it be deposited? These questions cannot be answered with great confidence because estimates of deaths from these attacks are highly sensitive to attack parameters and civilian shelter assumptions. However, reference can be made to several recent executive branch studies of counterforce attacks.

OTA drew on several executive branch studies, conducted between 1974 and 1978, of counterforce attacks. These studies differed widely in their results, primarily because of differences in the assumptions they made. OTA felt that it would be more useful to look at the ways in which these assumptions affect the results than to attempt to determine the “correct” assumption for each uncertainty. Consequently, a range of results is presented; it is believed that if OTA had done a new study of

this case the results would have fallen somewhere within this range. [5]

The executive branch countersilo studies that OTA drew on indicated that between 2 million and 20 million Americans would die within the first 30 days after an attack on U.S. ICBM silos. This range of results is so wide because of the extent of the uncertainties surrounding fallout. The key uncertainties are:

- Height of Burst.– If the fireball touches the ground, it vaporizes some dirt, irradiates it, and draws it up into the mushroom cloud. This material condenses to become fallout. The lower the height of burst, the more of the fireball touches the ground, and the more fallout that is produced. An air burst in which none of the fireball touches the ground creates negligible fallout. Because ICBM silos are very hard, a surface burst offers the greatest probability of destroying the silo with one explosion; it also maximizes fallout. The probability of destroying an ICBM silo is increased if two warheads are targeted against it; opinions differ as to whether the most effective tactic is to use two surface bursts, which doubles the amount of fallout, or one air burst and one surface burst.
- Weapon Design.— Some weapons derive a greater portion of their energy from fission (as opposed to fusion) than others; the more fission, the more fallout. The weapon yield affects the amount of fallout; the higher the yield of a given explosion, the greater the fallout.
- Wind.– The speed and direction of the wind at various altitudes determines the directions and distance from the explosion at which fallout is deposited, and influences fallout concentration. Winds typically vary with the season; indeed, this variance is so great that it can affect casualties by about a factor of three, as figure 16 shows. The hourly and daily variation of winds also affects casualties. It is important to bear in mind, when considering possible civil defense measures, that winds could not be accurately predicted even after an attack had taken place, much less in advance.
- Rain. – Raindrops collect fallout particles from the radioactive cloud, thereby creating areas of intense fallout where it is raining, and reducing fallout elsewhere.
- Terrain. — Hills, buildings, and ground temperature gradients (such as are caused by highways and small lakes) affect the exact pattern of fallout, creating hot spots in some places and relatively uncontaminated spots nearby.
- Distance.—Other things remaining constant, fallout decreases with distance from the explosion beyond roughly 50 miles [80 km].

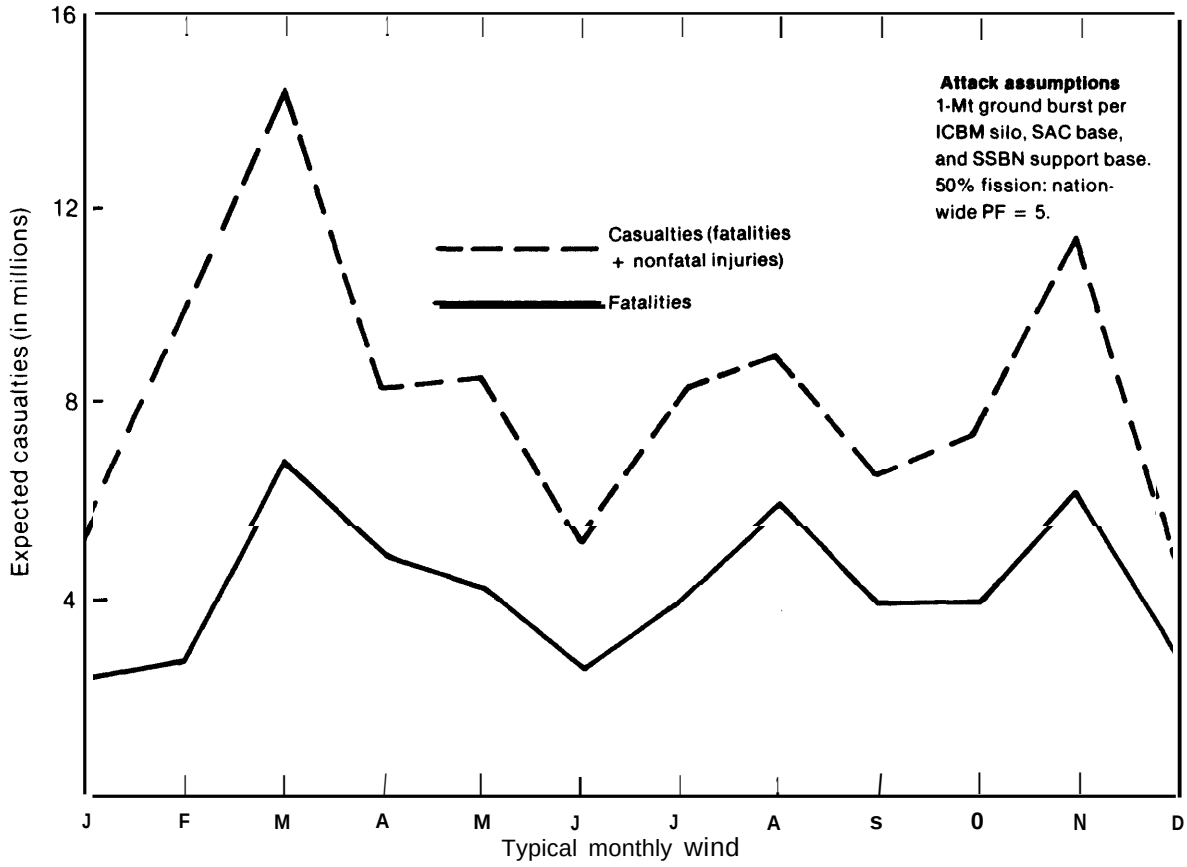
As chapter 11 explained, radiation from fallout in large doses causes death, in smaller doses causes illness, and in still smaller doses creates a probability of eventual illness or death (hence, .lowers life expectancy). As chapter I I I explained, protection can be obtained when matter is placed between the fallout and people— in general, the more matter (the greater the mass) between a source of radiation and a person, the greater the protection. The degree of protection offered by various materials is described as a protection factor (PF). The adequacy of a given PF depends on the intensity of the fallout. For example, a PF of 20 (typical of a home basement with earth piled over windows and against the walls) would reduce an outdoor radiation level of 60 rem per hour to an indoor level of 3 rem per hour. In this case, a person outdoors for 10 hours would almost certainly be killed by radiation, and a person in the basement shelter would have a good chance of survival. But if the outdoor level is not 60 reins per hour but 600 reins per hour, a PF of 20 is inadequate to save I ives.

Calculations of deaths from fallout are made by combining:

- an assumed distribution of fallout, with various intensities at various locations;

[5] For example, after the OTA analysis, was completed, a new study was completed showing fatalities from a counterforce attack with the current U S civil defense posture to be 8 to 12 million without warning, and 5 to 8 million with warning. See Roger Sullivan et al , "Civil Defense Needs of High-Risk Areas of the United States" (Arlington, Va System Planning Corporation, 1979), p. 22

Figure 16.—Expected Casualties as a Function of Typical Monthly Winds Resulting From an Attack on Selected Military Targets in the United States



- an assumed distribution of population within the areas where fallout is assumed to be deposited; and
- an assumed distribution of PFs for the population.

Some computer models use a grid (perhaps 4,000 yards on a side for a fine-grained model, but much larger in other cases) and assume that within each square of the grid the fallout intensity and population density are constant, with PFs mixed. Other calculations use regional or nationwide averages. In general, the calculations show lower numbers of deaths when they assume that the population is widely dispersed, and higher numbers when they take into account concentrations of population. The calculations also show lower numbers of deaths when they assume high PFs; in general, increasing PFs above 40 does not reduce casualties much in the calculations, but that does not mean that raising a PF above 40 might not save an individual's life in reality. The calculations also show lower numbers of deaths when the winds do not blow fallout into densely populated areas.

The studies mentioned previously made separate calculations for attacks including bomber and missile submarine bases, as well as silos. Assuming that there is no preattack evacuation, calculated deaths range from a low of 2 million to a high of 22 million. The differences result primarily from variations in assumptions regarding fallout protection: the high figure assumes approximately to degree of protection which people receive in their daily peacetime lives (PF of 3), and the low figure assumes that the entire population moves after the attack to fallout shelters with a PF of at least 25. A more reasonable assumption, that the fallout shelters which now exist

are utilized by people living near them, produces a calculation of **14 million dead. The same studies also assessed the effects of extensive preattack evacuation (crisis relocation), and found that it reduced the range of predicted deaths. However, the assumptions regarding fallout protection, both for those who are assumed to evacuate and for those who are assumed to remain near home dominate the results. Further detail** is in appendix D.

Given the threat U.S. bombers pose to the Soviet Union, a Soviet preemptive counterforce attack on bomber bases would probably seek to destroy the aircraft and supporting facilities rather than cratering the runways. To destroy airborne bombers launched on warning of attack, an attacker might detonate weapons in a spaced pattern over the base. Air-bursting weapons rather than ground-bursting them could reduce the threat of fallout but increase casualties from blast and thermal effects; if the weapons were detonated much above the optimum height of burst for maximizing overpressure on the ground, fallout would be negligible and blast damage would be reduced. The attacks against missile submarine bases are much less complex. Ususally a single high-yield weapon with medium-to-good accuracy will destroy docks, piers, cranes, and other facilities — and nearby cities, factories, and people as well.

Accordingly, it is certain that if the only difference between two attacks is that one attacks only ICBM silos and the other attacks bomber and missile submarine bases as well, the latter attack would kill more people. However, the variations in assumptions made about attack design, weather, and fallout protection obscure this. Since these variations reflect genuine uncertainties, it is not possible to determine which set of assumptions and which fatality calculation is most probable. However, some of the extreme assumptions do appear implausible. One Defense Department study notes that its highest fatality figure assumed the use of Soviet weapons larger than those which U.S. intelligence estimates the Soviets possess. Very low fatality estimates assume abnormally low winds, an absence of surface bursts, and /or virtually perfect fallout protection. On balance, it does not appear possible to sustain greater precision than to say that "studies of hypothetical counterforce attacks show deaths ranging from 1 million to 20 million, depending on the assumptions used. " However, the low end of this range (deaths below the **8 to 10 million level) requires quite optimistic assumptions, while the high end of the range is plausible only on the assumption that the attack is not preceded by a crisis period during which civilians are educated about fallout protection.**

The data on injuries contained in the executive branch studies are quite limited; for the counterforce attacks, however, the results suggest that injuries would about equal fatalities.

The Contamination Period

For several days or weeks, radioactive contamination would be so intense that people in fallout areas would have to stay in shelters or evacuate. What might be called the "shelter period" begins at each location when fallout starts arriving and ends when people can leave their shelters long enough to do a day's work. The length varies from place to place; many places will receive no fallout, and some hot spots will be hazardous long after surrounding areas are safe. Note, however, that people could go outside for brief periods before an 8-hour day outside a shelter became safe, and could not live in houses with a low protection factor for weeks afterwards. After 2 or 3 months people would ignore the residual radiation, though it would be far higher than is considered "safe" in peacetime.

For the first 10 to 30 days, shelterers would have to remain in shelters almost all the time. Brief excursions outside, for example, to obtain water or food, would substantially reduce the effective protection factor. Life in a shelter would be difficult at best. People would not know if the shelter offered a sufficient PF, or whether further attacks were imminent. The shelter might be dark, as power could be out, and windows would be covered with dirt. Unless the shelter had a good air filtration system, the air would become clammy and smelly, and carbon dioxide concentration would increase. Supplies of food and water might or might not

be adequate, depending on what people brought and how many people were in a shelter. Unless the shelter were specially stocked, medical supplies would probably be inadequate. This would be a severe problem in light of unhealthy conditions in shelters. People who required special medicines would be threatened unless they could obtain an adequate supply. While most people would have radios to receive broadcasts, few would have two-way radios to transmit. While phones might or might not work, it would be difficult to obtain help, as anyone in a contaminated area who left shelter would be in jeopardy from radiation. In particular, medical care would probably be unavailable because of the radiation risk of going to a hospital and the tremendous number of patients seeking help at the few hospitals that remained open.

Radiation sickness would present special problems. Exposures too low to cause acute radiation sickness nevertheless weaken bodily resistance to infection. Resistance would also be weakened by a deterioration in sanitation, prolonged exposure to heat or cold, lack of medical care, psychological shock, and inadequate food, water, and medicine. Hence shelterers would be especially vulnerable to contagious diseases, ranging from colds and influenza to typhoid fever. There is a trend in the United States away from immunization; as a result, many would contract diseases they otherwise would not.

While many people would contract radiation sickness and live, it is very difficult for the layman to determine whether an individual showing pronounced symptoms of radiation sickness has received a moderate, severe, or lethal dose of radiation. Moreover, acute psychological shock induces symptoms similar to radiation sickness, and vomiting— a symptom of both— is contagious in small spaces. Thus, someone who vomited would not know if he had received a moderate, severe, or lethal dose of radiation; if he had severe psychological shock; if he had vomited because of contagion; or if he had some other illness. This uncertainty about one's own condition and that of one's loved ones, and nausea itself, would increase the tension in a shelter. Moreover, nausea weakens people.

Some people will be better off than others: people in adequately equipped shelters of good PF; people who are neither very young, very old, or ill; people who have received little or no radiation before entering the shelter; people in less-crowded shelters. Moderate ambient temperature would be better than hot, and hot would be better than cold. People in snow zones in the winter, however, would be more likely than others to have adequate provisions as a precaution against being stranded at home by snow. In addition, much would depend on how shelterers used their time before fallout arrived to prepare the shelter.

Even if the winds were perverse, there would be substantial areas of the country that would receive little or no fallout. **In some cases (e. g.,** Oregon), it would be evident that no fallout could be expected unless the war continued after the counterforce attack; in other cases it would be several days before people in an uncontaminated area were certain that they had been among the lucky ones. Once it became clear that a given area had been spared, the people living there could be expected to step up their normal pace of activity. To the extent possible, help would be offered to the contaminated areas. Depending on circumstances, there might be large numbers of evacuees to care for. The major task, however, would be to keep the country going until the other survivors could emerge from shelters. Intense but rather disorganized activity would be likely, and essential production would probably take place.

Most productive resources would survive unscathed, but would shut down until the threat of attack had ended; those in fallout areas would remain closed until radiation levels had diminished, with the possible exception of such critical services as radio stations, water pumping facilities, and sewage disposal units. Some plants, and some sectors of the economy, would use productive resources as intensively as possible to meet the demands of the damaged areas and the injured, and to compensate for loss of production elsewhere. The burden imposed on the economy by the

Armed Forces would depend on the international situation.

Economic Disruption

Most economic damage would occur from lost production, but there would be other losses as well: fires would burn unchallenged, and machinery would suffer damage from being shut down in haste or not at all, or from being left outside unprotected. The major damage to the economy, however, would result from deaths and long-lasting injuries (to consumers and producers), and persona l tragedies and other traumas making people less able to work. The magnitude of economic loss could be expected to vary with the number of deaths.

The attack would cause considerable economic disruption in the uncontaminated area. Facilities there would need to produce a vastly different mix of goods and cope with the absence of goods that normally come from contaminated areas. Until people acted as if they believed the war was over, it could prove difficult to organize production in the uncontaminated areas. Uncertainties about the legal and financial arrangements that support production (money, contracts, credit, etc.) following a nuclear attack might impede production in the uncontaminated areas. Some workers, fearing further attacks, would spontaneously evacuate. Public disorder could also impede production. The changes and uncertainties would cause some economic disruption; however, the greater effort put forth would probably more than compensate for it.

Recuperation

Economic viability would not be at issue following a counterforce attack. Because the attack seeks no economic damage, it would be far less likely than a deliberate strike on economic targets to create any bottlenecks that would greatly hinder recovery. The Nation would be able to restore production and maintain self-sufficiency. The attack would cause enormous economic loss, but the Nation's capacity for growth would be at worst only slightly impaired. The major task would be ending disruption and disorganization rather than rebuilding the economy — putting the pieces back together. Most likely these tasks would be accomplished by a mixture of individual, local, State, and Federal initiatives, with Federal intervention used as a last resort.

The main problem areas would be:

1. Agriculture. The attack could be expected to destroy a tiny fraction of farmland with blast and fire; of much greater significance, fallout would contaminate a substantial fraction of cropland because many ICBMs are in or near the Great Plains. Other cropland would escape with little or no fallout. It is unlikely that more than a fraction of the livestock in nearby fallout areas would be adequately protected. Fallout would affect agriculture in two ways: by killing livestock and crops, and by preventing farmers from working in the fields.

Damage from fallout contamination of crops would depend on the time of year. Most crops take up relatively little fallout and external irradiation does not contaminate them. Moreover, it is easy enough to remove fallout particles from food. However, the vulnerability of crops to fallout varies significantly with the type of crop and the stage of its growth. For example, yield of various crops can be reduced 50 percent by the following doses, in roentgens (R): peas, less than 1,000 R; rye, 1,000 to **2,000 R; wheat, corn, cucumber, 2,000 to 4,000 R; cotton,** melons, 6,000 to 8,000 R; soybeans, beets, **800 to 12,000 R; rice, strawberries, 12,000 to 16,000 R; and squash, 16,000 to 24,000 R. At the same time, young plants are most vulnerable to radiation, while those near maturity are least vulnerable.**

Knowledge about radiation effects on crops is, however, limited because much more is known about how gamma radiation affects crops than about beta radiation effects. Since fallout emits both types, and since beta doses to plants could be from 1 to **20 times the gamma dose, this is a major uncertainty.**

Fallout would prevent farmers from working in fields for a time. Fallout does decay, and

weathering would further reduce its effects on people. By a year after the attack, fallout would no longer be of consequence to farmworkers in most areas. How soon after the attack they could begin work would depend on the amount of fallout deposited on a field.

The effects would thus depend significantly on time of year. An attack between October and January would have little effect, as fallout would have decayed enough by planting time to permit farmers to work the fields and to avoid serious damage to crops. Radiation on fields could be substantially reduced by plowing the fallout under or by scraping off the top layer of dirt. An attack in February or March would delay planting, reducing crop yields or making it necessary to shift to crops that mature more quickly. An attack between April and June could kill the entire crop. An attack in July or August could conceivably have little effect, if the plants were undamaged by radiation. But the resulting crop should be safe for human consumption in an emergency. An attack during or just before the harvest could result in the loss of the whole crop, not by damaging the plants, but by preventing farmers from harvesting.

Fallout would be more damaging to livestock than to plants. Animals are only slightly more resistant to radiation than are people; for sheep, cattle, and pigs in barns, where they are protected from direct contact with the ingestion of fallout, a dose of 400, 500, and 600 R, respectively, will kill half these animals. The median lethal dose is considerably lower for animals in pastures, where they can eat fallout along with grass. Poultry are considered more resistant; a dose of 850 R will halve the poultry in a barn. Many animals in heavy fallout areas would probably be killed, as farmers generally have no fallout shelters for animals. Moreover, depending on the damage the attack wreaks on human food crops, it might be necessary to use animal feed as human food. The consequence could be that it would take many years to rebuild the national livestock supply, and until then meat would become a scarce luxury.

2. Decontamination. Cities, farms, and factories in contaminated areas would require decontamination in order to reopen for human use. Decontamination involves moving fallout to areas where it can do less harm in order to reduce the dose rate to people in certain places. It can be done with bulldozers, street sweepers, firehoses, brooms, etc. It does, however, require people to place themselves at risk. Would enough people be willing to run these risks? Training is required for people to know that certain doses are tolerable and other doses are not; this training would make people less unwilling to face these risks, but will enough people have received this training?

3. Public health standards would have to be lowered following the attack. in peacetime, standards are often set cautiously; when acceptable exposure risk is unknown, it is preferable to err on the side of safety. Following the attack, that luxury would not be possible. Fields would be farmed while low-level radioactivity persisted; the risks, quite unacceptable in peacetime, would be preferable to starvation. The cost-benefit ratio would change: the benefits of individual safety would need to be weighed against the costs of foregoing critical production. Moreover, how applicable would our knowledge be for setting standards for the entire population after an attack? Could enough instruments be made available to enable everyone to know what dose they were receiving? And what role would politics play in setting standards when “acceptable risk” rather than “negligible risk” was at issue? Society would be running greater risks without knowing just how great the risks were; so doing would increase low-level radiation sickness, cancers, genetic damage, and so on.

4. Burdens on society would increase, removing people from production while increasing demand on production. Many people would suffer long-lasting, permanent, or debilitating injuries. Demands for more military force could well increase. Inefficiencies stemming from economic dislocation would reduce the outputs from any given set of inputs. Decontamination and civil defense would draw resources.

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5. Economic disorganization would be a problem, possibly a severe one. Once people were confident that the war had ended, money would retain its value, and so would property in uncontaminated areas. But the marketplace that organizes the American economy would be severely disrupted by abrupt shifts in demand, abrupt changes in supply, questions about the validity of contracts involving people or things in contaminated areas, etc. In addition, a major question would develop over how to share the losses from the attack in an equitable way.

Long-Term Effects

The main long-term damage would be caused by countersilo strikes, which release the great bulk of radiation even if bomber and missile submarine bases are also attacked. Radiation has long-term health consequences, such as cancers, other illnesses, deaths, and genetic damage, that blast does not.

Similarly, ecological damage would be caused mainly by countersilo attacks; this topic is dealt with in chapter V.

In the long run, the economy would recover, although it would be some decades before the people killed would be "replaced" in either a demographic or an economic sense. There would undoubtedly be permanent shifts in demand (e. g., there might be little market for houses without basements or fallout shelters), and supply of some goods (notably meat) might be scarce for some time.

An imponderable is the psychological impact. The United States has never suffered the loss of millions of people, and it is unlikely that the survivors would simply take it in stride. The suffering experienced by the South in the decade after 1860 **provides the nearest analogy, and a case can be made that these effects took a century to wear off.**

CASE 3: A COUNTERFORCE ATTACK AGAINST THE SOVIET UNION

As in the case of the Soviet counterforce attack on the United States (described in the previous section), the main threat to the civilian population, economy, and society is derived from fallout, while the damage done to the strategic forces is outside the scope of this study. Here too OTA drew on the executive branch for calculations, and here too the uncertainties are very great.

The First Day

Each of the parameters mentioned in the previous section as affecting the damage to the United States would also affect the damage to the Soviet Union. An additional source of variation is pertinent: the U.S. missiles mostly carry smaller warheads than their Soviet counterparts, but U.S. bombers carry weapons with quite high yields. Ground bursts of bomber-carried weapons (which are especially likely in an attack on Soviet bomber bases) would create very large amounts of fallout.

As in the case of a counterforce attack on the United States, sheltering is preferable to evacuation for protection provided there are no subsequent attacks. Depending on the time of year, the Soviets might have more difficulty than the United States in improvising fallout protection (both frozen earth and mud would create problems); on the other hand, Soviet preparations for such sheltering in peacetime are more extensive than their U.S. counterparts.

The executive branch has performed several calculations of fatalities resulting from counterforce attacks, and variations in the assumptions produce a range of estimates. All these studies except one assume a Soviet first strike and a U.S. retaliatory strike. As a result, estimates of Soviet fatalities are lower than they would be for a U.S. counterforce first strike,

partly because the United States would have fewer ICBMS available for a second strike, and partly because the Soviets are more likely to take precautionary civil defense measures before a Soviet first strike than before a U.S. first strike. All of these studies consider only fatalities in the so days following the attack; they exclude later deaths resulting from relatively less intense radiation or the effects of economic disruption.

For both counterforce and countersilo attacks, with an in-place Soviet population, the fatality estimates are very similar: for the former, from less than 1 to 5 percent of the population; for the latter, from less than 1 to 4 percent. The low end results from using smaller weapons air burst, while the high end results from using larger weapons ground burst. A comprehensive counterforce attack can logically be expected to kill more people than the countersilo attack because the latter is a subset of the former. However, other factors have a greater influnce on numbers of fatalities: A full counterforce attack in which the United States deliberately tried to minimize Soviet fatalities by using small weapons air burst, in which winds were favorable, and in which the Soviets had tactical or strategic warning, would kill far fewer people than a counters ilo-only attack in which the United States used one large weapon ground burst against each ICBM silo.

An unpublished Arms Control and Disarmament Agency (AC DA) analysis highlights the importance of sheltering and attack characteristics for fatal ities from a U.S. countersilo attack. One estimate is that, with the urban population 90-percent sheltered and the rural population given a PF of 6, Soviet fatalities would range from 3.7 million to 13.5 million, depending on attack parameters. With a degraded shelter posture (urban population 10-percent sheltered and rural population given a PF of 6), fatality estimates **for** the same set of attacks range from 6.0 m i l l ion to 27.7 million.

The Shelter Period

If bomber bases (or airfields with long runways that were attacked even though r-to bombers were present) are attacked, tactical warning could be of great importance to people living nearby. There would be an area near each base (roughly, the area more than 1 mile [2 km] but less than 10 miles **[16** km] from a surface burst) in which people who were sheltered at the moment of the blast would have a much greater chance of survival than those who were unsheltered. Soviet civil defense plans envisage that civilians in such high-threat areas would receive some warning, but it cannot be said to what extent this would actually be the case.

Many millions of Soviet citizens live in areas that would receive substantial amounts of fallout from such an attack. Those far enough away from the explosions to be safe from blast darnage would have some time (a range from 30 minutes to more than a day) to shelter themselves from fallout, but evacuation from high-faliout areas after the attack would probably not be feasible. The Soviet civil defense program gives attention to blast shelters rather than fallout shelters in urban areas (see chapter I I I), and while such blast shelters would offer good protection against fallout, some of them may not be habitable for the necessary number of days or weeks for which protection would be required.

The sheltering process would be much more tightly organized than in the United States. The Soviet Government has extensive civil defense plans, and while Americans would expect to try to save themselves under general guidance (informational in character) from the Federal authorities, Soviet citizens would expect the Government to tell them what to do. This introduces a further uncertainty: efficient and timely action by the authorities would be very effective, but it is also possible that Soviet citizens would receive fatal radiation doses while waiting for instructions or following mixed-up instructions. **I n any event, some** hours after the attack would see a situation in which a large number of people in contaminated areas were in fallout shelters, others were receiving dangerous doses of radiation, and those outside the fallout areas were congratulating themselves on their good luck

while hoping that no further attacks would take place.

Would Soviet shelterers be better off than their American counterparts? They have several advantages. They are more accustomed to crowding and austerity than are Americans, so would probably suffer less "shelter shock. " They would be more accustomed to following Government orders, so to the extent that orders proved correct and were correctly implemented, they would be more evenly distributed among shelters. Training in first aid and civil defense is widespread, which would improve people's ability to survive in shelters. If the U.S. attack used low-yield warheads, fallout would be less widespread and less intense.

Soviet shelterers face some problems that Americans would not. They would be more vulnerable than Americans to an attack in winter. The Soviet economy has less "fat," so other things being equal, Soviet citizens could bring less food and supplies into shelters than could Americans.

Public health is a major uncertainty. To the extent that shelters are well stocked, provided with adequate medications and safe ventilation, have necessary sanitary facilities, are warm and uncrowded, and have some people with first aid knowledge, health would be less of a problem. If Soviet citizens receive less fallout than Americans, they would be less weakened by radiation sickness and more resistant to disease. If conditions were austere but reasonably healthy, public health in shelters would be mainly a matter of isolating ill people and practicing preventive medicine for the others. Doctors would be unnecessary for most such tasks; people trained in first aid, especially if they have some access (by phone or radio) to doctors, could perform most tasks. To be sure, some people would die from being untreated, but the number would be relatively small if preventive care worked. However, isolating the ill would not be easy. It is likely that many people would be moderately ill (from flu, etc.) when they entered their shelter, and radiation would make the others more susceptible to contamination. The Soviet Government might send medical teams to contaminated areas, especially to shelters containing workers with key skills. The Soviet Army has built tanks and some other military vehicles with protection against fallout, and has trained its soldiers for operations in areas contaminated with fallout. In addition, as in the United States, military helicopters could ferry people and supplies into contaminated areas with limited exposure to crews. Using such resources would obviously improve health of shelterers, but priority military tasks might make these military resources unavailable.

People in hasty shelters, if they could be built, would face worse health problems, despite the legendary ability of Russians to endure hardships. Presumably these shelters would have inadequate supplies, heat, air filtration, sanitary facilities, waterproofing, and so on. Placing people in a cold, damp hole in the ground for 2 weeks with little food and makeshift toilets would make many people sick even in peacetime; how well would such problems be overcome in war?

Soviet civil defense presents a large question mark. Some believe that the Soviets have massive food stockpiles, meticulous plans detailing where each person should go, ample shelter spaces, subways and buildings convertible to shelters, and so on that would be valuable in the shelter period. Others contend that these claims are vastly overstated and confuse speculation about a plan with its existence and the existence of a plan with its operational effectiveness. (See chapter III on civil defense.) If Soviet civil defense works well, it would save many lives; if it doesn't, Soviet shelterers would face conditions at least as hazardous as their American counterparts.

Agricultural losses would, as in the United States, depend on the time of the year when the attack came and on the precise patterns of fallout. In general, Soviet agriculture appears more vulnerable because it borders on inadequacy even in peacetime–even relatively minor damage would hurt, and major crop losses could be catastrophic. On the other hand, for this very reason the Soviets would

know how to handle agricultural shortages: surviving production and stockpiles (the extent of Soviet food stockpiles is a matter of controversy, apart from the fact that they are lowest just before each harvest) would probably be used efficiently.

The economy outside the contaminated area would continue to function. There would be more than enough industrial facilities in uncontaminated areas to keep necessary production going. The key task facing Government planners, however, would be using available workers and resources to best advantage. How fast could planners generate new economic plans that were detailed enough for that task? Because the Soviet economy operates closer to the margin than does that of the United States, the Soviets could tolerate less loss of production than could the United States. This would make superproduction the norm, with key factories working all the time. It would lead to suspending production of many consumer goods. It would probably lead the Government to begin decontamination earlier and to take more risks with radiation exposure than would the United States. These actions to increase production would be aided in general by the Government's control of the economy, and in particular by keeping work groups together in shelters and host areas.

Recuperation

As in the United States, economic viability would not be threatened. The key question, which would begin to be answered in the shelter period, is how appropriate Soviet emergency plans are and how rapidly planning mistakes could be corrected. Major shifts, and the inefficiencies that accompany them, would be inevitable. To what extent could planning minimize them? Could a command economy do better under the circumstances than a mixed economy? The Soviet Union's long experience with central planning would mean that the changes would involve details within the existing system rather than changing from one economic system to another.

In the U. S. S. R., as in the United States, the crop loss caused by the attack would depend on season, fallout deposition, which crops were hit by fallout, and so on. Similarly, the amount of food reserves would vary with the season. The immediate goal for agriculture would be to send adequate food supplies to cities. Presumably, the Government would try to meet this goal by tightening controls rather than by giving farmers more capitalistic incentives. For a moderate attack like this one, with little physical damage, controls would probably work.

It is questionable whether adequate labor would be available for agriculture. Depending on the situation, millions of men might be mobilized into the Army. On the other hand the Soviets have well-established procedures for getting military personnel, factory workers, and others to help with harvests; moreover, following a nuclear attack, some workers in nonessential industries would be out of work, and could be sent to farms. The large number of farmers (perhaps 35 to 40 percent of the Soviet work force is in agriculture, compared to 2 or 3 percent in the United States), the fallout contaminating some farmland, and accepting more exposure to radiation would increase the Soviet population's exposure to radiation.

If a year's crop were lost, would there be austerity, short rations, or starvation? How much surplus food is there? In particular, would there be enough to maintain a livestock industry, or would meat be seen as a nonessential consumer good and feed grains diverted for human use?

As in the United States, the attack would create many burdens for the Soviet economy. Military expenditures would probably increase; people injured by the attack would need care, and fewer people would be alive and well to care for them; major changes in the economy would cause inefficiencies; lowered public health standards would increase early production at the expense of later health burdens.

The Soviet Union would not face certain problems that a market economy faces. The legal and financial devices supporting production – money, credit, contracts, and ownership of productive resources — would be far less important than in the United States. Instead, Soviet production would be guided by a central plan. There are reports that contingency planning has been done for postwar recuperation; such contingency plans (or the peacetime plan if there are no applicable contingency plans) would have to be adjusted to take account of the actual availability of surviving workers and economic assets. Without doubt such adjustments would be made, though there would be some waste and inefficiency.

Long-Term Effects

Chapter V discusses the likely long-term health hazards from such an attack.

All things considered, an attack of this nature could be somewhat less damaging than World War II was to the Soviet Union, and Soviet recovery from that conflict was complete. However, it helped that in 1945 the Soviets were victorious and able to draw on resources from Eastern Europe. Much would depend on whether the aftermath of this attack found the Soviet people pleased or appalled at the results of the war and on the relative power and attitudes of the Soviets' neighbors.

CASE 4: A LARGE SOVIET ATTACK ON U.S. MILITARY AND ECONOMIC TARGETS

This case discusses a massive attack that one normally associates with all-out nuclear war. The attack uses thousands of warheads to attack urban-industrial targets, strategic targets, and other military targets. The number of deaths and the damage and destruction inflicted on the U.S. society and economy by the sheer magnitude of such an attack would place in question whether the United States would ever recover its position as an organized, industrial, and powerful country.

OTA favored examining purely retaliatory strikes for both sides, but all of the available executive branch studies involved Soviet pre emption and U.S. retaliation. However, the differences between a Soviet first strike and a retaliation do not appear to be appreciably large in terms of damage to the civilian structure. Like the United States, the Soviets have a secure second-strike force in their SLBMs and are assumed to target them generally against the softer urban-industrial targets. Moreover, a U.S. first strike would be unlikely to destroy the bulk of Soviet ICBMs before they could be launched in retaliation.

The effects of a large Soviet attack against the United States would be devastating. The most immediate effects would be the loss of millions of human lives, accompanied by similar incomprehensible levels of injuries, and the physical destruction of a high percentage of U.S. economic and industrial capacity. The full range of effects resulting from several thousand warheads — most having yields of a megaton or greater— impacting on or near U.S. cities can only be discussed in terms of uncertainty and speculation. The executive branch studies that addressed this level of attack report a wide range of fatality levels reflecting various assumptions about the size of the attack, the protective posture of the population, and the proportion of air bursts to ground burst weapons.

The DOD 1977 study estimated that 155 million to 165 million Americans would be killed by this attack if no civil defense measures were taken and all weapons were ground burst. DCPA looked at a similar attack in 1978 where only half the weapons were ground burst; it reduced the fatality estimate to 122 million. ACDA's analysis of a similar case estimated that 105 million to 131 million would die.

If people made use of existing shelters near their homes, the 155 million to 165 million

fatality estimate would be reduced to 110 million to 14s million, and the 122 million fatalities to 100 million. The comparable ACDA fatality estimate drops to 76 million to 85 million. Again ACDA gets a lower figure through assuming air bursts for about 60 percent of the incoming weapons. Finally, if urban populations were evacuated from risk areas, the estimated prompt fatality levels would be substantially reduced. The DOD study showed fatalities of 40 million to 55 million, with DCPA showing a very large drop to 20 million from the 100 mill ion level. The primary reason for the 2-to-1 differential is the degree of protection from fallout assumed for the evacuated population.

In summary, U.S. fatality estimates range from a high of 155 million to 165 million to a low of 20 million to 55 million. Fatalities of this magnitude beg the question of injuries to the survivors. None of the analyses attempted to estimate injuries with the same precision used in estimated fatalities. However, DCPA did provide injury estimates ranging from 33 million to 12 million, depending on circumstances. An additional point worth noting is that al I of the fatality figures just discussed are for the first 30 days following the attack; they do not account for subsequent deaths among the injured or from economic disruption and deprivation.

The First Few Hours

The devastation caused by a single l-Mt weapon over Detroit (chapter I **I),** and of two similar weapons denoted near Philadelphia, have been described. In this attack the same destruction would take place in 30 or so other major cities (with populations of a million or greater). Many cities with smaller populations would also be destroyed. The effects on U.S. society would be catastrophic.

The majority of urban deaths will be blast induced, e.g., victims of collapsing buildings, flying debris, being blown into objects, etc. Except for administering to the injured, the next most pressing thing (probably ahead of handling the dead) for most survivors would be to get reliable information about what has occurred, what is taking place, and what is expected. Experience has shown that in a disaster Situation, timely and relevant information is critical to avoiding panic, helpful in organizing and directing productive recovery efforts, and therapeutic to the overall psychological and physical well being of those involved. Presumably, the civil preparedness functions would be operating well enough to meet some of this need.

Rescuing and treating the injured will have to be done against near insurmountable odds. Fire and rescue vehicles and equipment not destroyed wil I find it impossible to move about in any direction. Fires will be raging, water mains will be flooding, powerlines will be down, bridges will be gone, freeway overpasses will be collapsed, and debris will be everywhere. People will be buried under heavy debris and structures, and without proper equipment capable of lifting such loads, the injured cannot be reached and will not survive. The fortunate ones that rescuers can reach will then be faced with the unavailability of treatment facilities. Hospitals and clinics in downtown areas would likely have been destroyed along with most of their stocks of medical supplies. Doctors, nurses, and technicians needed to man makeshift treatment centers are likely to have been among the casualties. The entire area of holocaust will be further numbed by either the real or imagined danger of fallout. People will not know whether they should try to evacuate their damaged city, or attempt to seek shelter from fallout in local areas and hope there will be no new attacks. No doubt some of both would be done.

If this situation were an isolated incident or even part of a small number of destroyed cities in an otherwise healthy United States, outside help would certainly be available. But if 250 U.S. cities are struck and damaged to similar levels, then one must ask, “Who is able to help?” Smaller towns are limited in the amount of assistance they can provide their metropolitan neighbors. **It** is doubtful that there would be a strong urge to buck the tide of evacuation

in order to reach a place where most of the natives are trying to leave. Additionally, the smaller cities and towns would have their own preparedness problems of coping with the anticipated arrival of fallout plus the influx of refugees. In light of these and other considerations, it appears that in an attack of this magnitude, there is likely not to be substantial outside assistance for the targeted areas until prospective helpers are convinced of two things: the attack is over, and fallout intensity has reached safe levels. Neither of these conditions is likely to be met in the first few hours.

The First Few Days

Survivors will continue to be faced with the decision whether to evacuate or seek shelter in place during this interval. The competence and credibility of authority will be under continuous question. Will survivors be told the facts, or what is best for them to know, and who decides? Deaths will have climbed due to untreated injuries, sickness, shock, and poor judgement. Many people will decide to attempt evacuation simply to escape the reality of the environment. For those staying, it likely means the beginning of an extended period of shelter survival. Ideally, shelters must protect from radiation while meeting the minimums of comfort, subsistence, and personal hygiene. Convincing people to remain in shelters until radiation levels are safely low will be difficult, but probably no more so than convincing them that it is safe to leave on the basis of a radiation-rate meter reading. There will be unanswerable questions on long-term effects.

Sheltering the survivors in the populous Boston to Norfolk corridor will present unprecedented problems. Almost one-fifth of the U.S. population lives in this small, 150- by 550-mile [250 by 900 km] area. Aside from the threat of destruction from direct attack, these populations are in the path of fallout from attacks on missile silos and many industrial targets in the Pittsburgh, St. Louis, and Duluth triangle. Depending on the winds at altitude, the fallout from the Midwest will begin arriving 12 to 30 hours after the attack.

At the time when fallout radiation first becomes intense, only a fraction of the surviving urban population will be in adequate fallout shelters. Those that are sheltered will face a variety of problems: making do with existing stocks of food, water, and other necessities or else minimizing exposure while leaving the shelter for supplies; dealing with problems of sanitation, which will not only create health hazards but also exacerbate the social tensions of crowds of frightened people in a small space; dealing with additional people wanting to enter the shelter, who would not only want to share scarce supplies but might bring contamination in with them; dealing with disease, which would be exacerbated not only by the effects of radiation but by psychosomatic factors; and finally judging when it is safe to venture out. Boredom will gradually replace panic, but will be no easier to cope with. Those with inadequate shelters or no shelters at all will die in large numbers, either from lethal doses of radiation or from the combination of other hazards with weakness induced by radiation sickness.

The conditions cited above are generally more applicable to urbanites who are trying to survive. The problems of rural survivors are somewhat different, some being simpler—others more complex. With warning, people living in rural areas could readily fabricate adequate fallout shelters. However, it might be more diifficult for a rural shelteree to have current and accurate information regarding fallout intensity and location. The farm family is likely not to have suffered the traumatic exposure to death and destruction, and consequently is probably better prepared psychologically to spend the required time in a shelter. (Possible consequences to livestock and crops are addressed later in this section.)

Outdoor activity in or near major cities that were struck would likely be limited to emergency crews attempting to control fires or continuing to rescue the injured. Crews would wear protective clothing but it would be necessary to severely limit the total work hours of any one crew member, so as not to risk dangerous accumulations of radiation. Areas not

threatened by fallout could begin more deliberate fire control and rescue operations. Whether a national facility would survive to identify weapons impact points and predict fallout patterns is doubtful.

The extent of death and destruction to the Nation would still be unknown. For the most part, the agencies responsible for assembling such information would not be functioning. This task would have to wait until the numbing effect of the attack had worn off, and the Government could once again begin to function, however precariously.

The Shelter Period (Up to a Month)

As noted earlier, after the initial shock period, including locating and getting settled in shelters, the problem of sheltering large masses of people will be compounded as the shelter time extends. Survival will remain the key concern. People will experience or witness radiation death and sickness for the first time. Many previously untreated injuries will require medical attention, if permanent damage or death to the individual is to be avoided. Stockpiles of medical, food, and water supplies are sure to become items of utmost concern. Whether some people can safely venture outside the shelter for short periods to forage for uncontaminated supplies will depend on fallout intensity, and the availability of reliable means of measuring it.

This period will continue to be marked by more inactivity than activity. Many areas will have been freed from the fallout threat either by rain, shifting winds, or distance from the detonations. But economic activity will not resume immediately. Workers will remain concerned about their immediate families and may not want to risk leaving them. Information and instruction may not be forthcoming, and if it is, it may be confusing and misleading, and of little use. Uncertainty and frustration will plague the survivors, and even the most minor tasks will require efforts far out of proportion to their difficulty. Many will interpret this as symptomatic of radiation effects and become further confused and depressed. The overall psychological effects will likely worsen until they become a major national concern, perhaps on the same level with other incapacitating injuries.

Deaths occurring within the first 30 days of an attack are categorized as prompt fatalities. This duration is a computation standard more than it is related to specific death-producing effects, and is the basis for most fatality estimates. However, deaths from burns, injuries, and radiation sickness can be expected to continue far beyond this particular interval.

The Recuperation Period

Whether economic recovery would take place, and if so what form it would take, would depend both on the physical survival of enough people and resources to sustain recovery, and on the question of whether these survivors could adequately organize themselves.

Physical survival of some people is quite probable, and even a population of a few million can sustain a reasonably modern economy under favorable circumstances. The survivors would not be a cross-section of prewar America, since people who had lived in rural areas would be more likely to survive than the inhabitants of cities and suburbs. The surviving population would lack some key industrial and technical skills; on the other hand, rural people and those urban people who would survive are generally hardier than the American average.

While the absolute level of surviving stocks of materials and products would seem low by prewar standards, there would be a much smaller population to use these stocks. Apart from medicines (which tend to have a short shelf life and which are manufactured exclusively in urban areas), there would probably not be any essential commodity of which supplies were desperately short at first. A lack of medicines would accentuate the smallness and hardiness of the surviving population.

Restoring production would be a much more difficult task than finding interim stockpiles. Production in the United States is extremely complex, involving many intermediate stages.

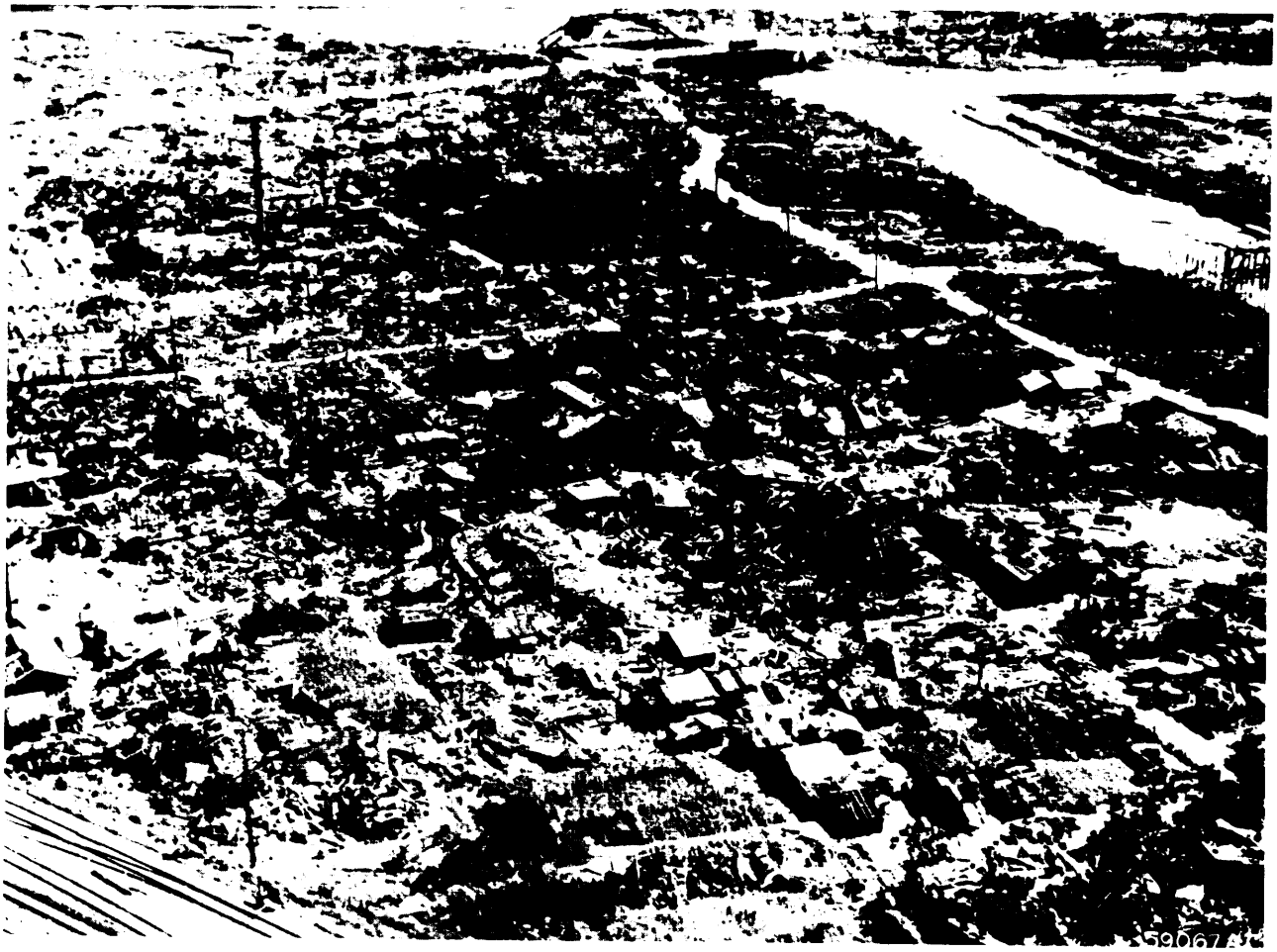

Photo credit: U.S. Air Force

A part of Hiroshima after atomic blast

New patterns of production, which did not rely on facilities that have been destroyed, would have to be established.

It cannot be said whether the productive facilities that physically survived (undamaged or repairable with available supplies and skills) would be adequate to sustain recovery. It seems probable that there would be enough equipment and that scavenging among the ruins could provide adequate "raw materials" where natural resources were no longer accessible with surviving technology.

The most serious problems would be organizational. Industrial society depends on the division of labor, and the division of labor depends on certain governmental functions, Physical security comes first—a person is reluctant to leave home to go to work without some assurance that the home will not be looted. While some degree of law and order could probably be maintained in localities where a fairly dense population survived, the remaining highways might become quite unsafe, which would reduce trade over substantial distances. The second requirement is some form of payment for work. Barter is notoriously inefficient. Payment by fiat (for example, those who work get Government ration cards) is inefficient as well, and requires a Government stronger than a postwar United States would be likely to inherit. A strong Government might grow up, but most survivin$_g$ citizens would be reluctant to support a dictator-

ship by whatever name. The best solution is a viable monetary system, but it would not be easy to establish. Regions or localities might develop their own monies, with "foreign" trade among regions.

The surviving resources might not be used very efficiently. Ideally one would want to conduct a national survey of surviving assets, but the surviving Government would probably not be capable of doing so, especially since people would fear that to acknowledge a surviving stock was to invite its confiscation. To make use of surviving factories, workers would have to live nearby, and they might be unwilling to do so in the absence of minimally adequate housing for their families. Ownership of some assets would be hopelessly confused, which would diminish the incentives for investment or even temporary repairs.

There is a possibility that the country might break up into several regional entities. If these came into conflict with each other there would be further waste and destruction.

In effect, the country would enter a race, with economic viability as the prize. The country would try to restore production to the point where consumption of stocks and the wearing out of surviving goods and tools was matched by new production. If this was achieved before stocks ran out, then viability would be attained. Otherwise, consumption would necessarily sink to the level of new production and in so doing would probably depress production further, creating a downward spiral. At some point this spiral would stop, but by the time it did so the United States might have returned to the economic equivalent of the Middle Ages.

The effect of an all-out attack would be equally devastating to the U.S. social structure. Heavy fatalities in the major urban areas would deprive the country of a high percentage of its top business executives, Government officials, medical specialists, scientists, educators, and performers. There is no measure for estimating the impact of such lasting losses on our society. In addition to the irreplaceable loss of genius and talents, the destruction of their associated institutions is still another compounding of effects that is overlooked by some recovery estimates. Who could calculate how long to *get over the loss* of Wall Street, an MIT, a Mayo Clinic, and the Smithsonian?

The American way of life is characterized by material possessions, with private ownership of items representing substantial long-term investments (such as homes, businesses, and automobiles) being the rule rather than exception. Widespread loss of individual assets such as these could have a strong, lasting effect on our social structure. Similarly, the question of whether individual right to ownership of surviving assets would remain unchanged in a postattack environment would arise. For example, the Government might find it necessary to force persons having homes to house families who had lost their homes.

The family group would be particularly hard hit by the effects of general nuclear war. Deaths, severe injuries, forced separation, and loss of contact could place inordinate strains on the family structure.

Finally, major changes should be anticipated in the societal structure, as survivors attempt to adapt to a severe and desponding environment never before experienced. The loss of a hundred million people, mostly in the larger cities, could raise a question on the advisability of rebuilding the cities. (Why reconstruct obvious targets for a nuclear Armageddon of the future?) The surviving population could seek to alter the social and geopolitical structure of the rebuilding nation in hopes of minimizing the effects of any future conflicts.

How well the U.S. political structure might recover from a large-scale nuclear attack depends on a number of uncertainties. First, with warning, national level officials are presumed to evacuate to outlying shelter areas; State and local authorities will take similar precautions, but probably with less success, especially at the lower levels. The confidence and credibility of the system will come under severe strains as relief and recovery programs are imple mented. Changes in an already weakened

structure are sure to result as many normal practices and routines are set aside to facilitate recovery. Survivors may demand more immediate expressions of their likes, dislikes, and needs. Widespread dissatisfaction could result in a weakening of the Federal process, leading to a new emphasis on local government. An alternative possibility is martial law, which might be controlled in theory but decentralized in practice.

All of this assumes that there would be no significant ecological damage, a possibility discussed in chapter V. Chapter V also discusses long-term health hazards.

CASE 4: A LARGE U.S. ATTACK ON SOVIET MILITARY AND ECONOMIC TARGETS

A U.S. retaliatory attack against the Soviet Union would destroy 70 to 80 percent of its economic worth. The attacking force would consist primarily of U.S. strategic bombers and Poseidon/Polaris SLBMs, since most U.S. land-based ICBMs are assumed lost to a Soviet first strike. Bombers carry gravity bombs and short-range attack missiles having yields of about 1 Mt and 200 kt respectively. Poseidon SLBMs nominally carry up to 10 RVs of 40 kt each.

The attack would strike the full set of Soviet targets —strategic offensive forces, other military targets, economic targets, and cities. Population would in fact be struck, although killing people would not be an attack objective in itself. The objectives would be to cause as much industrial damage as possible and to make economic recovery as difficult as possible. The attacks might not be limited in time. Concentrations of evacuees would probably not be struck, but industries that recovered very quickly after the attack could be.

The immediate effects of the attack would be death and injury to millions of Soviet citizens, plus the destruction of a large percentage of Soviet economic and industrial capacity. As with the all-out Soviet attack, the executive branch studies provided a wide range of casualty estimates. Since the thrust of those analyses was to look at the potential effectiveness of Soviet civil defense, casualties were estimated under various assumptions re lated to the posture of the population.

If the Soviet population remained in-place, fatality estimates range from a high of 64 million to 100 million (26 to 40 percent of the Soviet population) to a low of 50 million to 80 million (20 to 32 percent). The high-value range is due to the different data bases used by DOD and ACDA and the higher protection levels assumed by AC DA. The low-value range results from the use of day-to-day alert status by the interagency intelligence study as compared to ACDA's use of generated forces, and the types of weapons used against the economic target base in the two studies. With evacuation, the ACDA study estimated that fatalities would be reduced to 23 million to 34 million. It is difficult to judge whether these figures represent a high or low estimate. They could be considered as representing the low side because of the coarseness of Soviet data as used by ACDA. On the other hand, some would say that the evacuation scheme assumed by ACDA was unrealistic, and the results should be considered a high estimate. Nevertheless, Soviet fatalities are lower than the United States for both in-place and evacuated population postures. The lower Soviet fatalities are again primarily due to major differences in the yields of the weapons detonating in each country, and to the greater proportion of Soviet population that lives in rural areas.

As to the cause of fatalities (blast, thermal radiation, and direct nuclear radiation versus fallout radiation), DCPA data suggests that, in large attacks, that is, attacks that include economic or economic and population targets, fatalities are primarily due to prompt effects as opposed to fallout. Prompt effects account for at least 80 percent of the fatalities for all population postures when economic targets or population are included in the attack. ACDA

notes a similar result in its study for attacks that include counterforce and other military targets. The reason for this is that in attacks on targets near urban areas, that is, attacks involving economic targets or population, those protected enough to survive the blast effects also have enough protection to survive the fallout. Conversely, those who do not have enough protection against fallout in urban areas near targets will not have enough protection against prompt effects and will already be dead before fallout has an effect.

Estimates of Soviet injuries were generally not included in the analyses. However, one study suggested that injuries might be roughly equal to fatalities under certain attack and exposure assumptions.

The First Few Hours

As chapter **11 I** notes, Soviet civil defense can have substantial impact on the full range of effects. Fallout shelters, blast shelters, and industrial hardening can reduce the overall damage from nuclear attack. First aid and civil defense training can ameliorate health problems. Storing supplies in shelters lengthens shelter stay time. Thus, the issue is how well Soviet civil defense would in fact work. Many unknowns— numbers of shelters, amount of food and medicine stock piles, small er amounts of surplus resources than the United States–prevent a judgment in detail. It seems safe to assume, however, that Soviet civil defense measures would be at least as effective as U.S. measures and probably better.

Preattack preparations would have a decided influence on damage caused. Since a U.S. retaliatory attack is by definition preceded by a Soviet first strike, it would seem logical that some evacuation would have occurred. However, there are reasons why evacuation might not have taken place. These include the following Soviet concerns: an evacuation could increase the risk of a U.S. attack; the U.S. attack might be so close at hand that an evacuation could increase casualties; a prolonged evacuation might be such an economic disruption that it would be better to wait until war appeared certain; or war through miscalculation. **I** n any event, a Soviet decision to strike first would allow the Soviets to make preparations—distribute supplies, improve and stock shelters, increase production of essential goods, harvest grain, protect livestock, conduct civil defense training, harden industrial facilities, and so on. These actions would also make Soviet citizens more responsive to civil defense instructions, especially to a warning that an attack was underway. While these actions would be observed by the United States, they would be more ambiguous than an evacuation, so the United States could see them as safeguarding against an attack rather than preparing for one.

The effects of evacuation in reducing casualties could be diluted to some extent by varying U.S. attack strategy. Spreading the attack over a period of time could extend shelter periods, enhance economic disruption, and delay rescue and emergency operations.

The Soviet Union, despite its vast geographical size, is vulnerable to an urban/industrial attack in many of the same ways as the United States. Although there has been extensive publicity on their reported dispersal of industry, indications are that population and industry are becoming more and more concentrated. While some industries may have been moved away from cities, many others have been built near cities. Indeed, some of the industries recently built away from cities are themselves so concentrated that they form new targets of their own. Hedrick Smith describes

> the Kama River Truck Plant as an archetype of the gigantomania of Soviet planners, as a symbol of the Soviet faith that bigger means better and the Soviet determination to have the biggest at any cost.
>
> Kama is the kind of massive crash project that appeals to Russians. It emanates brute strength. In 1971, Soviet construction brigades started from scratch to build the world's largest truck plant in the open, rolling, windswept plains about **600** miles east **of** Moscow Kama was not just one factory but six, all huge The production complex, costing **in** the **billions,** occupies 23 square miles, an area larger than the entire island of Manhat-

tan. At full capacity, Kama is slated to produce 150,000 heavy trucks and 250,000 diesel engines a year, dwarfing anything in Detroit or the German Ruhr.[6]

The attack could cause "derussification. " The U.S.S.R. is a nation of nationalities, of which Great Russians — who dominate politics, industry, and much else— comprise about 48.5 percent of the population. Most Great Russians live in cities, so an attack would reduce their numbers and influence. Derussification could weaken Great Russians' control of the U. S. S. R., with unforeseeable consequences.

Timing makes a critical difference in destruction. An attack at night would have people with their families and more dispersed; they would seek shelter in apartment buildings. An attack during the day would strike people at factories and offices; to the extent they left to find family members, chaos would result as in the United States, but to the extent they sought shelter at work, they would be organized by economic task. Such organization would be useful for postattack recovery.

An attack in winter would expose more people to bitter cold and impede evacuation; an attack in spring or fall, when many roads are made impassable by mud, would hinder evacuation by motor vehicle. An attack near harvest time could result in the loss of an entire year's crop, thus leaving food reserves at a low point. This effect could be magnified if the United States attacked agricultural targets, such as storage silos, dams, and drainage facilities.

Even time of month makes a difference because of the Soviet practice of "storming." The Soviet factory month in practice divides into three periods: "sleeping," the first 10 days; "hot" work, the second 10; and "feverish" work, the third. This division occurs because the economic plan calls for a specified output from each plant by the end of the month, but the inputs needed often arrive only after the 15th or 20th of the month. Thus, perhaps 80 percent of a factory's output is produced in the last 10 or 15 days of the month. (This 80 percent is typically of such reduced quality that Soviet consumers often refuse to buy merchandise made after the 20th of a month.) Hypothetically, an attack around the 15th or 20th of a month would cause the loss of most of a month's production, and would destroy the large inventory in factories of partially completed goods and of inputs that cannot be used until other inputs arrive.

On the other hand, the U.S.S.R. has several strengths. Cities are in general less flammable than U.S. cities, as there are more large apartment buildings and fewer wood frame houses. These buildings would also provide better shelter, especially those that have shelters built in. People would expect to follow instructions and would be less likely to evacuate spontaneously. The Party apparatus would probably survive with a far lower casualty rate than the population at large because it is well distributed and because blast shelters have been constructed for party members. Russians are likely to be less traumatized by shelter conditions, as they are more accustomed to austerity and crowding. The nation is larger, which in theory provides more land area over which people could relocate, but much of the area is mountain, desert, or arctic.

The First Few Days

Actions in this period would greatly affect the number of casualties and the amount of economic damage. Obviously, much damage would have been caused in the first hour. Many people trapped in the rubble could be rescued, would be seriously injured but could survive with medical care or first aid, would be able to seek shelter or evacuate, could prepare hasty fallout shelters, could improve existing shelters, and so on. Some industries would be damaged but not destroyed; if small fires were extinguished, undamaged equipment hardened against blast, exposed equipment protected from rust, and so on, more resources would be available for recovery. Likewise, farms could harvest crops, shelter livestock,

[6] Hedrick Smith, *The Russians (New* York: Ballantine Books, 1977), p. 241.

and protect harvested crops in the few days before fallout deposition.

The issue is not what could be done but what would be done. Proper use of time— organization and prioritization to get the most important tasks done with the least wasted effort and resources—would be critical. The Soviet system offers a major advantage in this period. As we noted in the case of a counterforce attack, the Government's role in this crisis would be more clearly defined, and its control over individual action and the economy would be much stronger than that of the U.S. Government in a comparable situation. Its experience with central planning and a command economy would be good preparation for the actions needed —decisions involving large shifts in behavior and resources, obeyed without argument. Its decisions would save some people and industries and condemn others, but delay in order to make better decisions could easily condemn more. Evacuation would have to be ordered in this period, or else would-be evacuees would have to wait until radiation had reached safe levels. For cities damaged only slightly, evacuation would prove difficult but not impossible. With many rail yards and some key bridges out, it would be difficult to get trains to smaller cities. Destruction of petroleum refineries, some petroleum storage capacity (especially that located in rail marshaling yards that were attacked), and some electric power generators, would further impede evacuation by train. Fallout contours would be difficult to predict, so it would be hard to select the best evacuation routes and relocation centers. An attack in winter would add other problems.

Survivors in Soviet cities would face the same severe problems as those in U.S. cities. Many would be injured, trapped in rubble, irradiated with initial nuclear radiation, etc. Many shelters would be destroyed or damaged. Power would be out, so water pressure would be too low for fighting fires. Rubble would impede rescue.

Undamaged areas, especially those not threatened by heavy fallout, would face severe burdens. They would receive many evacuees in the first few days, would send rescue teams and resources to devastated areas, and would strive to produce as much as possible. Evacuees in undamaged areas would be pressed into work in fields and factories, and would be sheltered in public buildings or private homes. The performance of undamaged areas would thus largely determine the nation's ability to prosecute the war and to achieve economic viability. The Government would, however, face a dilemma in how to use resources surviving in undamaged areas: it could maximize current production, leaving workers and resources vulnerable to further attacks, or it could seek to protect workers and resources, thus reducing current production. The specific choices would depend on the likelihood of further attacks, criticality of various products, and so forth, but the dilemma would stand.

An all-out attack would exacerbate the inefficiencies that Soviet industry has in peacetime. The Government would have to decide what it needed to have produced, and whether the factories existed to have them produced. The Government would have far more difficulty correlating inputs and outputs and arranging for their transportation. It would have to assign people to jobs, and arrange to transport, shelter, and care for workers. Many workers would be sick, in shelters, killed, traumatized, or debilitated by radiation sickness. However, the Government would probably be able to control what movement of people did take place. Even in peacetime, the Government has very high control over mobility. People are not in the habit of going anywhere without permission, and everyone's actions must be justified and accounted for. There is little independent travel. The internal passport system strengthens these controls. I n wartime, the Government would presumably strengthen its control of transportation. People would have nowhere to go where they could be sure of shelter from fallout unless the Government arranged their transportation and shelter. This control would

help the Government maintain economic organization following attack.

The Shelter Period

By all reports, the Soviets are better prepared than Americans to spend extended periods of time in shelters. In their literature well-conceived protective structures are seen that should afford good survivability. Life in shelters and evacuation areas would in some ways be similar to that described in earlier cases. Actions taken before fallout deposition would affect casualties. Public health, number and quality of shelters, and amount of food and medicine stockpiled are uncertainties. Civil defense and first aid training would mitigate deaths, but to an unpredictable extent. People in uncontaminated areas would be best off, followed by those in fallout shelters in contaminated areas, those in secure fallout shelters in blast areas, and those in hasty shelters in contaminated areas.

One public health problem would be especially acute in this case. Antibiotics, which are invaluable in fighting many diseases, are in short supply in the U.S.S.R. even in peacetime. Antibiotics have a short shelf life and cannot be frozen. Large doses of radiation destroy most of the body's antibodies, which fight diseases. Antibiotics are typically used to compensate for the drastic decrease in antibodies in radiation victims, as it takes the body a long time to rebuild its antibodies after large radiation doses. Because of the U.S.S.R. 'S limited supply of antibiotics, many people could be expected to die from diseases.

In areas contaminated by fallout but undamaged by blast, shelter life would be less intolerable. Utilities might be working, buildings would be undamaged so would offer better shelter, people would be uninjured, there would be time to prepare and provision shelters, there would be less inclination to evacuate, and there would be less pressure to leave shelters prematurely.

Fallout deposition patterns would become clear in this period, and would largely determine the damage to agriculture and which industries would need to remain closed. Harvesting crops uncontaminated by fallout would be impeded by fuel shortages, but evacuees would be plentiful and could harvest crops by hand. Similarly, evacuees could work in surviving industries in uncontaminated areas.

The key issue that the Government would face would be successful organization. Production would be far below prewar levels. It would take some time before the Government could take inventory, set priorities, arrange for inputs of workers, resources, and power, and transport the outputs. Most needs in this period would be met from inventory. The Covernment would thus need to establish strict controls over inventory; it could be necessary to implement severe rationing of food, as was done in Leningrad in World War 11.

Problems of organization would be especially critical in light of the intense struggle for resources and the need to use resources as widely as possible. The competition for petroleum, discussed previously in Case 2, would be minimal compared to the competition here. The military, agriculture, industry, transportation, and life support systems would all have urgent claims on resources. Everything would be in short supply; there would be hundreds of bottlenecks instead of one. How would the Government mediate among these claims? There would be far less margin for error than in peacetime, and a decision to use resources for one purpose would almost automatically pre elude other courses of action. Viability would be at issue, and deaths would increase because of delays in achieving it.

What sacrifices would the Government demand? Obviously, each critical sector would be called on to make some, and consumer goods would probably be sacrificed completely. Public health would be sacrificed to some extent by starting production in contaminated areas early and by giving people contaminated food rather than nothing.

The Government would probably be able to maintain control. Food rationing, control of transportation and shelters, and internal

passports would help the Government restart the economy. Its economic plans would be the only alternative to chaos, and people would expect to obey them and their demands even without controls. Many party members would survive. Contenders for resources would struggle inside the Government, but external threats, the specter of chaos, the urgency of decisions, and the recognized impossibility of getting everything needed would dampen the debate. All sectors would make sacrifices. The military, for example, might be forced to forego fuel-intensive training. In agriculture and industry, manual labor—which would be plentiful – would substitute for machinery. People would use wood for fuel where possible; many would go cold. Coal-burning locomotives woud likely be taken from storage. Decisions would be taken quickly and set rigidly, Productivity would decrease before it increased. The standard of living would be far lower, and some would die in this period and the next as a result. The question is— how many?

Recuperation

Production– and with it, standard of living and the number of people production could support —would go down before it went up. Industries would use inventories of supplies for production, then would have to close until supply could be reestablished. Transportation would wind down as petroleum refining was cut off, and petroleum supplies became exhausted or requisitioned by the military. People would be diverted from production by being sick or injured, caring for the sick or injured, or being drafted for military service. What production took place would be far less efficient. Many workers would be debilitated by minor cases of radiation sickness, other illness, malnutrition, psychological shock, and so on. Many would be called on to do tasks for which they lacked the training or the physical strength. Factories would be damaged or could not obtain necessary parts, so industrial processes would have to substitute labor for capital or use shortcuts that would reduce the quality of the product or the efficiency of the process.

If things went well, production would stabilize at a level that made good use of surviving resources, and would recover from there. The Government would increase its control over people and the economy, production of consumer goods would be delayed, many resources would flow to the military, public health would be lower, but sacrifices would pay off. Soviet engineers and plant managers reputedly are skilful at improvising solutions to mechanical problems. Such skills, Government organization and control, and brute force could overcome bottlenecks, use production to expand capacity, and give people austere but adequate food, housing, medical care, and other necessities.

The recovery could go poorly, however. A great many people could require medical care that could not be provided, and would die. The harvest could be lost, and more would die. Starving people would find and eat grain to be planted next year, reducing that crop and causing others to starve. Transportation could collapse, preventing factories from obtaining inputs and making it impossible for their products to be distributed, forcing them to close. Hardening might save key machine tools, but these tools might be buried under tons of rubble or be in intensely radioactive areas, pre eluding their use. The Government might be unable to conduct a detailed resource inventory that could integrate these tools into the economy, or there might be no way of transporting them to a factory that could use them. A war or threat of war, from NATO, China, or both, might divert surviving industry and materials into producing for the war effort and away from the economy. Which way the economy would go is unpredictable, for there are far too many unknowns. But should economic productivity fall precipitously, for whatever reason, the economy could support fewer people, and more would die. Indeed a failure to achieve viability could cause as many Soviet deaths as the attack itself.

I n summary, the effects of a large-scale nuclear attack against Soviet military and urban-industrial targets would remove that nation from a position of power and influence for the

remainder of this century. Soviet fatalities, due to asymmetries in weapons yields and population densities, would be lower than those for the United States. However, there is no evidence that the Soviet economy and its supporting industry would be less severely damaged than their U.S. counterparts. Nor is there any evidence that the Soviets face a lower risk of finding themselves unable to rebuild an industrial society at all.