CHAPTER FOUR

Attacking Russia's Nuclear Forces

In this chapter, we put the analytical tools of our model to work describing a major U.S. attack on Russia's nuclear forces. The attack scenarios use land-based and sea-based strategic missiles to deliver between 1,124 and 1,289 warheads with an explosive yield of between 294.9 and 320.6 megatons. The ranges represent low and high levels of targeting against Russian strategic naval and aviation sites. This is a type of attack that has traditionally been an option in the U.S. SIOP. At times it was designated MAO-1, for Major Attack Option-1. This chapter presents NRDC's approximation of that kind of attack, which we will call Major Attack Option-Nuclear Forces (MAO-NF).

In our analysis, we cover the eight categories that currently make up the infrastructure of Russia's nuclear forces—the likely targets in an attack of this kind. These categories include: silo-based, road-based, and rail-based ICBMs, SSBN and long-range bomber bases, nuclear warhead storage sites, the nuclear weapons design and production complex, and command, control, and communication facilities. This kind of attack is termed a "counterforce" attack because the targets are military rather than civilian and because heavily populated areas are excluded. In this case, the military targets are all nuclear related. Russian/Soviet forces in the recent past were many times their current size. If existing trends continue, they probably will be much smaller in the future. Nevertheless, a detailed examination of a U.S. counterforce attack today can be a benchmark case study to help analyze future arsenals and different-sized attacks.

We divide our discussion of each of the eight Russian target categories into three subsections. The first subsection describes the kinds of targets in each category. The second subsection explains our reasons for selecting the attacking warhead aimpoints, the height of bursts, and the number of warheads per target. We base these selections on detailed analysis of the vulnerability of the targets to nuclear explosions. The third subsection describes the scale of casualties that result from the attack. As we shall see, the numbers of casualties depend upon several parameters that are included in our model. The monthly variation in wind speed and direction, for example, affects fallout patterns. We treat two other important parameters—the degree of population sheltering from fallout and the fission fraction of the total yield of a thermonuclear warhead—as uncertainties in our calculations.

At the end of the chapter, we summarize our results by totaling and assessing what happens in each of the eight categories to both people and targets. Depending upon the time of year, our statistical assessment is that the MAO-NF attack employing 1,289 U.S. warheads causes between 11 and 17 million casualties, including between 8 and 12 million fatalities.

SILO-BASED ICBMS

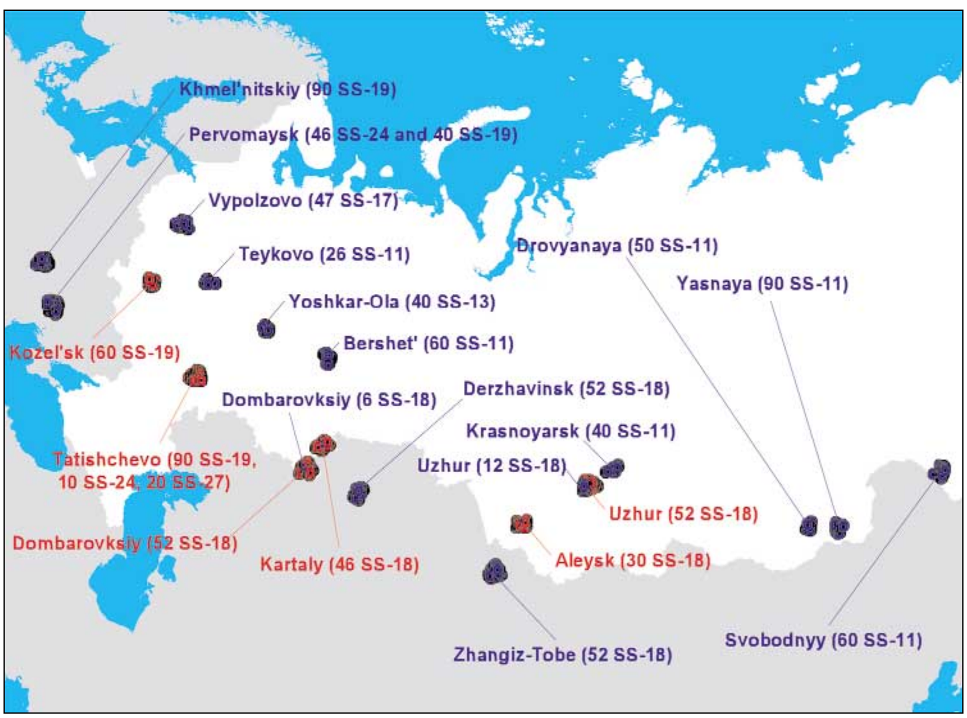
Description of Targets

As of mid-2001, Russia has 360 operational ICBM silos and 52 associated silo launch control centers distributed throughout six missile fields: Kozelsk, Tatishchevo, Uzhur, Dombarovskiy, Kartalay, and Aleysk. These fields are arrayed in a 3,700-kilometer arc from just west of Moscow eastward to Siberia. Many of these silos will be eliminated if START II enters into force. Since the end of the Cold War, the number of silos, missiles, and the nuclear warheads they carry has been reduced greatly, in part a result of the Strategic Arms Reduction Treaty I (START I). This is depicted in Figure 4.1. The current ICBM force consists predominantly of SS-18s and SS-19s, with a modest number of SS-24s and SS-27s.

Warhead Requirements and Aimpoints

To attack a missile silo with a nuclear weapon, a war planner must make some estimate as to how "hard" it is. The degree of "hardness" determines the silos' ability to withstand the effects of a nuclear explosion—and thus protect the underground missile. The vulnerability numbers for former and current Russian silos are listed in Table 4.1. Using these assigned vulnerability data, we calculate the damage radii for severe or moderate damage to each silo type by a 300-kt W87 (U.S. MX/Peacekeeper ICBM)

FIGURE 4.1
Past and Present ICBM Silo Fields
The 360 active (colored red) and 711 dismantled (colored blue) missile silos in Russia and the former Soviet Union. Note several of the fields were in Ukraine and Kazakhstan.



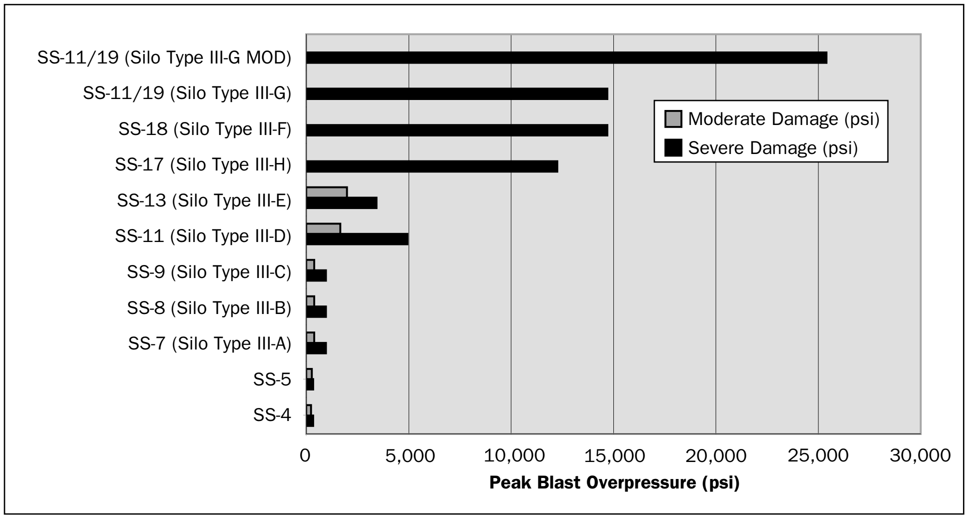


FIGURE 4.2
Peak Blast Overpressure Damage to Soviet-Built Silos
These values of peak blast overpressure are computed to produce a 50 percent probability of severe or moderate damage to the indicated silo types. Note that the correction for the yield-dependent blast wave duration (given by the vulnerability number's K-Factor) is not applied in this figure.

warhead (also given in Table 4.1). These calculations show the progressive hardening of ICBM silos during the Cold War.[1] The severe damage radius for a 300-kt ground burst on the hardest silo type (type III-G MOD) is computed to be 137 meters. This damage radius is slightly larger than the accuracy of the MX/Peacekeeper (estimated to be 91 meters) and the calculated radius of the crater formed by the ground burst (ranging from 57 meters in hard rock to 115 meters in wet soil). Figure 4.2 shows the computed peak blast overpressure necessary to produce a 50 percent probability of achieving severe or moderate damage for various Soviet silos.

TABLE 4.1
Vulnerability Numbers for Soviet-Built Silo Types
N/A indicates "a lesser level of militarily significant damage has not been defined." The computed damage radii for a 300-kt warhead (the yield of the U.S. Peacekeeper warhead) are for surface bursts. Source for the vulnerability numbers: *NATO Target Data Inventory Handbook* (1989).

Missile System	Year Missile System First Deployed	Silo Type	VN[2] for Severe Damage[3]	300-kt Severe Damage Radius (meters)	VN for Moderate Damage[4]	300-kt Moderate Damage Radius (meters)
SS-4	1958	—	31P1	491	29P0	551
SS-5	1961	—	31P1	491	30P0	514
SS-7	1962	III-A	37P6	390	32P2	471
SS-8	1963	III-B	37P6	390	32P2	471
SS-9	1967	III-C	37P6	390	32P2	471
SS-11	1966	III-D	46L8	241	40L6	311
SS-13	1969	III-E	44L7	254	41L6	291
SS-17	1975	III-H	51L7	164	N/A	N/A
SS-18	1974	III-F	52L7	154	N/A	N/A
SS-11/19	1974	III-G	52L8	165	N/A	N/A
SS-11/19	1974	III-G MOD	55L8	137	N/A	N/A

U.S. war planners calculated that blast overpressures of 10,000 to 25,000 psi were required to severely damage the hardest Russian silos. These figures, and even higher ones, have been cited in the open literature.[5] Clearly this assessment of the hardness of Russian silos has a significant impact on the U.S. nuclear war planning process. For example, in an *Air Force* article, the Commander-in-Chief of Strategic Air Command, Gen. Bennie Davis stated: "Anytime you can get superhardening values well above 6,000 psi, you automatically complicate the targeting problem [i.e., for the attacker]."[6] According to General Davis, the complication is partially overcome by assigning "two or more RVs" to achieve the requisite high kill probability. The following figures illustrate General Davis' point: the probability of severely damaging a SS-11 silo (5,000 psi) using one Minuteman III (MM III) W78 warhead is 0.66 (assuming a yield of 335 kt and a CEP of 183 meters), whereas the probability of using one such MM III warhead on a SS-17 silo (12,000 psi) is only 0.39. The probability of severely damaging a SS-17 silo increases to 0.63 if two such MM III warheads are used and to 0.77 if three such MM III warheads are used.

By raising the height of burst above ground level, it is possible to reduce the total amount and extent of lethal fallout.

To achieve maximum kill probabilities against Russian ICBM silos, we assume that U.S. war planners assign accurate warheads with high yields to these targets. The most likely U.S. weapons they would assign would be W87 and W78 ICBM warheads and W88 and W76 SLBM warheads. U.S. nuclear-armed cruise missiles or bombers take too long to reach the silos considering the probable requirement in the SIOP to attack the silos before Russian forces launch the missiles. Table 4.2 shows the single-shot kill probabilities (SSPK—one warhead per silo) and double-shot kill probabilities (DSPK—two warheads per silo) for ground bursts of various U.S. ICBM and SLBM warheads. While ground bursts produce higher kill probabilities, they also cause more extensive fallout.

Achieving significant kill probabilities requires at least one MX warhead, or one W88 warhead, per silo, especially for the SS-11/19 III-G MOD silo type. To generate high probabilities of severe damage requires allocating two such warheads per silo.

TABLE 4.2
Single-Shot and Double-Shot Kill Probabilities for U.S. ICBM and SLBM Warheads Attacking Active Russian Silo Types
For Trident I and II warheads, a range is given for circular error probable (CEP). Single-shot kill probabilities are indicated by SSPK, and double-shot kill probabilities are indicated by DSPK.

Warhead	Yield (kt)	CEP (m)	SSPK (SS-18, Silo Type III-F)	DSPK (SS-18, Silo Type III-F)	SSPK (SS-11/19, Silo Type III-G)	DSPK (SS-11/19, Silo Type III-G)	SSPK (SS-11/19, Silo Type III-G MOD)	DSPK (SS-11/19, Silo Type III-G MOD)
W76 (Trident I)	100	500	0.022	0.044	0.024	0.047	0	0
W76 (Trident I)	100	229	0.103	0.195	0.112	0.211	0	0
W76 (Trident II)	100	183	0.155	0.286	0.169	0.309	0	0
W76 (Trident II)	100	129	0.286	0.490	0.309	0.523	0	0
W62 (MM III)	170	183	0.230	0.407	0.254	0.443	0.183	0.333
W78 (MM-III)	335	183	0.360	0.590	0.403	0.644	0.299	0.509
W88 (Trident II)	475	183	0.442	0.689	0.496	0.746	0.375	0.609
W88 (Trident II)	475	129	0.687	0.902	0.744	0.934	0.608	0.846
W87-0 (MX)	300	91	0.805	0.962	0.848	0.977	0.726	0.925

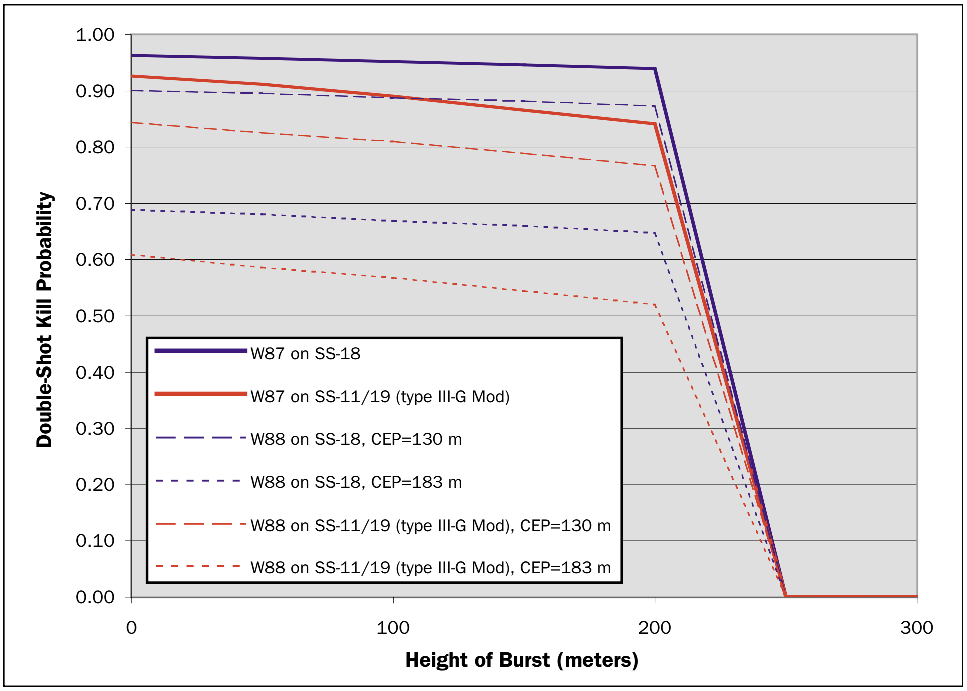


FIGURE 4.3
Double-Shot Kill Probabilities for W87 and W88 Warheads Against Russian SS-18 and SS-11/19 Silo Types
As a function of height of burst.

By raising the height of burst above ground level, it is possible to reduce the total amount and extent of lethal fallout. Figure 4.3 demonstrates that double-shot kill probabilities against Russian silos are roughly constant from a ground burst to a height of burst of about 200 meters, and then quickly fall to zero as the altitude is increased further. The height of burst at which a weapon is detonated will have some error associated with it, called the Probable Error Height of Burst (PEH).[7]

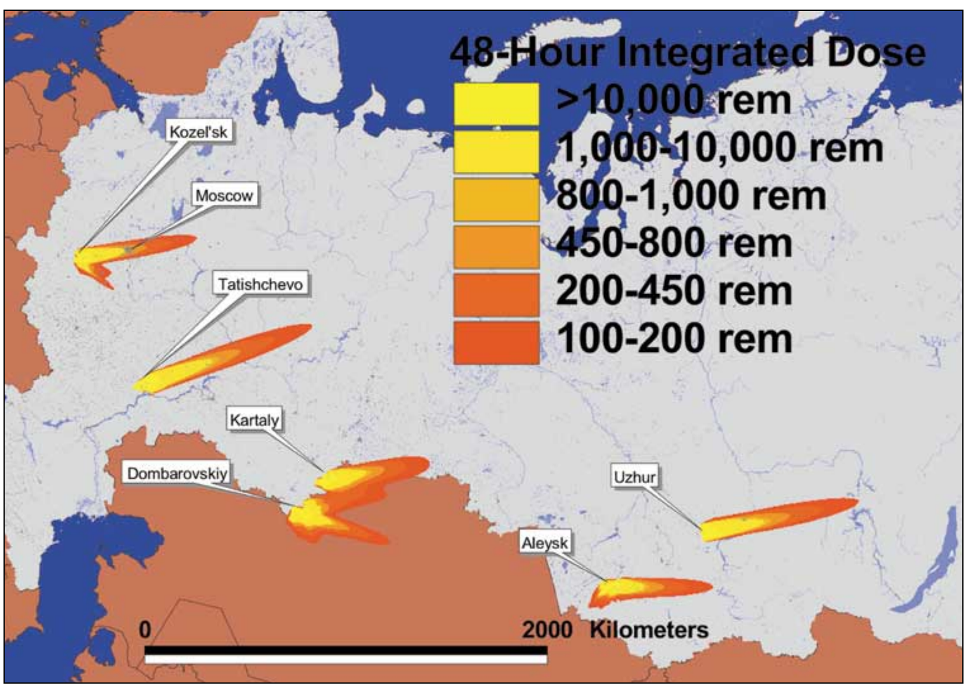
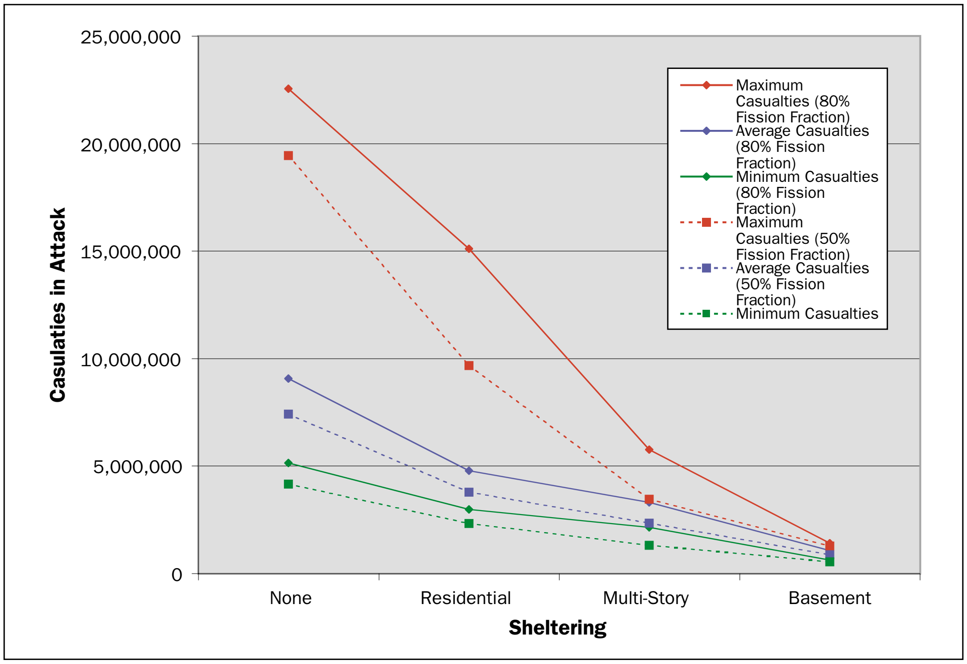


FIGURE 4.4
Fallout Patterns from an Attack on All Active Russian ICBM Silos
This calculation uses wind patterns typical for the month of June and assumes a weapon fission fraction of 50 percent. Radiation dose is integrated over the first two days after the attack for an unsheltered population. For these input parameters, total casualties are calculated to be 19.7 million, 16 million of which are calculated to be fatalities. Over 175,000 square kilometers would be contaminated by fallout to such an extent that unsheltered people would have a 50 percent chance of dying of radiation sickness.

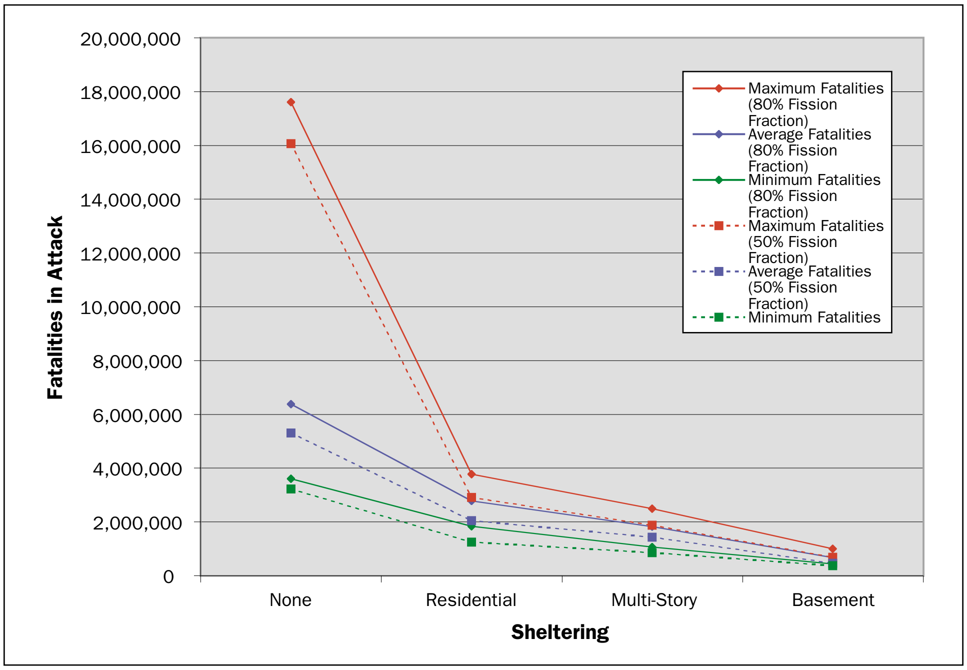
FIGURE 4.5
Summary Casualty Data for an Attack on Russian ICBM Silos
Maximum, mean, and minimum casualty figures are presented as a function of sheltering for assumed warhead fission fractions of 50 and 80 percent.



While we do not know the magnitude of these errors for U.S. nuclear weapons, it is unlikely that the PEH is appreciably less than 200 meters. In this case, ensuring high kill probabilities against silos would necessitate surface bursts.

Based upon the vulnerability analysis and the limited number of high-yield W87 and W88 warheads that are available, we assign two W87 (MX/Peacekeeper) warheads for each of the 150 SS-19 silos (assuming they are of type III-G MOD), two

FIGURE 4.6
Summary Fatality Data for an Attack on Russian ICBM Silos
Maximum, mean, and minimum fatality figures are presented as a function of sheltering for assumed warhead fission fractions of 50 and 80 percent.



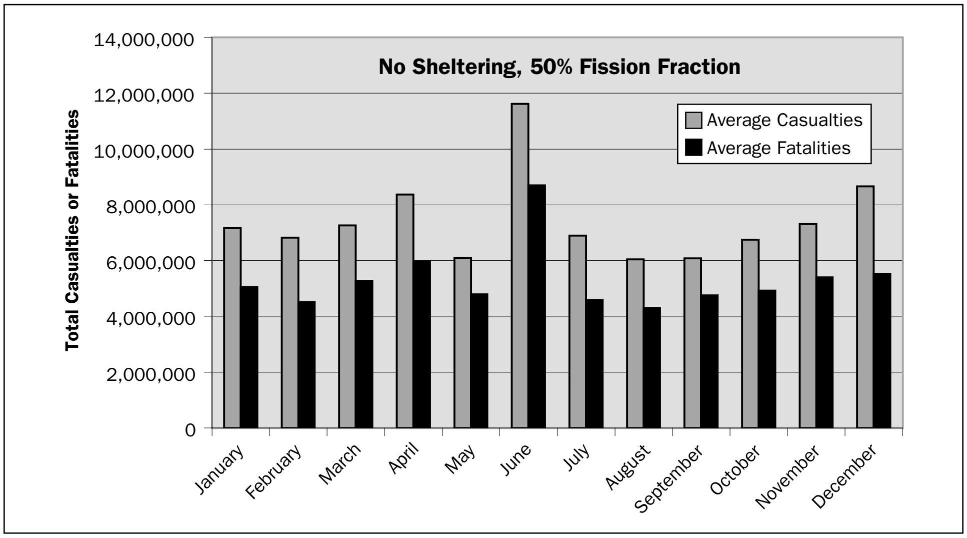


FIGURE 4.7
Monthly Variation of Fallout Casualties for an Attack on Russian ICBM Silos Assuming Weapon Fission Fractions of 50 Percent and No Sheltering
These variations are due to wind speed and direction. Casualties and fatalities have been averaged with respect to the angular resolution of the wind rose data (see Endnote 7).

W87 warheads for each of the ten SS-24 and 20 SS-27 silos (also assuming they are of type III-G MOD), and a mixture of W87 and W88 (Trident II) warheads for the 180 SS-18 silos (assuming they are of type III-F). Our attack on Russian silos uses a total of 500 W87 warheads (all that are available) and 220 W88 warheads (with a cumulative yield of 250,000 kilotons). We select ground bursts for all attacking warheads. Using this warhead allocation for these targets, we calculate that 93 percent of the SS-19, SS-24, and SS-27 silos would be severely damaged (167 out of 180 silos) and 94 percent of the SS-18 silos (169 out of 180 silos) would be severely damaged (see Table 4.2). Only 24 silos would not be severely damaged.

The attack uses 500 W87 warheads—equivalent to all MM III missiles converted to single-warhead missiles carrying the W87 with an improved accuracy of 91 meters. The attack also uses about one-half of the available W88 warheads—slightly more than the maximum number of warheads that could be deployed aboard one Trident

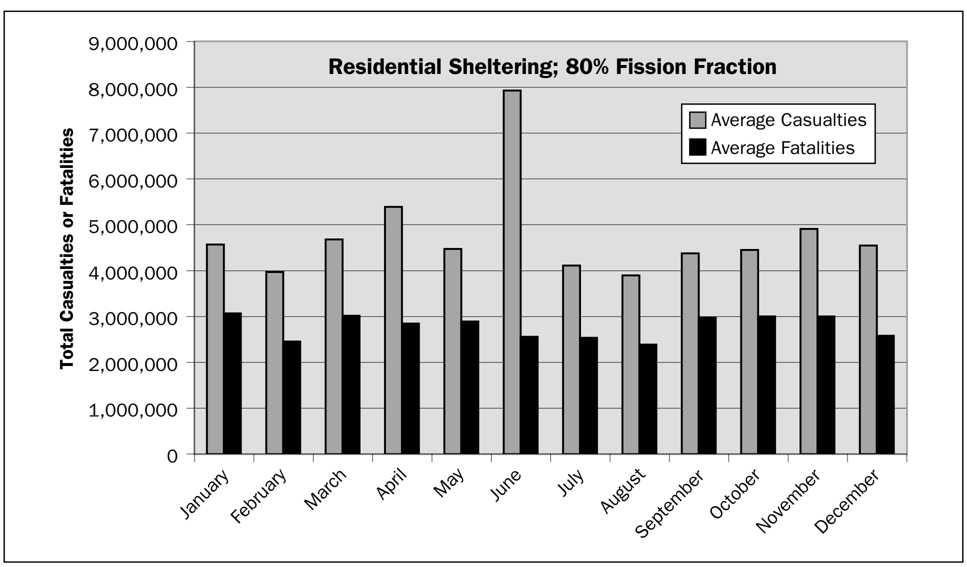
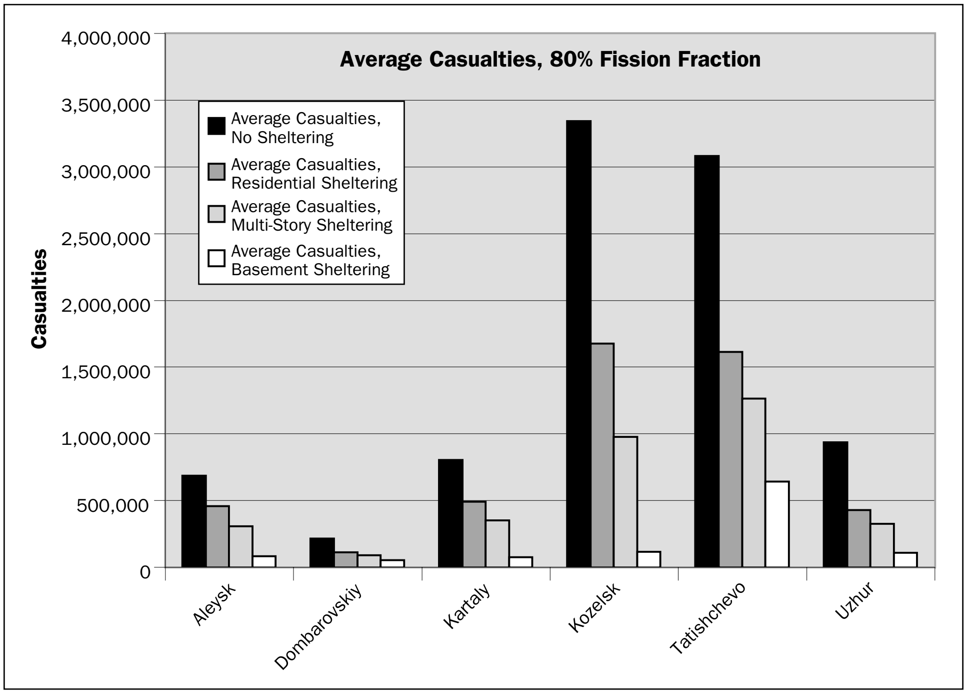


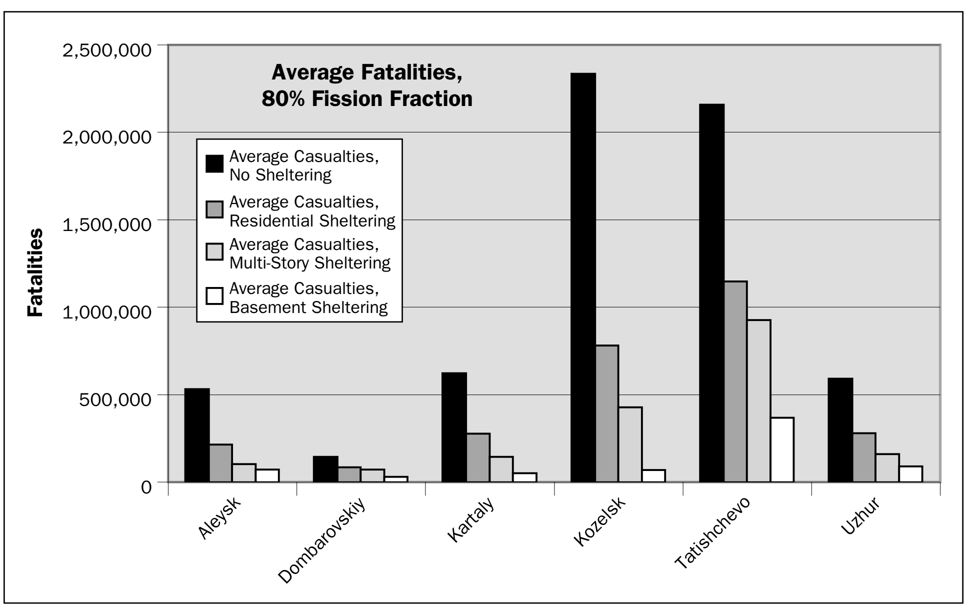
FIGURE 4.8
Monthly Variation of Fallout Casualties for an Attack on Russian ICBM Silos Assuming Weapon Fission Fractions of 80 Percent and Sheltering Typical of Residential Structures
These variations are due to wind speed and direction. Casualties and fatalities have been averaged with respect to the angular resolution of the wind rose data (see Endnote 7).

FIGURE 4.9
Casualties, as a Function of Missile Field and Sheltering
The cumulative yield detonated at each missile field is: Aleysk—28.5 Mt; Dombarovskiy—31.2 Mt; Kartaly—26.6 Mt; Kozelsk—36 Mt; Tatishchevo—72 Mt and Uzhur—49.4 Mt.



SSBN. If an additional 360 W78 warheads (each having a yield of 335 kt and an accuracy of 183 meters) are assigned one to each Russian silo target, the total number of severely damaged silos would only increase by seven. This fact illustrates another complication posed by super-hardened silos: achieving near-100 percent kill against many such targets is only possible by allocating a disproportionately greater number of attacking warheads. At this point of diminished returns, obtained by assigning more attacking warheads to achieve a higher kill probability, an alternative option would be to integrate missile defense capabilities with offensive forces. Finally, it

FIGURE 4.10
Fatalities, as a Function of Missile Field and Sheltering



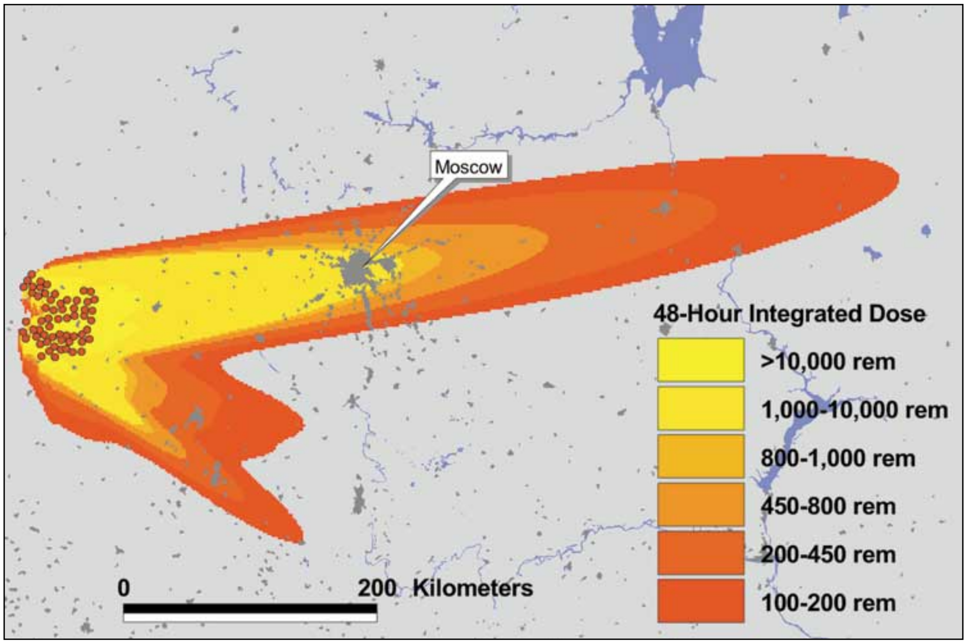


FIGURE 4.11
A Close-up of the Kozelsk Missile Field Fallout Pattern
Calculated for the month of June, with a weapon fission fraction of 80 percent. The calculated dose is to an unsheltered population. For these input parameters, total casualties are calculated to be 16.1 million, 13.3 million of which are fatalities.

should be noted that in NRDC's MAO-NF, we do not attack the 52 silo launch control centers, some or all of which are not co-located with missile silos.

Casualties and Sensitivity Analysis

As we will demonstrate, an attack on the silos represents a far greater threat to Russian civilians and to the environment than an attack on the other seven categories that make up Russia's nuclear forces. Figure 4.4 shows the fallout patterns that result from our MAO-NF attack on all active Russian silos, assuming the most

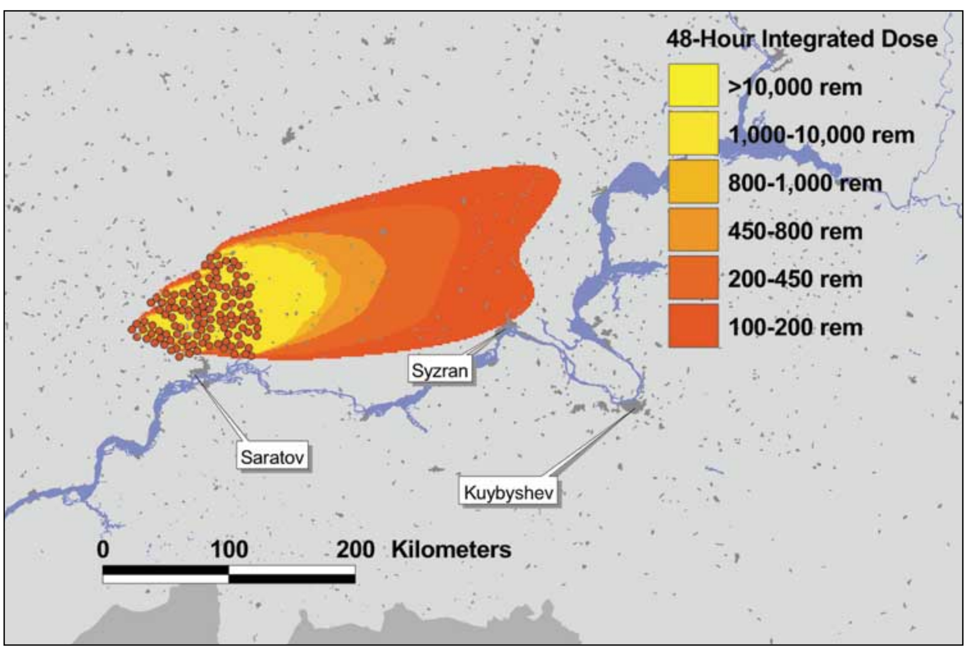
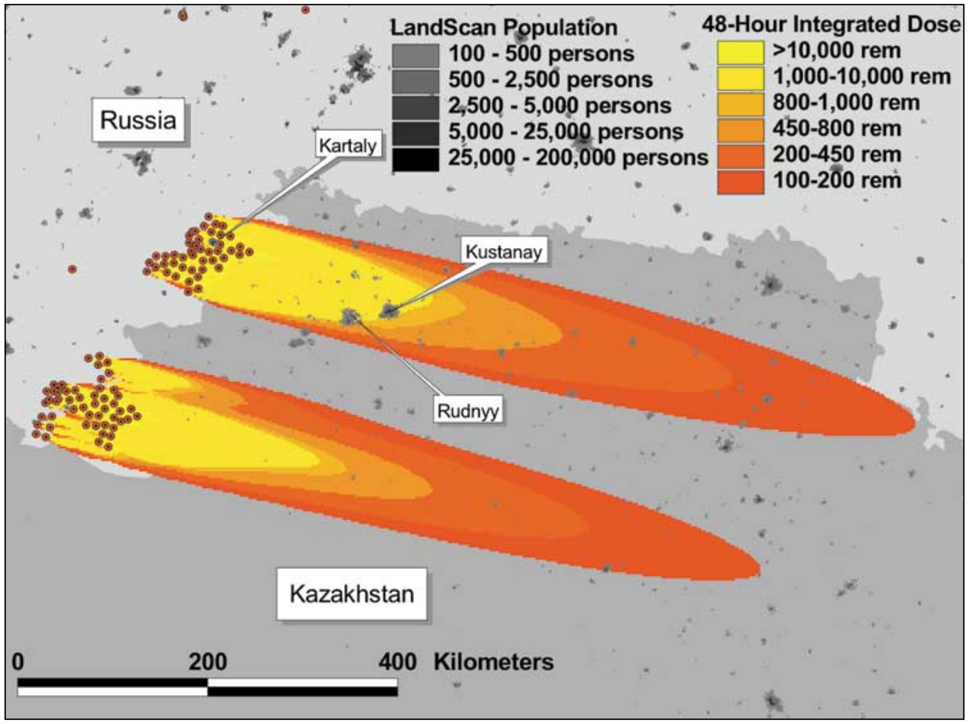


FIGURE 4.12
A Close-up of the Tatishchevo Missile Field Fallout Pattern
Calculated for the month of December and a fission fraction of 50 percent. The calculated dose is to a population sheltered in multi-storied structures. For these input parameters, total casualties are calculated to be 450,000, including 270,000 fatalities.

FIGURE 4.13
A Close-up of Fallout Impacting Kazakhstan
From the attack on the Dombarovskiy and Kartaly missile silos. In this calculation, wind patterns for the month of February and a fission fraction of 50 percent are used, and the calculated dose is to an unsheltered population. For these input parameters, total casualties are calculated to be 977,000, including 745,000 fatalities. The population density, shown in gray, has been overlaid on the fallout patterns. About 60,000 square kilometers in northern Kazakhstan would be contaminated by fallout to such a level that half of unsheltered persons would die as a result.



probable winds for the month of June, a 50 percent fission fraction for all weapons, and an unsheltered population. The vast swaths of fallout spread over 175,000 square kilometers and threaten approximately 20 million Russian civilians. It should be recalled that the purpose of the attack is to destroy 360 missile silos.

Our conclusions about casualties from fallout are affected by the variability of meteorological conditions, population sheltering, and the fission fraction of U.S. warheads. To assess these variations, we have run 288 possible attack scenarios for: the twelve months of the year,[8] three wind conditions,[9] four kinds of sheltering,[10] and two fission fraction percentages.[11] In sum, 288 calculations for each of 360 silos represents 100,800 individual silo fallout calculations. Figures 4.5 through 4.13 present a statistical picture of the Russian casualties and fatalities from the silo attack over this reasonable range of input parameters.

The number of casualties from fallout ranges from 4.1 million to 22.5 million persons assuming no sheltering occurs, and between 1.3 and 15.1 million if all affected people could stay inside residential or multi-story structures for at least two days after the attack (see Figure 4.5). Calculations using the assumption of no sheltering illustrate the total number of civilians at risk. Under the assumption of no sheltering, the number of fatalities from fallout ranges from 3.2 million to 17.6 million persons. If all affected persons could stay inside residential or multi-story structures for at least two days following the attack, that number fatalities drops to between 0.8 and 3.8 million (see Figure 4.6).

The large difference in the number of casualties for a given level of sheltering depends primarily upon the monthly variation in the wind direction and speed. Figure 4.7 displays this variation in casualties by month under the assumptions of a fission fraction of 50 percent and no population sheltering, and Figure 4.8 displays this variation in casualties by month under the assumption of a fission fraction of 80 percent and residential sheltering. We find the maximum number of casualties in the month of June (see Figures 4.7 and 4.8). During this month, the winds blow fallout from the Kozelsk missile field directly towards Moscow. In Figure 4.8, the number of fatalities for June is not appreciably larger than for other months because the assumption of residential sheltering restricts the lethal area to just outside Moscow.

Figures 4.9 and 4.10 show how the number of casualties and fatalities vary with the specific missile field attacked. While considerable seasonal variation exists, attacks against the two missile fields in European Russia (Kozelsk and Tatishchevo) result in larger numbers of casualties, by an order of magnitude, than against the missile fields in Siberia because of the greater population in the vicinity of the missile fields. Figures 4.11 and 4.12 provide close-ups of the fallout patterns over the Kozelsk missile field near Moscow and the Tatishchevo missile field on the Volga River, respectively. Figure 4.13 provides a close-up of the fallout patterns produced from the attack on the missile fields in Siberia, which is calculated to contaminate significant areas of Kazakhstan.

ROAD-MOBILE ICBMS

Description of Targets

The Russian road-mobile ICBM force currently consists of 360 single-warhead SS-25 missiles. Depending upon resources, an improved version of the missile, the Topol-M (SS-27) may replace some SS-25s. [12] The SS-25s are currently mounted on a seven-axle chassis of the MAZ cross-country vehicle. According to the Russian Government:

FIGURE 4.14
A Drawing of Deployed Russian SS-25 Launchers
Source: *Soviet Military Power.*[13]

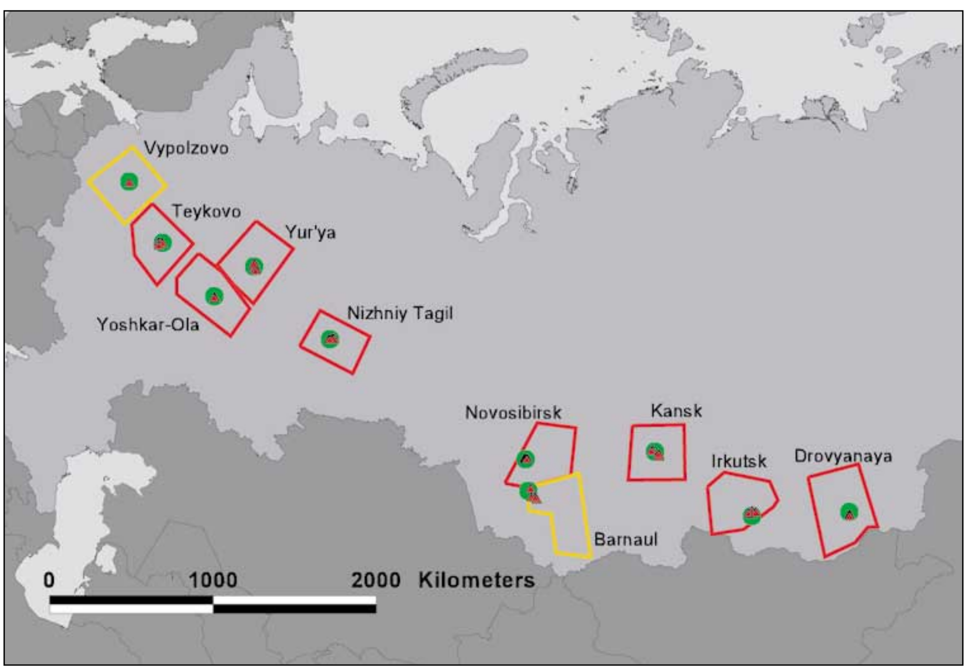
> *The road-mobile launcher can operate either autonomously or as part of the road-mobile missile complex. Special Krona shelters with hinged roofing are provided in permanent garrisons for missile launching from autonomous road-mobile launchers. The missile can also be launched from unprepared launching sites if the terrain relief allows.*[14]

Figure 4.14 is a depiction by the Pentagon of SS-25 transporter-erector-launcher (TEL) vehicles dispersing from their garrison in groups of three. Also shown are two communications vehicles (displaying long antennas) and another vehicle, probably a personnel carrier.

Whereas the SS-25 disperses to the field in groups of three, in garrison they are organized in groups of nine.[15] The Krona shelters at the garrisons have been described as having, "fixed concrete structure foundation[s]."[16] Some SS-25 bases are former SS-20 intermediate-range ballistic missile bases (the SS-20 was eliminated under the 1987 Intermediate-Range Nuclear Forces Treaty). The START I MOU refers to the garrisons as "restricted parking areas." The treaty provides the coordinates for 40 restricted parking areas associated with ten SS-25 bases: Barnaul,[17] Drovyanaya, Irkutsk, Kansk, Nizhniy Tagil, Novosibirsk, Teykovo, Vypolzovo, Yoskkar-Ola, and Yur'ya. The START I MOU also specifies large "deployment areas" associated with the ten bases, presumably roaming areas for the MAZ vehicles. The locations of the SS-25 bases, restricted parking areas (or garrisons), and deployment areas are shown in Figure 4.15.

Figure 4.16 indicates the locations of the Teykovo SS-25 garrisons and the main operating base superimposed on a map of the area. Note the rail spur terminating at the location of the base.[18] The Teykovo garrisons are separated by 15-25 kilometers. Figure 4.17 is a map of the Irkutsk SS-25 garrisons and the main operating base. Figure 4.18 is a recent Ikonos satellite image of two Yur'ya garrisons.

FIGURE 4.15
SS-25 Bases, Garrisons, and Deployment Areas
Bases (green circles), garrisons (red triangles), deployment areas (orange and red polygons). Base locations, garrison locations, and deployment areas shown in red are from the July 2000 START I MOU. Deployment areas shown in orange are notional.



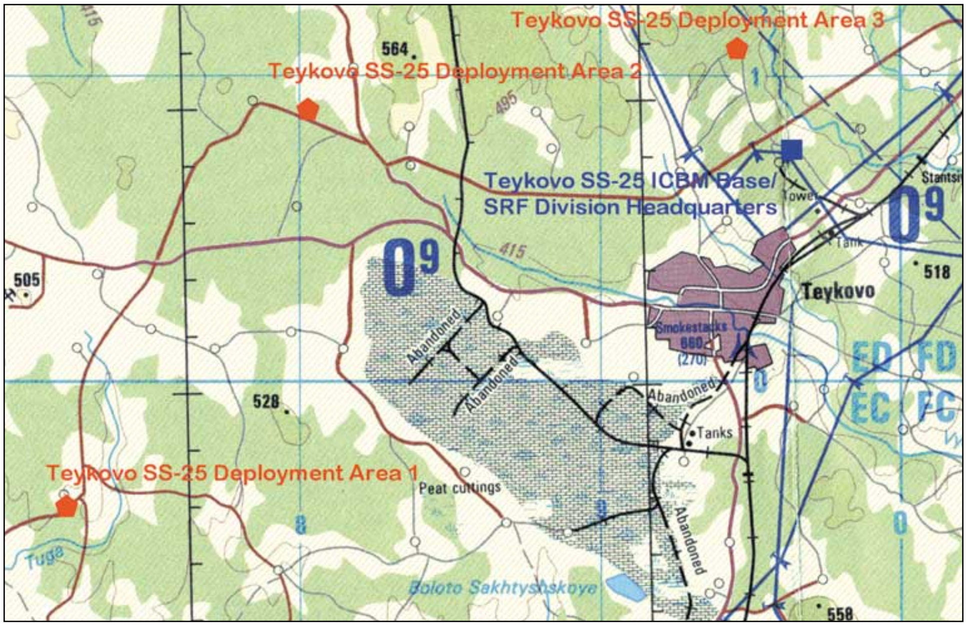


FIGURE 4.16
Teykovo SS-25 Garrisons and Main Operating Base
Source: U.S. JOG N037-12 (Series 1501 Air, Edition 3, "Map Information as of 1993").

Warhead Requirements and Aimpoints

In general there are five kinds of targets associated with Russia's road-mobile ICBMs:

- The hardened organizational and/or communications structures located at the ten regimental bases
- The 360 Krona shelters in the 40 garrisons near the associated bases
- Any of the 120 groups of three MAZ ICBM launcher vehicles that may disperse during a crisis
- Any dispersal (secondary) bases within the deployment areas

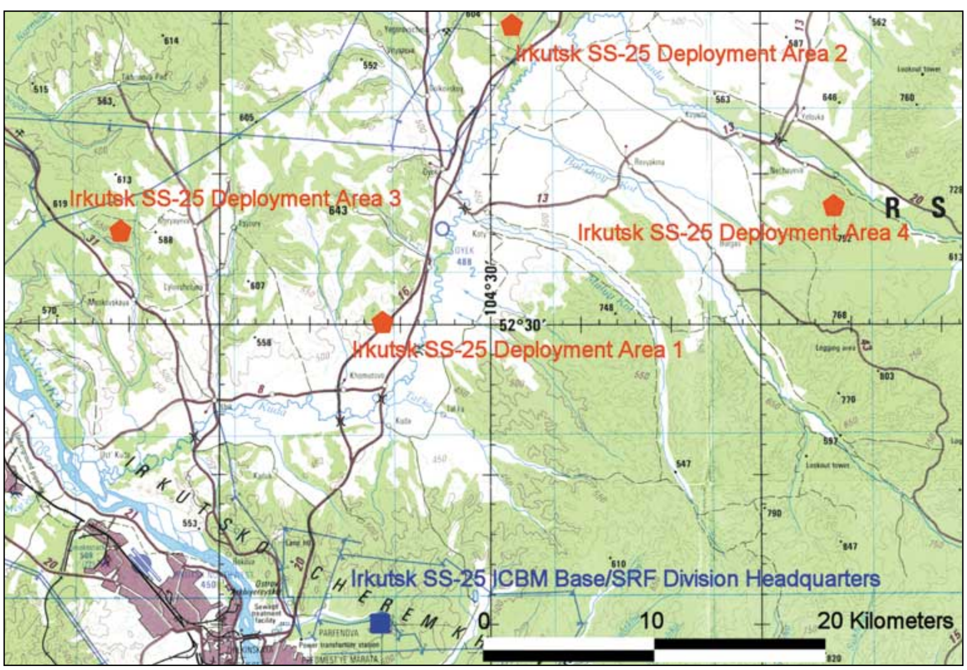


FIGURE 4. 17
Irkutsk SS-25 Garrisons and Main Operating Base
Source: U.S. JOG NN48-11, Series 1501, Edition 2, "Compiled in 1984."

▶ Any air defense sites intended to protect dispersed MAZ launcher vehicles or the garrisons from U.S. bomber/cruise missile attacks

Targeting dispersed SS-25s is difficult. The 1988 edition of the U.S. Defense Department's *Soviet Military Power* refers to the SS-25 as "inherently survivable," its very purpose from the Soviet point of view. Allocating warheads to dispersed SS-25s depends upon the capability to locate them. Increasing the chances depends upon several factors. First, intelligence about past dispersals during training exercises may reveal preferred routes, refueling points, and backup bases. In a crisis, military commanders would probably be reluctant to disperse the SS-25s in alternate ways. Second, there may be some U.S. capability to monitor the locations of the MAZ vehicles in real time. A group of three large SS-25 transporter-erector-launchers, and their support vehicles, would be obvious in high-resolution satellite imagery or aerial photography. Third, monitoring communications between SS-25s in the field and command centers may reveal their locations.

The 1969 Defense Intelligence Agency *Physical Vulnerability Handbook—Nuclear Weapons* assigns a vulnerability number of 11Q9 to road-mobile missiles with ranges of 700, 1,100, and 2,000 nautical miles or with intercontinental ranges.[19] The damage level for this vulnerability number is defined as "transporter overturned and missile crushed." [20] The kill mechanism has been likened to flipping a turtle on its back. For a 100-kt weapon, the optimum height of burst to attack a target with a vulnerability number of 11Q9 is approximately 1,250 m (no local fallout would be expected), and the corresponding damage radius is 2,875 m. Thus dispersed SS-25 vehicles can be threatened over an area of approximately 26 square kilometers by a single W76 air burst. If, for example, a MAZ vehicle is traveling at 20 kilometers per hour, then one W76 explosion must occur within about 15 minutes of noting the location of the moving vehicle. While this time interval is roughly consistent with depressed-trajectory launches of SLBMs, it would require additional time to communicate the SS-25 locations to the SSBNs and retarget the missiles. The fact that Trident I or Trident II SLBMs are MIRVed, with up to eight warheads per missile, means that a group of moving SS-25 launcher vehicles could also be pattern-attacked with W76 warheads over an area of some 200 square kilometers.

Alternatively, field-dispersed SS-25 vehicles may be sought out and destroyed by long-range

FIGURE 4.18
Ikonos Satellite Image of Two SS-25 Garrisons at Yur'ya
The garrisons are the square, fenced structures in upper and lower left. The resolution in this image—taken March 24, 2000—is approximately 16 meters. Source: spaceimaging.com.

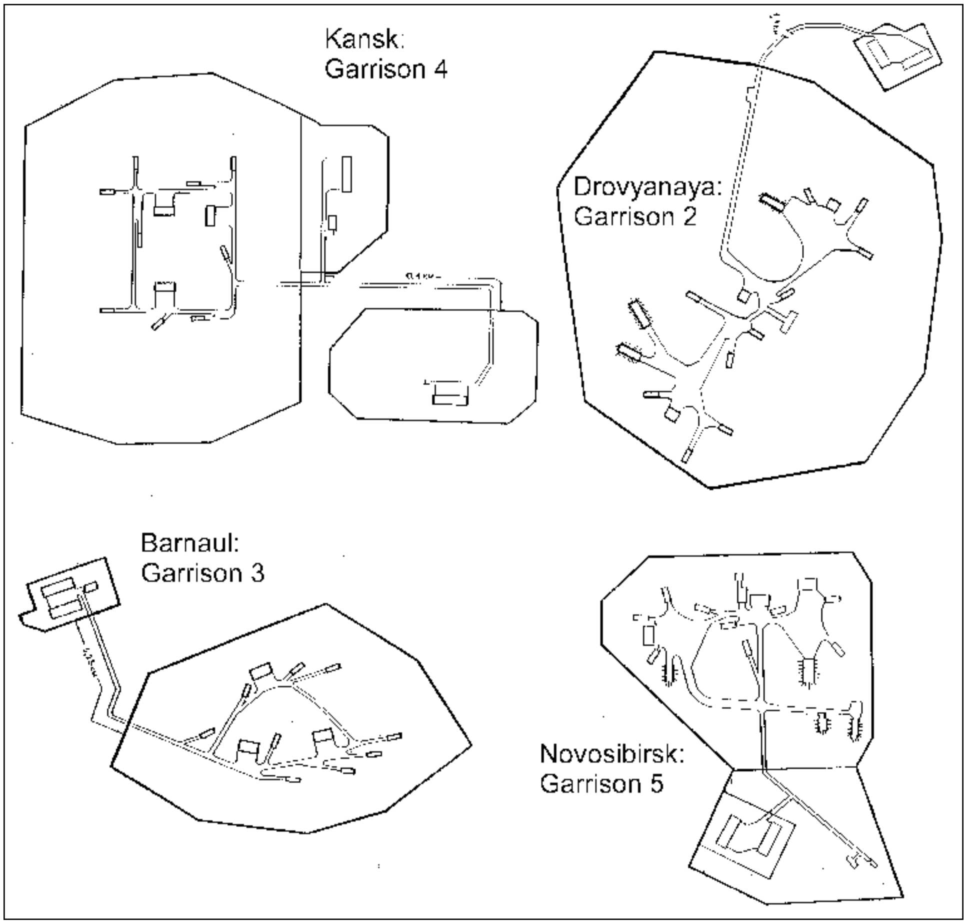


FIGURE 4.19
Diagrams of SS-25 Road-Mobile Garrisons
Source: INF Treaty data declaration. Drawings are reproduced to the same scale, 1:17,500.

strategic bombers, like the B-2. Given that the SS-25 ICBM carries only one warhead of probably limited accuracy, it is reasonable to expect that Russian planners treat it as a countervalue weapon. A recently declassified CIA document lists it as such.[21] If SS-25's are part of Russia's strategic reserve, intended to be held back to deter or carry out subsequent nuclear attacks, then it is likely that Russia would take a great effort to conceal at least a portion of them from U.S. strategic bombers on search-and-destroy missions.

The START I MOU data exchange provides information about the 40 SS-25 garrisons. The areas of the garrisons range from 0.1 km^2 to 0.45 km^2, with an average area of 0.275 km^2. The earlier INF data exchange contained diagrams of SS-20 garrisons at the Kansk, Barnaul, Novosibirsk, and Drovyanaya operating bases. In these diagrams—a sample of which is displayed in Figure 4.19—the Krona shelters are shown as rectangles, approximately 30 by 10 meters in size.

We do not have the specific vulnerability numbers (VN) associated with the individual SS-25 Krona shelters.[22] Therefore, we assume that the Krona shelters are either "aboveground, flat or gable roof, light-steel-framed" structures, where the VN for severe/moderate damage are given as 13Q7/11Q7, or "aboveground, arch, earth-mounded, drive-in" shelters, where the VN for severe/moderate damage are given as 26P3/25P1.[23] The vulnerability for the first of these two structure types (light-steel-framed) is given in terms of the dynamic pressure, which relates to the

TABLE 4.3
Attacking Two Types of SS-25 Garrison Structures

Structure Type	Attacking Warhead Yield (kt)	Optimum Height of Burst (m)	Damage Radius (m)	Mean Area of Effectiveness (km^2)
Steel-framed	100	1,000	1,990	12.4
Earth-mounded	100	0	503	0.79
Steel-framed	300	1,600	3,121	30.6
Earth-mounded	300	0-200	745	1.7
Steel-framed	475	1,900	3,750	44.2
Earth-mounded	475	0-300	876	2.4

wind velocity produced in the explosion.[24] The vulnerability number given for the earth-mounded structure implies a high damage threshold with respect to peak blast overpressure.[25]

Table 4.3 shows the optimum height of burst, damage radii, and mean area of effectiveness (i.e., π multiplied by the damage radius squared) for two types of structures—steel-framed and earth-mounded—when attacked by W76 (100 kt), W87 (300 kt) or W88 (475 kt) warheads. Note the mean area of effectiveness of the lowest-yield warhead (the W76) against the harder structure type (earth-mounded) is about twice the area of any SS-25 garrison. For the more vulnerable, steel-framed structure, any of the three warhead types are capable of destroying all of the Krona shelters in a garrison, but the damage radii are less than one-fifth the separation distance between any of the SS-25 garrisons associated with a main base. Therefore, even if 300-kt or 475-kt warheads are used, one warhead would have to be allocated per

Table 4.4
Probabilities of Achieving Severe and Moderate Damage as a Function of the Separation Between the Explosion and the Target for the Earth-Mounded Structure Type Associated with SS-25 Garrisons
For the W76 ground bursts, two values of the CEP are given, corresponding to Trident I (183 meters) and Trident II (130 meters).

Distance from Ground Zero to Target (m)	C.E.P. (m)	Probability of Achieving Severe Damage for a VN of 26P3: earth-mounded structures)	Probability of Achieving Moderate Damage (for a VN of 25P1: earth-mounded structures)
0	130	0.996	0.997
0	183	0.979	0.985
100	130	0.990	0.993
100	183	0.966	0.973
200	130	0.957	0.969
200	183	0.914	0.931
300	130	0.865	0.891
300	183	0.805	0.835
400	130	0.676	0.725
400	183	0.631	0.675

garrison. One important difference between the two bounding vulnerability assumptions is that if the Krona shelters are steel-framed, the attacking warhead would be detonated at an optimum height of burst that would preclude local fallout.[26]

Table 4.4 lists the probability of achieving severe damage by a W76 ground burst to an earth-mounded Krona shelter as a function of the separation between the explosion and the shelter. These calculations reveal that even if the Krona shelters have been hardened to this level, two W76 ground bursts near the center of the garrison would be sufficient to destroy the Krona shelters with a high probability, as they are arrayed within several hundred meters of the garrison center. The assumption that the Krona shelters are earth-mounded necessitates ground bursts for attacking W76 warheads.

Given this vulnerability analysis, we choose for MAO-NF an SLBM attack using 100-kt W76 warheads, limited to the road-mobile SS-25's operating base and garrison targets. We assign two W76 ground bursts to each of the ten SS-25 operating bases and 40 garrisons.[27] In all, we use 100 W76 warheads with a cumulative yield of ten megatons. We do not target dispersed road-mobile launchers in our MAO-NF because our current scenario is limited to U.S. launch-ready weapons (which today excludes the U.S. strategic bomber force), and because targeting dispersed SS-25's with ICBM or SLBM warheads appears problematic.

Casualties and Sensitivity Analysis

Our quantitative assessments about damage and casualties are affected by the variability of meteorological conditions, and our assumptions regarding population sheltering, and the fission fraction of U.S. warheads. To assess these meteorological variations and uncertainties we have performed 288 calculations for each of the

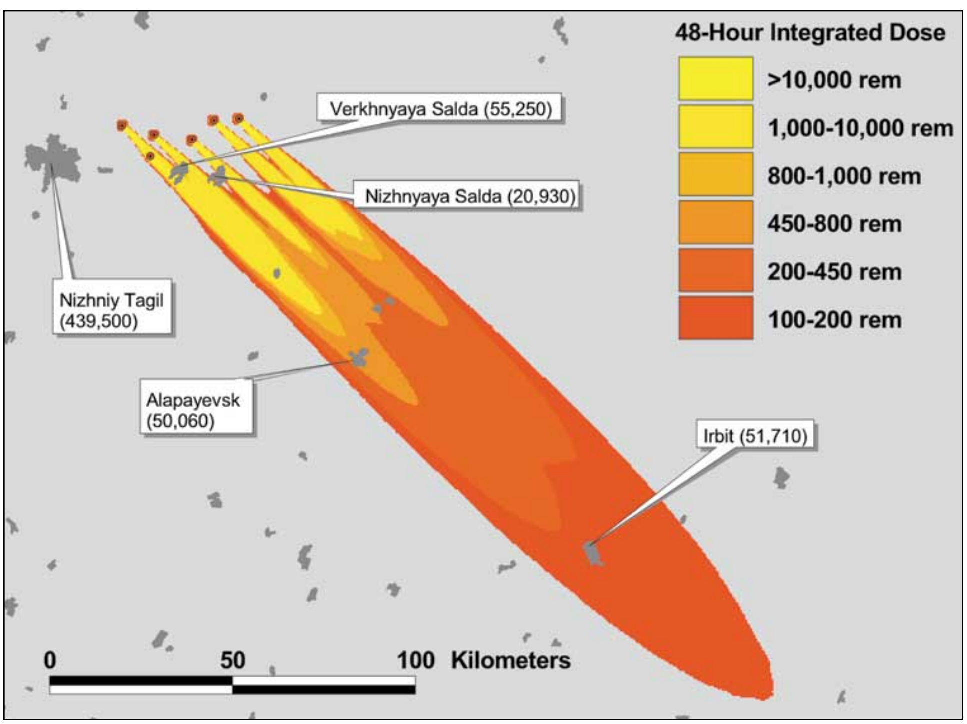
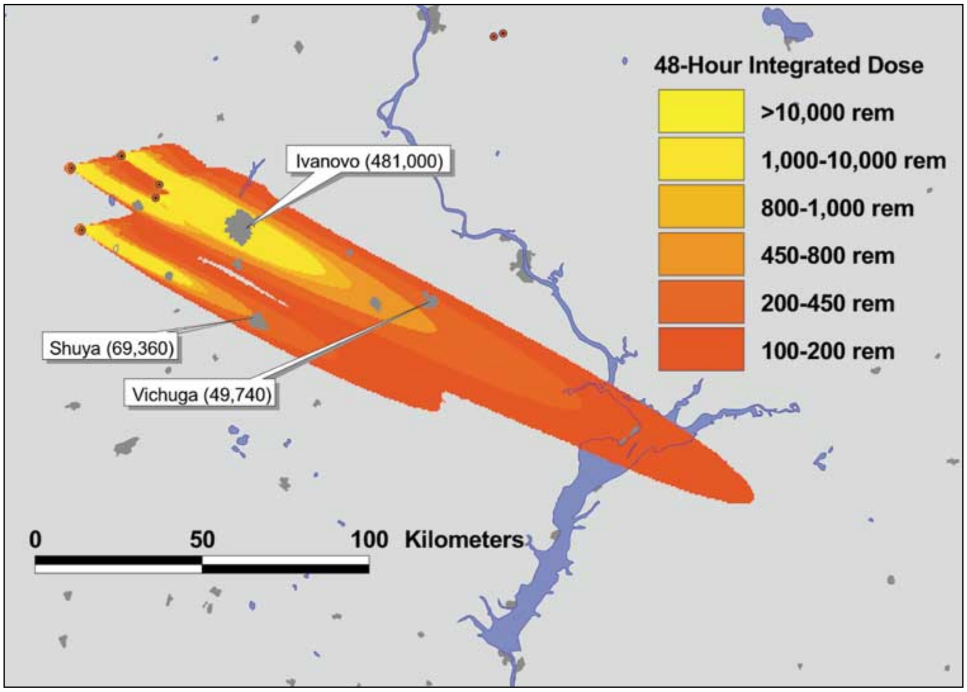


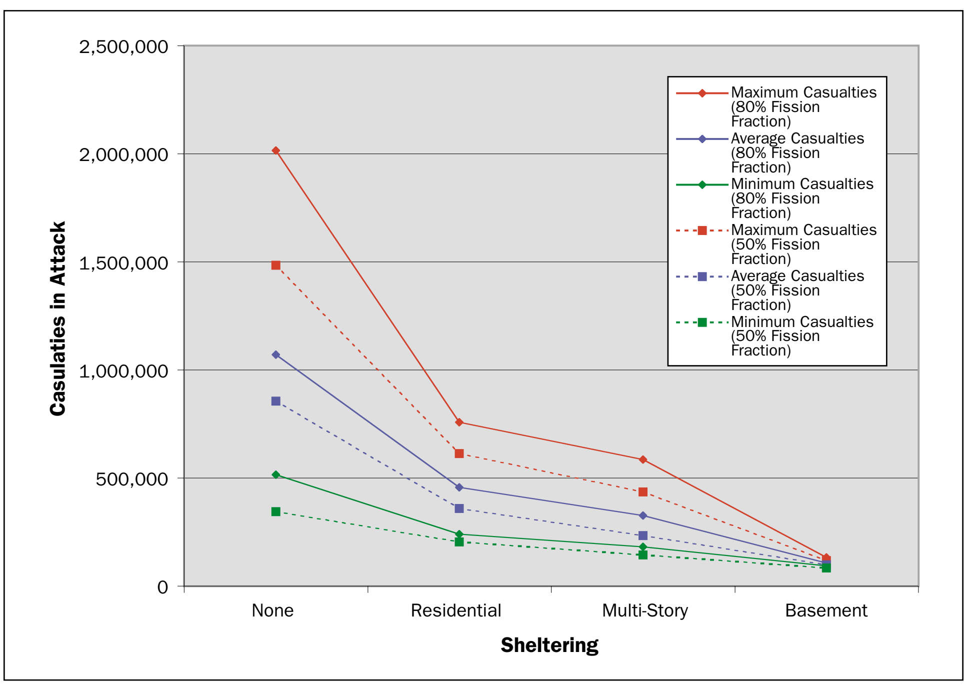
FIGURE 4.20
Twelve-Warhead Attack on the Nizhniy Tagil SS-25 Garrisons and Base
For the month of November, assuming an unsheltered population and a warhead fission fraction of 80 percent. The total number of casualties is computed to be 162,000, 132,000 of which are fatalities.

FIGURE 4.21
Twelve-Warhead Attack on the Teykovo SS-25 Garrisons and Base
For the month of December, assuming an unsheltered population and a warhead fission fraction of 80 percent. The total number of casualties is computed to be 804,000, 613,000 of which are fatalities.



SS-25 bases and garrisons.[28] The number of casualties depends upon the proximity of the targets to major urban areas. To illustrate the variation, we compare an attack using W76 warheads on the Nizhniy Tagil SS-25 site and on the Teykovo SS-25 site. Figure 4.20 shows the effects of twelve surface bursts on the SS-25 Nizhniy Tagil garrisons and base. The Russian city of Nizhniy Tagil (1989 population 439,500) is located only 22 kilometers from the nearest SS-25 garrison, yet the most probable

FIGURE 4.22
Summary Casualty Data for an Attack on Russian SS-25 Garrisons and Bases
Casualties are plotted as a function of population sheltering and warhead fission fraction. Variations in the number of casualties for a given warhead fission fraction and population sheltering reflect seasonal variations in the most probable wind speeds and directions.



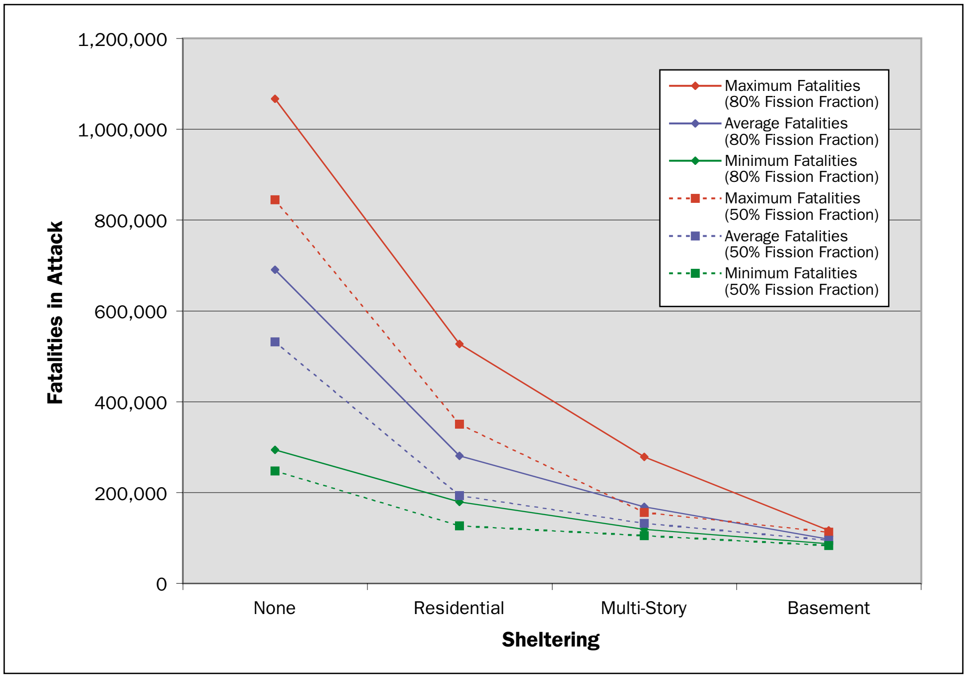


FIGURE 4.23
Summary Fatality Data for an Attack on Russian SS-25 Garrisons and Bases
Fatalities are plotted as a function of population sheltering and warhead fission fraction. Variations in the number of fatalities for a given warhead fission fraction and population sheltering reflect seasonal variations in the most probable wind speeds and directions.

wind patterns for all months of the year blow the fallout away from the city. Nevertheless several smaller cities lie in the path of the descending fallout and the computed casualties for an unsheltered population (and assuming a fission fraction of 50 percent) vary from 47,000 to 171,000 people, with fatalities ranging from 45,000 to 113,000 depending on the month. If in the unlikely event the fallout blew over the city of Nizhniy Tagil, the number of casualties would be four to six times higher. By contrast, as shown in Figure 4.21, the fallout from a W76 attack against the Teykovo SS-25 base/garrison creates lethal conditions within the city of Ivanovo (1989 population 481,000) itself, causing many more casualties.

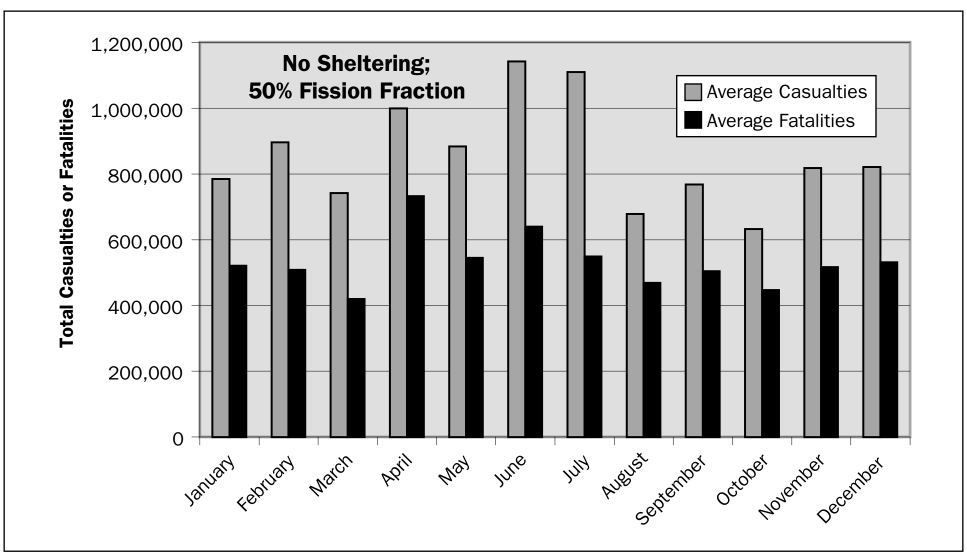
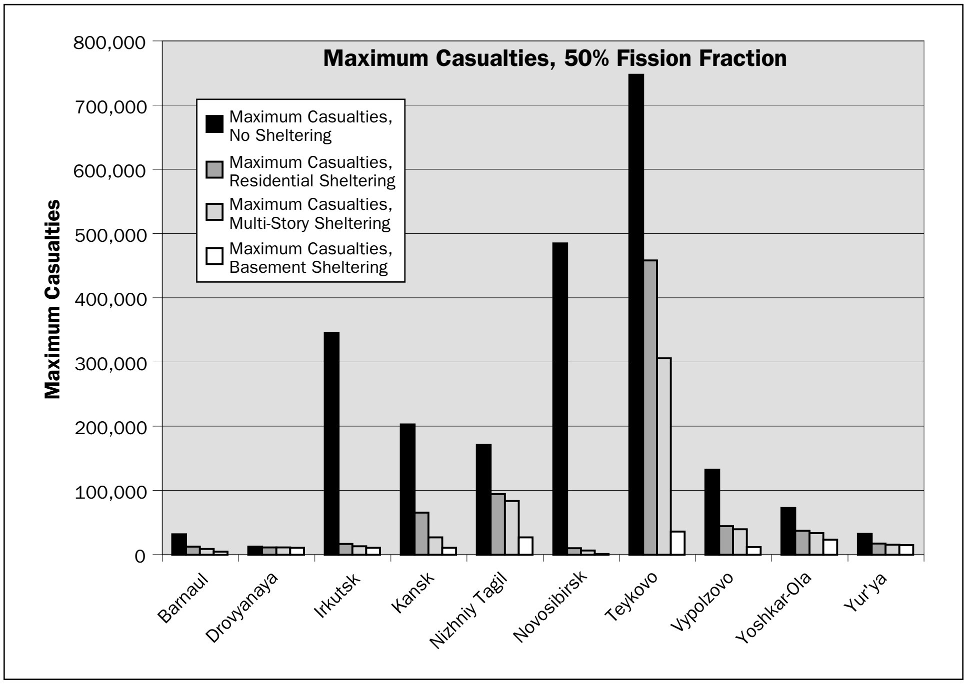


FIGURE 4.24
Casualties as a Function of the Month of the Year for an Attack on Russian SS-25 Garrisons and Bases
These variations are due to wind speed and direction. Casualties and fatalities have been averaged with respect to the angular resolution of the wind rose data (see Endnote 7).

FIGURE 4.25
Maximum Casualties Associated with Each Road-Mobile Garrison/Base Complex
As a function of population sheltering for a warhead fission fraction of 50 percent.



Figures 4.22 and 4.23 show the range of casualties and fatalities due to seasonal variations in wind speed and direction as a function of population sheltering and warhead fission fraction for the full attack of 100 W76 warheads against the 50 SS-25 targets. The figures show that total casualties or fatalities depend more on the population sheltering than on the warhead fission fraction, but both parameters are significant. The total number of casualties ranges from 344,000 to 2 million persons assuming no sheltering occurs, and between 142,000 and 757,000 if all affected persons could stay inside residential or multi-story structures for at least two days following the attack. Under the assumption of no sheltering, the number of fatalities from fallout ranges from 244,000 to just over one million persons. If all affected people could stay inside residential or multi-story structures for at least two days following the attack, that number of fatalities drops to between 105,000 and 527,000.

Figure 4.24 shows how monthly variation in wind patterns influences the number of casualties. Figure 4.25 displays maximum casualties for individual base/garrison complexes for the four values of sheltering factors used in these calculations. For most of the SS-25 base/garrison complexes, notably Irkutsk and Novosibirsk, even sheltering in residential structures for the first two days following the attack would drastically reduce the computed number of casualties from the fallout.

RAIL-MOBILE ICBMS

Description of Targets

Each of Russia's 36 rail-mobile SS-24 ICBMs carries ten 550-kt warheads, for a total of 360 high-yield warheads. According to the Russian government these weapons are part of:

FIGURE 4.26
A Drawing of an SS-24 Train and Missile
Source: *Soviet Military Power.*[29]

> *A sophisticated complex, which carries the missile, technological equipment, special-purpose systems, the attending personnel, as well as the command and control equipment. . . . A rail-mobile missile regiment incorporates a train with three rail-mobile launchers carrying the RS-22V [i.e., SS-24] missiles, a command post, railway cars with auxiliary and personnel life support systems.*[30]

The rail-mobile ICBMs either remain stationed at a permanent location (see Figure 4.26) or move over the railway tracks. The missile can be launched from any point.

According to the July 2000, START I MOU data exchange between the U.S. and Russia, there are 36 deployed SS-24 ICBMs presumably on 12 trains at three bases:

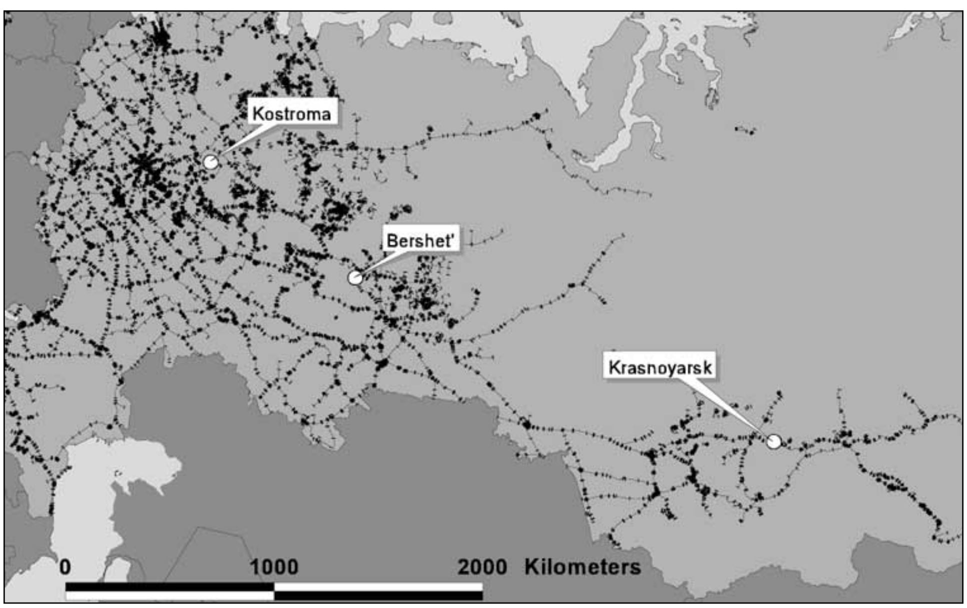
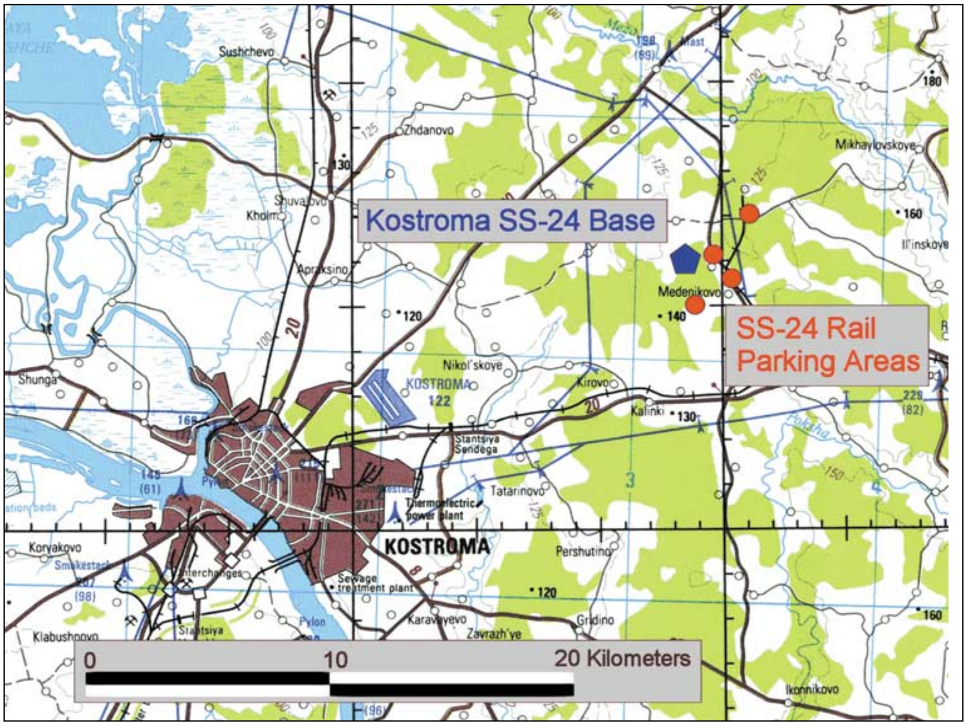


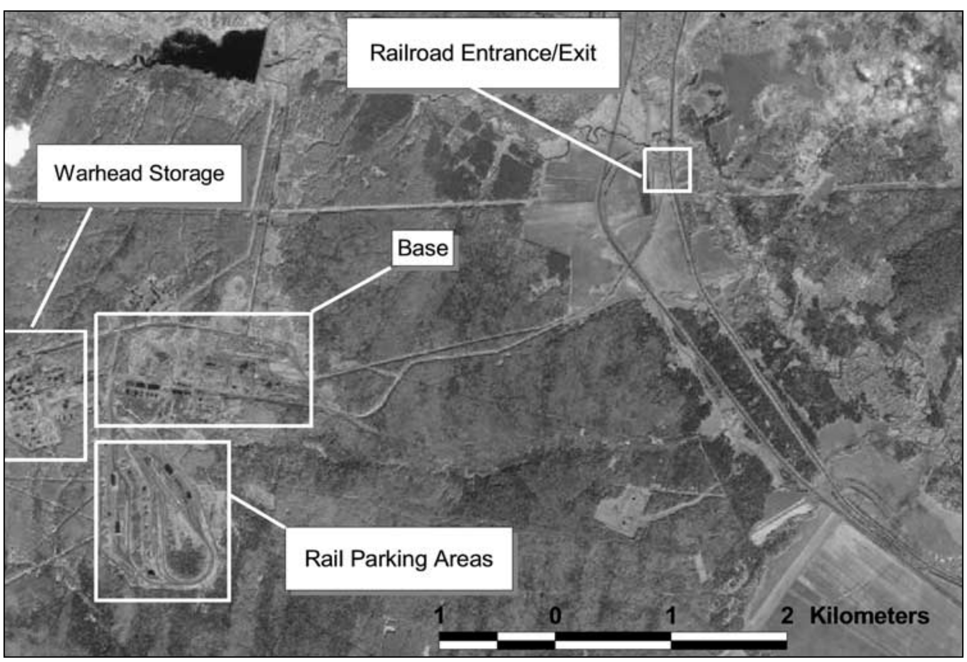
FIGURE 4.27
Russia's Railroad Network and the Three SS-24 Rail-Mobile ICBM Bases

FIGURE 4.28
Kostroma Rail-Mobile ICBM Base
In 1989, the city of Kostroma had a population of 278,400. Source: U.S. JOG NO 37-9, Series 1501, Edition 2, "Compiled in 1982."



Bershet', Kostroma, and Krasnoyarsk. Figure 4.27 shows the locations of the three bases overlaid onto the Russian rail network. The START data gives coordinates for four rail parking areas and one railroad exit/entrance point associated with each of the three SS-24 bases. Figure 4.28 displays the START data for the Kostroma SS-24 base superimposed on a U.S. JOG. The base is located along a rail spur close to what is a major city in European Russia.

FIGURE 4.29
An Ikonos Satellite Image of the Bershet' Rail-Mobile ICBM Base
This image was taken on July 22, 2000: 16-meter resolution shown). Source: spaceimaging.com.



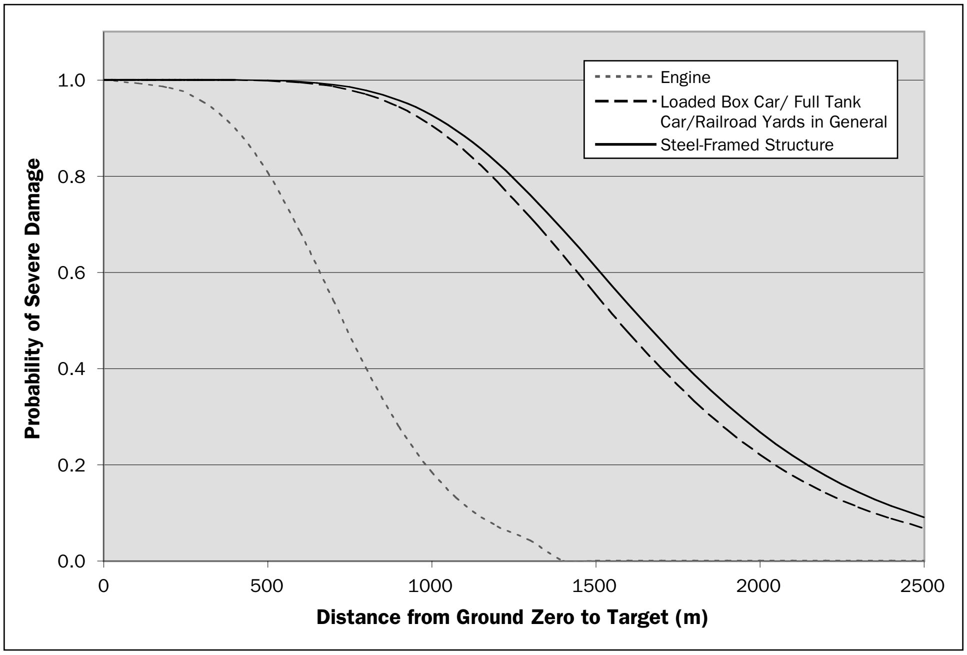


FIGURE 4.30
Probability of Severe Damage to Light Steel-Framed Structures, Loaded Box Cars/Full Tank Cars, and Engines
As a function of distance between ground zero and target. For this calculation we use the vulnerability numbers given in Table 4.5, and use a yield of 100 kt, a HOB of 500 meters and a C.E.P. of 184 meters.

Figure 4.29 is an Ikonos satellite image (16-meter resolution) displaying the Bershet' SS-24 base. The superimposed white rectangles are from the START MOU. The fact that the rail parking areas are several hundred meters south of the declared START locations reflects the imprecision of the START MOU coordinate data—where latitude and longitude are given to the nearest minute.[31]

Warhead Requirements and Aimpoints

The rail-mobile SS-24 poses a similar targeting problem to the road-mobile SS-25. The SS-24s can be launched whether at their bases or at any point on Russia's rail

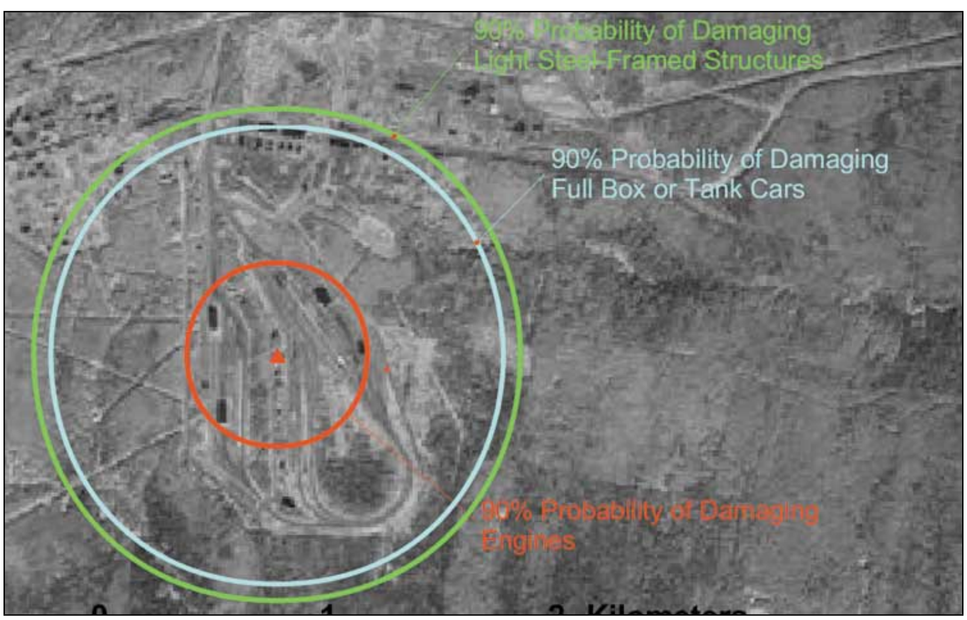


FIGURE 4.31
Damage Probability Contours for the Specified Target Types at the Bershet' Rail-Mobile SS-24 Base
Source: spaceimaging.com.

lines. There may also be dispersed parking sites for SS-24 trains when they are not at the main base. Table 4.5 lists vulnerability numbers associated with rail systems. The NTDI Handbook lists the SS-X-24 ICBM as a type of missile system in the category of surface-to-surface missile sites. The NTDI Handbook also lists a light-steel-framed structure as one of the missile-ready structures for this target category, and this structure type is apparently that shown in Figure 4.26. Note that the dynamic pressure required to damage locomotives is substantially greater than for other rail components, and according to the NTDI Handbook it is necessary to crater railroad tracks in order to damage them.

Figure 4.30 plots the probability of achieving severe damage to three of the items in Table 4.5 as a function of distance between ground zero and target for a 100-kt air burst at 500 meters HOB. Figure 4.31 shows the distance at which 90 percent probability of severe damage is achieved to these rail components superimposed on a close-up of the Ikonos image of the SS-24 base at Bershet'. It is clear that one W76 air burst is sufficient to damage the trains, cars, and associated

TABLE 4.5
Nuclear Weapons Vulnerability Data for Rail Systems
Source for the Vulnerability Numbers: *NATO Target Data Inventory Handbook* (1989).

Item	Vulnerability Number	Dynamic Pressure (psi) for 100 kt Air Burst (HOB=500m)	Damage Radius (m) for 100 kt Air Burst (HOB=500 m)	Damage
Railroad yards in general	13Q5	2.5	1,723	Severe damage to the installation consisting of grave damage to rolling stock requiring essentially complete replacement and severe damage to most types of contents, and associated damage generally as follows: severe track blockage; severe structural damage to single-story transit sheds and maintenance shops; overturning of control and switch towers; light damage to locomotive tenders; and moderate to severe damage to electric power facilities and other aboveground utilities.
Aboveground, flat or gable roof, light-steel-framed [structure type]	13Q7	2.2	1,806	Severe damage: failure of one or more structural elements (roof, wall, or closure) enclosing protected spaces that house missiles, equipment, and/or personnel and causing damage to contents by crushing, translation impact due to overpressure, or impact by collapse of a structural element and associated damage generally as follows: physical damage to associated equipment located at the launch site to such extent that the items are rendered inoperative and require major repair.
Loaded box cars	13Q5	2.5	1,723	Severe damage requiring replacement with possible exception of the trucks. Contents damaged beyond salvage point except heavy iron casings or the like.
Full tank cars	13Q5	2.5	1,723	Distortion or rupture of tank shell requires major repair or replacement. Tracks may escape serious damage. Loss of contents by leakage or by fire.
Locomotives	21Q5	47.0	807	Forcefully derailed or overturned.
Roadbed and tracks	45Z0	[Crater]	*	Disruption of rail lines by cratering the roadbed, and dislodging and twisting of tracks.

TABLE 4.6
Calculated Casualties and Fatalities from Five 100-kt Air Bursts over Russia's SS-24 Bases
The LandScan population figures are probably indicative of the average density in the vicinity of the bases. The OTA algorithm was used.

SS-24 Base	Casualties	Fatalities
Kostroma (two W76 warheads)	1,219	265
Bershet' (one W76 warhead)	1,042	249
Karsnoyarsk (two W76 warheads)	1,452	784

structures at this base. Using the separation between rail parking spaces given in the START MOU for the other two SS-24 bases, we estimate that in total five W76 warheads would be sufficient to cause severe damage to rail components at all three SS-25 bases.

Casualties and Sensitivity Analysis

At 500 meters height of burst, no local fallout is predicted. Therefore in terms of attacking the rail-mobile SS-24 bases, the calculated casualties are limited essentially to the base personnel, and include 3,700 casualties and 1,300 fatalities (see Table 4.6).

SSBN BASES AND FACILITIES

Description of Targets

In May of 2000, Admiral Vladimir Kuroedov, Commander-in-Chief of the Russian Navy, said the Russian Navy consisted of:

> *Regionally dislocated strategic groups of the North, Pacific, Baltic and Black Sea Fleets, and also the Caspian Flotilla. The regional dislocation of the Russian Navy requires the support and development of their independent structures, ship-building and ship repair industries. . . . The base of the North and Pacific Fleets is missile strategic and multi-purpose submarines, aircraft-carriers, landing vehicles, naval missile and anti-submarine Air Force. The base of the Baltic, Black Sea and Caspian Fleets is multi-purpose men-of-war, trawlers, diesel submarines, coastal missile and artillery forces and battle Air Force. The special geographical location of some Russian regions requires the presence of ground and anti-aircraft forces within the structure of the Navy.*[32]

The Northern Fleet has responsibility for wartime operations in the Atlantic and Arctic regions as well as for peacetime operations in the Mediterranean.[33]

During the Cold War, the Soviet naval strategy served multiple objectives, including

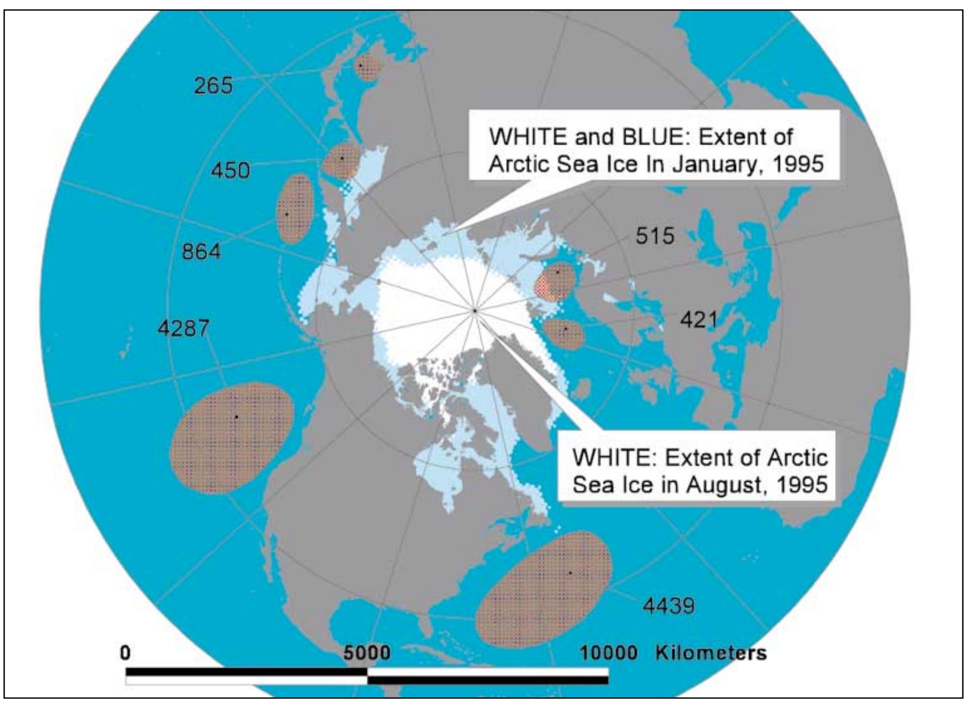
- Deterring nuclear attack by the United States with strategic weapons, such as submarine-launched ballistic missiles (SLBMs) on nuclear-powered ballistic missile submarines (SSBNs); and protecting the SSBNs with naval surface and aviation forces

▶ Controlling the ocean areas contiguous to the Soviet Union, including the Black Sea, the White Sea, the Sea of Japan and Sea of Okhotsk, and key straits
▶ Preventing strikes by U.S. naval forces against the Soviet Union by seeking out and destroying those forces at sea
▶ Neutralizing U.S. bases, e.g., in the Mediterranean and throughout the Pacific region and Alaska
▶ Attacking allied sea lines of communication, e.g., connecting the United States and NATO [34]

By the early 1960s Soviet SSBNs were already achieving the first objective of deterrence by patrolling the Atlantic Ocean. By the end of the decade, submarines of the Pacific Fleet were on regular patrol as well.[35] The SLBMs initially had a maximum range of 2,400 km, which increased to 7,800 km in the 1970s.[36] Figure 4.32 is a 1987 Pentagon depiction of the patrol areas for Russian SSBNs with the approximate areas in thousands of square kilometers.[37] By the 1970s, the SSBNs were able to threaten the United States from military zones, referred to as "bastions," in seas adjacent to Russia. These areas included the White Sea to the east and south of the Kola Peninsula, and the Sea of Japan, and the Sea of Okhotsk.

The principal trends of the last decade for the Russian Navy have been a sharp decline in the number of patrols, reduced maintenance and training, limited research and production, and the scrapping or sale of dozens of Soviet-built vessels. A recent article in *Jane's Defense Weekly* reports that the Russian Navy's operational readiness might be as low as 10 percent.[38] With respect to the Pacific Fleet, for example, the following selected events from the year 2000 reveal the pervasive problems confronting the Russian navy today:

FIGURE 4.32
Soviet SSBN Patrol Areas circa 1987
With the approximate areas in thousands of square kilometers.



- In January 2000, four Russian sailors and a retired officer were arrested for stealing radioactive fuel from a Pacific Fleet strategic submarine in Kamchatka. A search of their apartments turned up submarine parts and equipment, some containing gold, silver, platinum, and palladium.[39]
- During naval exercises on April 10, 2000, the Russian destroyer *Burnyy* fired ten anti-aircraft shells into the left side of the *Admiral Vinogradov*, a large Russian anti-submarine vessel, producing a hole above the waterline.[40]
- In March 2000, five Pacific Fleet sailors suffocated in a submarine compartment, which they had entered in order to collect metal to sell for scrap. The accident occurred in Chazhma Bay.[41]
- In a letter to the governor of Kamchatka, acting commander of the nuclear submarine fleet Rear Admiral Yuri Kirillov stated that military communication lines between the fleet command and nuclear submarines were being disrupted by thieves who were stealing the cables to sell for scrap. "We are desperately losing this war and many units are on the brink of losing their fighting efficiency."[42]
- On April 28, 2000, a military court severely sentenced Pacific Fleet Rear Admiral Vladimir Morev for attempting to sell air defense artillery radar equipment to Vietnam.[43]
- On June 16, 2000, leaked ballistic missile fuel at the Nakhodka naval base formed a toxic cloud (containing nitric acid), which hovered over the town of Fokino, affecting perhaps a dozen people.[44] In the Primorye region, a total of some 2,500 metric tons of missile fuel are currently stored in deteriorating tanks, and funds are not available to send most of this material to recycling plants in western Russia.[45]
- According to a high-ranking military source in the Pacific Fleet, fleet commanders had power for only a few hours per day because of electricity outages. "Data transmission units" were down for nine hours per day and submarine crews were reduced to preparing meals with wood fires.[46]
- The crew of a Japanese fishing boat near the island of Hokkaido spotted a huge, floating metal object on July 26, 2000, bearing the Russian word "inflammable" on an exposed piece. The object turned out to be an antenna, which was part of a Pacific Fleet anti-submarine warning system. It broke off during an earthquake in 1994 and Russian sailors had been searching for it ever since.[47]
- In Vladivostok on July 29, 2000, the entire crew of the BDK-101 large-assault ship abandoned their posts and went ashore to the Pacific Fleet Headquarters to ask for protection from their commanding officer. The crew claimed that they were "constantly beaten, badly fed, punished without cause and forced to work at all hours."[48]
- Due to an acute shortage of fuel, the July 30, 2000 Navy Day parade of ships in Vladivostok was canceled—a first in the history of the Pacific Fleet.[49]
- On September 14, 2000, the destroyer *Admiral Panteleyev*, one of Russia's largest anti-submarine warships, accidentally fired a 100 mm shell at a town in the Khasansk region during a Pacific Fleet exercise. The explosion produced a crater 1.5 meters deep approximately 200 meters from the town of Slavyanka. Reportedly one senior citizen suffered a concussion.[50]

In January 2000, four Russian sailors and a retired officer were arrested for stealing radioactive fuel from a Pacific Fleet strategic submarine in Kamchatka. A search of their apartments turned up submarine parts and equipment, some containing gold, silver, platinum, and palladium.

▸ On October 13, 2000, the Russian Navy command decided to disband one of three submarine combined units of the Pacific Fleet's Maritime Territory Flotilla for lack of funds. The unit of some two-dozen submarines was based at the military town of Fokino, about two hours from Vladivostok. Reportedly only a few submarines will be deployed to other locations, and the rest will be dismantled at the nearby Zvezda plant.[51]

Today, the principal Russian naval targets for U.S. strategic nuclear weapons are likely to be the SSBN basing areas of the Northern Fleet and the Pacific Fleet. Twelve SSBNs are deployed at two Northern Fleet bases and five SSBNs are at one Pacific Fleet base.

Northern Fleet

During the Cold War the Soviet Union created a vast military/nuclear complex on the Kola Peninsula (which is known by the Russians as the "land of the dammed") and along the adjacent White Sea.[52] The main strategic sites for the Northern Fleet are shown in Figure 4.33.

Most of the Soviet Navy's newest warships had home parts at Severomorsk and ten other deep harbors in this region. The Kola Inlet (Kol'skiy Zaliv) extends approximately 70 kilometers inland before becoming the Tuloma River. Along the shores of the Kola Inlet are the cities of Murmashi, Kola, Murmansk (the largest city north of the Arctic Circle), Severomorsk (headquarters of the Northern Fleet), Polyarnyy (a major base for Northern Fleet submarines and ships) and Skalistyy. In addition to the Murmansk-

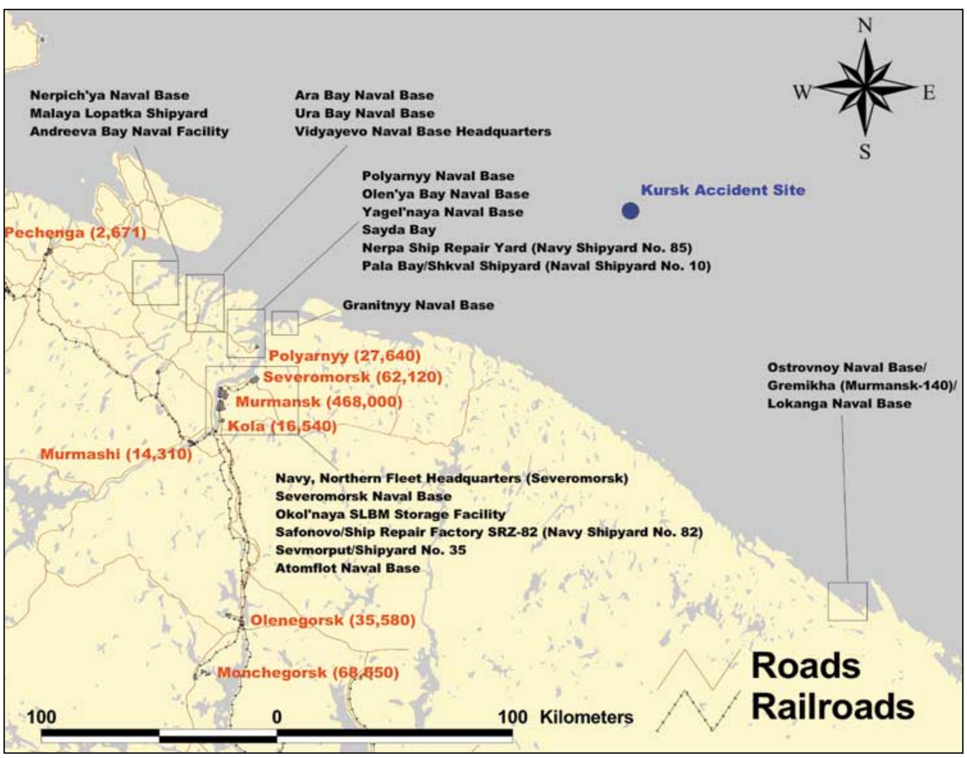


FIGURE 4.33
Main Sites of the Russian Northern Fleet
Population data from the 1989 Census is shown in red, and the approximate location of the *Kursk* submarine accident site is shown in blue.

Severomorsk-Polyarnyy complex, ships and submarines are based at the ports of Gremikha, which is approximately 200 km eastwards from the Kola Inlet, and the Litsa Guba/Bolshaya Litsa Complex, which has four bases—three on the eastern side of the fjord: a nuclear submarine maintenance area, a base for nuclear attack submarines and a base for Typhoon and other SSBNs—and another submarine maintenance facility on the western side, and westward in the port of Pechenga. There are reportedly several tunnel facilities (in Sayda Bay) for submarine repair and missile reloading.

Pacific Fleet

The main Russian Navy Pacific Fleet facilities in the Far East are shown in Figures 4.34 and 4.35. The two largest cities potentially affected by MAO-NF in the Russian Far East are Vladivostok and Petropavlovsk-Kamchatskiy. Vladivostok is a port city of 700,000 on the Sea of Japan at the eastern end of the Trans-Siberian Railway (a seven-day rail journey from Moscow) and about 70 kilometers from China. Vladivostok ceased to be a closed city in 1992. Approximately 35 kilometers east of Vladivostok is the large submarine disassembly plant Zvezda, and 40-60 kilometers southeast of Vladivostok are several main naval facilities, including Chazma Naval Yard and Abrek Bay Naval Headquarters. Approximately 2,300 kilometers northeast of Vladivostok, on Russia's Kamchatka Peninsula, lies the city of Petropavlovsk-Kamchatskiy (1989 population 268,700) and the Rybachiy Naval Base, home to the Pacific Fleet's remaining SSBNs (see Figure 4.35). Both the city and the naval base are situated along Avachinskaya Bay near the southern end of the Peninsula. Rybachiy Naval Base and the city of Petropavlovsk-Kamchatskiy are separated by about 20 kilometers.

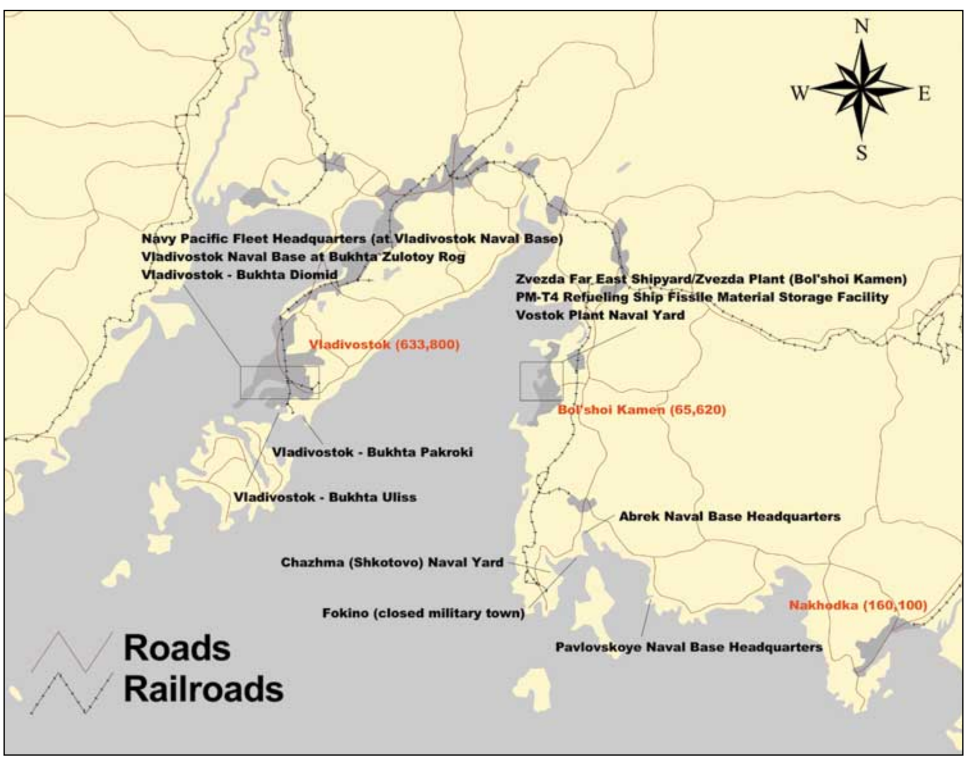
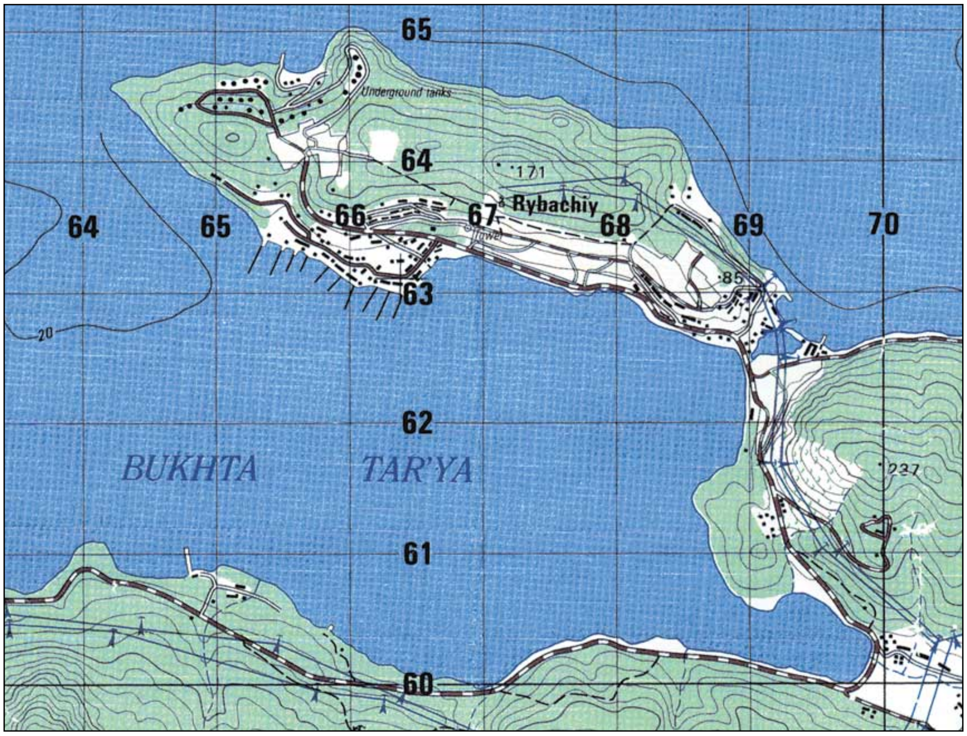


FIGURE 4.34
Main Sites of the Russian Pacific Fleet in Primorskiy Kray
These sites are located at and near the city of Vladivostok. Population data comes from the 1989 Soviet Census.

FIGURE 4.35
The Russian Naval Base of Rybachiy on the Kamchatka Peninsula
Near the city of Petropavlovsk-Kamchatskiy.



Warhead Requirements and Aimpoints

Since long-range Russian SSBN patrols are now infrequent, for MAO-NF we assume that many, most, or possibly all, of the moored submarines are at some stage of alert and are thus potential stationary firing platforms. We also explore the possibility that Russian SSBNs might disperse to other naval bases.

Vulnerability numbers for naval targets are provided in Table 4.7, showing three levels of damage (A, B and C) for three characteristics (seaworthiness, mobility and

FIGURE 4.36
Probability of Severe Damage to Surfaced Submarines, Aircraft Carriers and Destroyers for a W76 Ground Burst as a Function of Distance Between Ground Zero and Target
A CEP of 183 meters was used for these calculations.

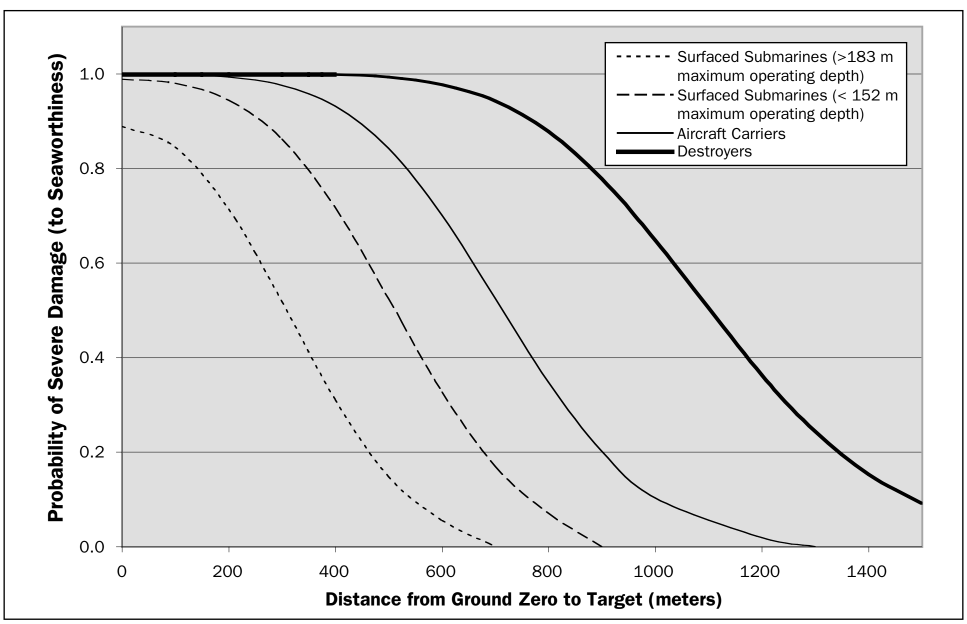


TABLE 4.7

Nuclear Weapons Vulnerability Data for Naval Targets

Naval shore structures and some associated objects, submarines and surface vessels. Types “A”, “B” and “C” damage to submarines and surface ships refer to successively more severe damage to seaworthiness, mobility and weapon delivery capabilities. Vulnerability numbers followed by an asterisk are for Equivalent Target Area Dimensions (Contact Burst) width/height. SS stands for single story, MS for multi-story, WF for wood framed, WB for masonry load-bearing wall, SF for steel-framed buildings with at least a 10-ton crane capacity, LSF for light-steel-framed buildings without cranes or with a 10-ton crane capacity, VLSF for very light steel-framed buildings, and RC for reinforced concrete building types. Source: *Physical Vulnerability Handbook—Nuclear Weapon* (U), pp. I-11, I-19 and I-20.

STRUCTURES AND OBJECTS (OTHER THAN SUBMARINES AND SURFACE SHIPS)

Target	Damage	VN
Naval Operating Base Administration Buildings (MS/SF or RC)	SDC	12P2
Naval Operating Base Administration Buildings (MS/WB)	SSD	10P0
Naval Operating Base Supply Buildings (MS/SF or RC)	SDC	12P2
Naval Operating Base Supply Buildings (SS/WB)	SSD	10P0
Naval Operating Base Supply Buildings (MS/WB)	SSD	10P0
Naval Operating Base Supply Buildings (SS/VLSF)	SSD	12Q7
Naval Operating Base Barracks (MS/WB)	SSD	10P0
Naval Operating Base Barracks (SS or MS/WF)	SSD	8P0
Naval Shipyard and Repair Base (Small Vessels and Submarines); Major Shops (Foundry, Machine, etc.); SS/SF	MSD	12Q7
Naval Shipyard and Repair Base (Small Vessels and Submarines); Major Shops (Foundry, Machine, etc.); SS/RC	MSD	12Q6
Naval Shipyard and Repair Base (Small Vessels and Submarines); Assembly Area (Locomotive and Crawler Cranes)	Overturning Cranes	15Q6
Naval Shipyard and Repair Base (Large Vessels); Shipways and Fitting-Out Areas	Overturning Light Portal and Tower Cranes	11Q7
Naval Shipyard and Repair Base (Large Vessels); Major Shops (Foundry, Machine, etc.); SS/SF	MSD	13Q7
Naval Shipyard and Repair Base (Large Vessels); Major Shops (Foundry, Machine, etc.); SS/RC	MSD	13Q6
Naval Shipyard and Repair Base (Large Vessels); Assembly Area (Locomotive and Crawler Cranes)	Overturning Cranes	15Q6
Naval Shipyard and Repair Base (Large Vessels); Shipways and Fitting-Out Areas	Overturning Portal and Tower Cranes	13Q8
Naval Shipyard and Repair Base (Large Vessels); Shipways and Fitting-Out Areas	Overturning Gantry Cranes	14Q9
Naval Shipyard and Repair Base (Large Vessels); Shipways and Fitting-Out Areas	Distortion of Runways of Overhead Cranes	15Q7
Naval Shipyard and Repair Base (Large Vessels); Shipways and Fitting-Out Areas	Overturning Hammerhead Cranes	17Q9
Graving Docks and Dry Docks	Sidewall Collapsed and Dock Obstructed or Gate Ruptured	52P0/ 31P0*
Graving Docks and Dry Docks	Sidewall cracked and Lock Obstructed by Crater Lip or Gate Ruptured	40P0/ 31P0*
Steel Floating Dry Docks	Deformation of sidewalls and overturning of cranes	16P0
Steel Floating Dry Docks	Overturning of cranes on sidewalls	13Q8
Wooden Wharves and Piers	Unseating of Timber Stringers and Floor System	17P0
Concrete or Stone Wharves, Piers and Quays	Destruction	46P0
POL Storage		
Ammunition Storage		

SUBMARINES AND SURFACE SHIPS

	Seaworthiness			Mobility			Weapons		
	A	B	C	A	B	C	A	B	C
Surfaced Submarines (>183 meters maximum operating depth)	30P0	29P0	27P0	—	—	28P0	28P0	26P0	23P0
Surfaced Submarines (<152 meters maximum operating depth)	24P0	22P0	21P0	—	—	—	—	—	—
Aircraft Carriers, Cruisers, Transports, LST’s, Landing Craft and Landing Vehicles	20P0	18P0	15P0	15P0	14P0	13P0	13P0	11P0	7P0
Destroyers	15P0	14P0	13P0	13P0	12P0	11P0	13P0	11P0	7P0

Target	Damage	VN
Merchant Ships	Unseaworthy; in danger of sinking, capsizing, or breaking up	20P0
Merchant Ships	About one-half loss of seaworthiness	18P0

weapons delivery) for submarines and ships. A description of the damage levels is provided in Table 4.8. Figure 4.36 shows the probability of achieving severe damage to seaworthiness (and thus also severe damage to weapons systems) for various vessel types as a function of distance between W76 ground zero and target. The damage radius for severe damage to surfaced submarines (capable of operating deeper than 183 meters) is found to decrease rapidly to zero for heights of burst of only several hundred meters. Therefore we select W76 ground bursts for all Russian naval targets.

In our MAO-NF, we examine two levels of attack against Northern Fleet targets and three levels of attack against Pacific Fleet Targets. We limit the first level of attack against the Northern Fleet to the pier areas of the two Russian naval bases where Typhoons, Delta III, and Delta IV SSBNs are moored. We use a total of 18 W76 warheads to cause severe damage to the SSBNs and the pier areas. In the second level of attack, all of the other Northern Fleet's naval bases are also attacked using an additional 74 warheads, for a total of 92 W76 warheads for the second level of attack. Table 4.9 provides summary information on the targets chosen for these two Northern Fleet attack scenarios in our MAO-NF.

TABLE 4.8
Definitions of Damage Levels for Naval Targets
Description of the three levels of damage to ship and submarine seaworthiness, mobility and weapons delivery. Source: *Physical Vulnerability Handbook—Nuclear Weapon* (U), p. I-20.

Impairment Type	Description
Seaworthiness, Type A	For ships: In danger of sinking, capsizing, or breaking up because of widespread, uncontrollable flooding or loss of girder strength. Danger is present even in normal weather, but there is some chance of saving the ship. For submarines: In danger of settling to the bottom because of damage to its structure of buoyancy-control gear.
Seaworthiness, Type B	For ships: About half-loss of seaworthiness, evidenced by appreciable plastic deformation of structure, possibly leading to rupture. This includes loss of girder strength or of topside structure to an extent that the ship is in danger of being swamped or being broken up in stormy weather. Any flooding is confined by compartmentation or by a side-protection system. For submarines: Loss of ability to submerge in a controlled manner because of damage to structure or buoyancy-control gear.
Seaworthiness, Type C	For ships: Slight plastic deformation of structure, which may cause minor leakage. Hogging or sagging, or topside structural damage may occur, but not enough to endanger the ship, even in stormy weather. For submarines: Slight reduction of maximum safe diving depth but can submerge in a controlled manner.
Mobility, Type A	For ships: Can at best just barely maintain steerageway in a desired direction, because of damage to main propulsion equipment, auxiliary machinery, and control gear, or because of personnel casualties. For submarines: Seaworthiness impairment controls.
Mobility, Type B	For ships: About half loss of mobility. Can maintain steerageway in a desired direction without difficulty, but cannot achieve speeds appreciably greater than half top speed, and/or cannot maneuver normally within its remaining speed range, because of damage to equipment and/or control gear, or because of personnel casualties. For submarines: Seaworthiness impairment controls.
Mobility, Type C	For ships or submarines: Slight loss of ability to achieve top speed and/or to maneuver normally, because of equipment damage or personnel casualties.
Weapon Delivery, Type A	Weapons can be released, but it is almost impossible to deliver them effectively because the target-acquisition and communication equipments are inoperative, either from damage to equipment or topside structure, or because of personnel casualties.
Weapon Delivery, Type B	About half-loss in ability to deliver weapons effectively, because of damage to equipment or topside structure, or because of personnel casualties.
Weapon Delivery, Type C	Slight reduction in weapon-delivery efficiency due to equipment or topside structural damage, or to personnel casualties.

TABLE 4.9
Northern Fleet Aimpoints for Two Levels of Attack.

Level of Attack	Target Description	Number of Aimpoints
1	**Nerpich'ya Naval Base:** (in Zapadnaya Litsa Bay approximately 50 km west of the mouth of the Kola Inlet); 3 Typhoon SSBNs (60 SLBMs); piers potentially distributed over 2,700 meters of coastline	8 (300 meters between aimpoints)
1	**Yagel'Naya Naval Base:** (in Sayda Bay near the town of Skalistyy at the mouth of the Kola Inlet); 2 Delta III (32 SLBMs) and 7 Delta IV SSBNs (112 SLBMs); piers potentially distributed over 3,500 meters of coastline	10 (300 meters between aimpoints)
Total Aimpoints for Attack Level 1		***18***
2	**Murmansk-Pinagoriy Area and Sevmorput Shipyard:** (central and northern portions of Murmansk); SSBN repair yard (refueling prior to 1992)	0 (withhold on cities under MAO-NF)
2	**Safonovo Ship Repair Factory SRZ-82:** (10 km northeast of Murmansk) nuclear ship and sub repair	1
2	**Severomorsk Naval Base:** (15 km northeast of Murmansk) 30 surface ships, including heavy aircraft carrier *Admiral Kuznetsov*, heavy nuclear-powered missile-armed cruisers of the Admiral Ushakov class (Krov) and the *Marshal Ustinov* missile-armed cruiser of the Slava class; piers potentially distributed over 10,000 meters of coastline	11 (750 m separation between aimpoints)
2	**Okol'naya SLBM Storage Facility:** (1 km east of Severomorsk)	1
2	**Polyarnyy Naval Base:** (26 km northeast of Murmansk) minor surface combatants; diesel submarines; a naval station of the Kola flotilla (surface ships and submarines of offshore defense brigades); piers potentially distributed over 1,000 meters of coastline	4 (300 m between aimpoints)[53]
2	**Pala Bay/Shkval Shipyard:** (24 km northeast of Murmansk) auxiliaries; piers potentially distributed over 1,500 meters of coastline	2 (750 m between aimpoints)
2	**Olen'ya Bay:** (25 km northeast of Murmansk) former SSBN base; surface ships and submarines of offshore defense brigades; piers potentially distributed over 1,700 meters of coastline	5 (300 m between aimpoints)
2	**Nerpa Ship Repair Yard and Kut Bay Docking Area:** (24 km northeast of Murmansk) piers potentially distributed over 3,000 meters of coastline	5 (750 m between aimpoints)
2	**Sayda Bay:** (western end) piers	2
2	**Granityy Naval Base:** (13.5 km east of the mouth of the Kola Inlet) torpedo and missile boats	2
2	**Teriberka:** (piers, 65 km southeast of the mouth of the Kola Inlet) patrol ships	1
2	**Ostrovnoy Naval Base:** (located at the city of Gremikha, 280 km southeast of the mouth of the Kola Inlet); piers potentially distributed over 3,000 meters of coastline	4 (750 m between aimpoints)
2	**Port Vladimir:** (19 km west of the mouth of the Kola Inlet) minor surface combatants (minesweepers, etc.)	1
2	**Ura Bay Naval Base and adjacent Piers:** (35 km northwest of Murmansk) piers potentially distributed over 8,000 meters of coastline	10
2	**Ara Bay:** (40 km northwest of Murmansk) piers potentially distributed over 3,000 meters of coastline	8 (300 m between aimpoints)
2	**Bolshaya Lopatka Naval Base:** (in Zapadnaya Litsa Bay approximately 50 km west of the mouth of the Kola Inlet) piers potentially distributed over 2,000 meters of coastline	6 (300 m between aimpoints)
2	**Malaya Lopatka:** (in Zapadnaya Litsa Bay approximately 50 km west of the mouth of the Kola Inlet)	2
2	**Andreeva Bay:** (in Zapadnaya Litsa Bay approximately 50 km west of the mouth of the Kola Inlet)	1
2	**Pechenga:** (96 km northeast of Murmanks) conventional submarines and escort ships	2 (the north end and mid-way up the fjord)
2	**Severodvinsk:** (along the White Sea near Arkhangel) workshops for construction and modernization of submarines; base for minor surface ships; SLBM loading facility	5 (spaced mid-way along the length of the Severodvinsk inlet)
2	**Belomorsk:** (along the White Sea 300 km west of Arkhangel) a naval station of the Kola flotilla; surface ships and submarines	1
Total Aimpoints for Attack Level 2		***92***

We take a similar approach in selecting Pacific Fleet targets. However, since three sites are in or near populated areas, these are not included in the first two levels of attack. We limit the first level of attack to the pier area of the Rybachiy Naval Base where five Delta III SSBNs are moored. Twelve W76 warheads are used to cause severe damage to the SSBNs and the pier areas. In the second level of attack, all but three of the other Pacific Fleet's naval bases are targeted as well with an additional 18 warheads, bringing the total to 23 W76 warheads. In the third level of attack, three additional sites in the vicinity of populous areas are attacked with 22 warheads, bringing the total to 45 W76 warheads for the third attack level. Table 4.10 provides a summary of the Pacific Fleet targeted in MAO-NF. In all cases, we select surface bursts with the objective of causing severe damage to ships or submarines moored at pier areas.

Casualties and Sensitivity Analysis

The first level of attack against Russian naval sites in NRDC's MAO-NF—targeting only the pier areas where SSBNs are moored—requires a total of 30 W76 warheads. In our judgment, this is likely to be the minimum level of attack against this component of Russian strategic nuclear forces in the actual U.S. SIOP. Figures 4.37 and 4.38 contrast the fallout patterns calculated for NRDC's first and second levels of attack against Northern Fleet targets. Even in the first level of attack against the Russian Northern Fleet, almost one megaton of nuclear explosive yield is detonated (as surface bursts) at each of the two SSBN bases, and consequently the range of lethal fallout extends some 100 kilometers from the ground zeroes for an unsheltered population. This is farther than distances between Nerpich'ya Naval Base or Yagel'naya Naval Base and the city of Murmansk.

TABLE 4.10
Pacific Fleet Aimpoints for Three Levels of Attack

Level of Attack	Target Description	Number of Aimpoints
1	Rybachiy Naval Base	12
Total Aimpoints for Attack Level 1		***12***
2	Pavlovskoye Naval Base	3
2	Abrek Bay	3
2	Navy Site 34 Fresh Fuel Storage Facility	1
2	Zavety Il'icha Naval Base	1
2	Sovetskaya Gavan Naval Station	1
2	Chazma Naval Yard	1
2	Ol'ga Naval Base	1
Total Aimpoints for Attack Level 2 (including attack level 1 targets)		***23***
3	Bolshoi Kamen	3
3	Korsakov Naval Base	1
3	Vladivostok-area Naval sites	18
Total Aimpoints for Attack Level 3 (including attack level 1 and 2 targets)		***45***

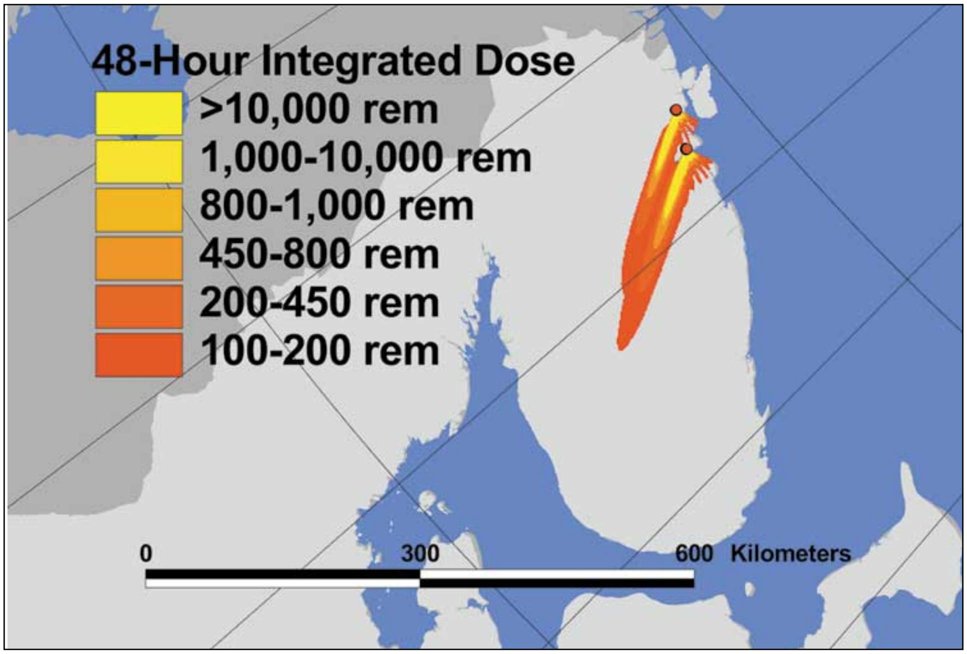


FIGURE 4.37
Fallout Patterns over the Kola Peninsula for the First Level of Attack
Against Russian SSBNs at Nerpich'ya and Yagel'Naya Naval Bases. This calculation uses the most probable wind patterns for the month of December, and assumes the 18 attacking W76 warheads have a fission fraction of 80 percent and the population is unsheltered. Principally as a result of fallout, a total of 307,000 casualties are calculated to occur, including 259,000 fatalities.

Figures 4.39 and 4.40 show the summary casualty data for the first and second levels of attack, respectively, against Northern Fleet targets as a function of warhead fission fraction and population sheltering. Figures 4.41 and 4.42 plot casualties and fatalities by month for the first and second levels of attack against Northern Fleet targets. Seasonal changes in wind speed and direction cause the monthly variation.

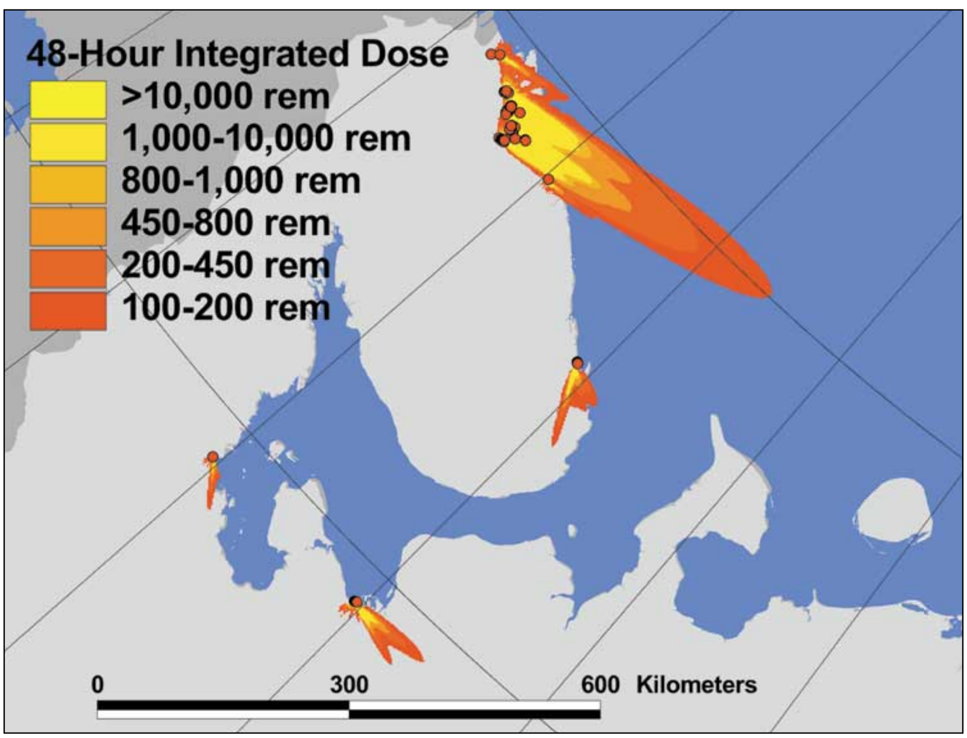
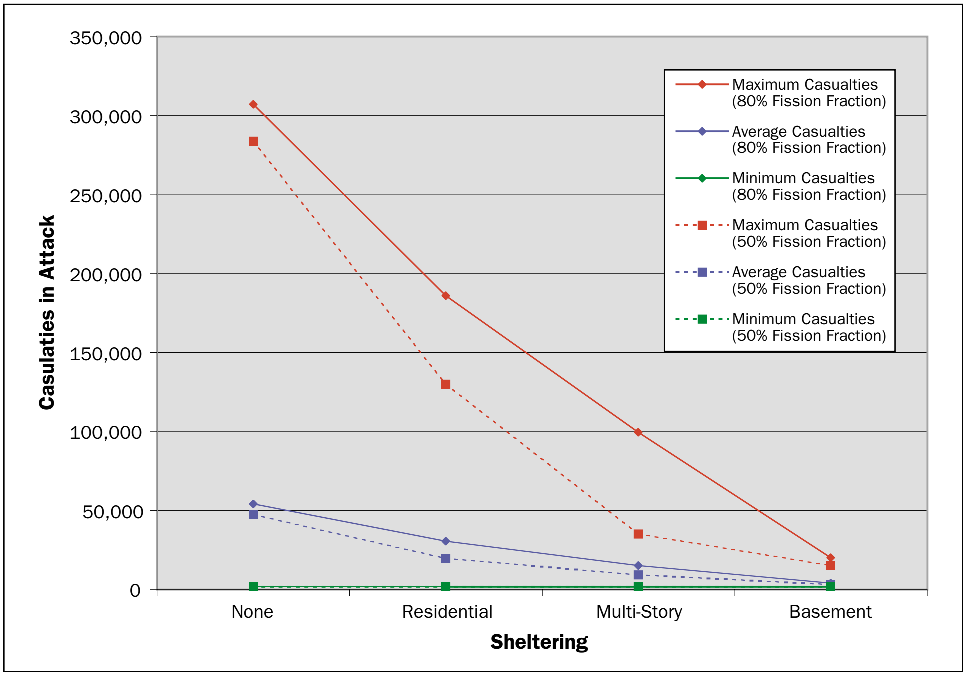


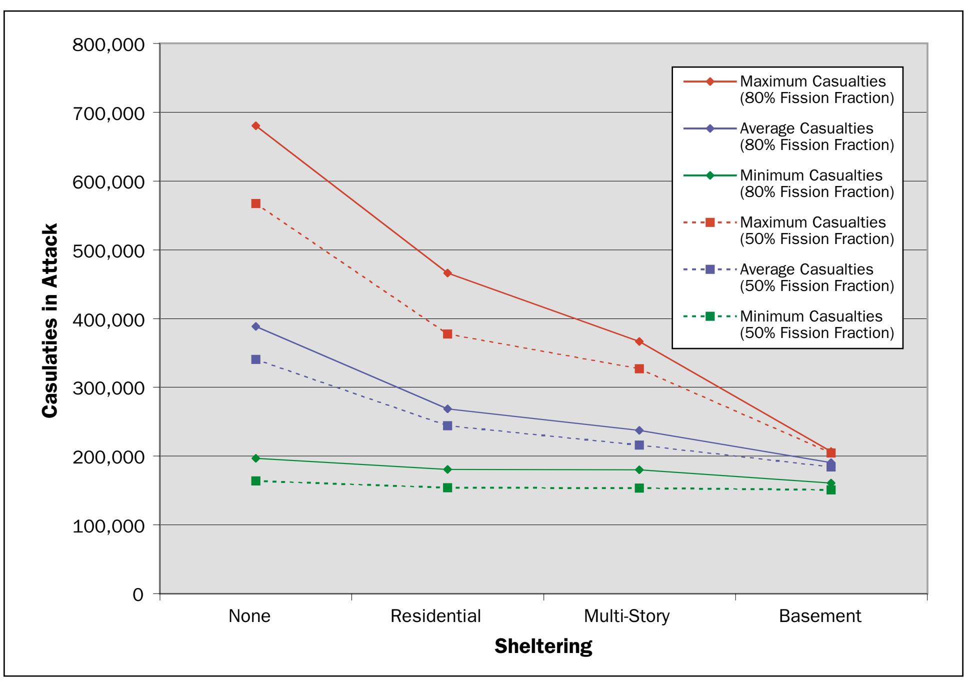
FIGURE 4.38
Fallout Patterns over the Kola Peninsula for the Second Level of Attack
Against Russian SSBNs at Nerpich'ya and Yagel'Naya Naval Bases and 18 other Northern Fleet facilities. This calculation uses the most probable wind patterns for the month of August, and assumes that the 92 attacking W76 warheads have a fission fraction of 80 percent and the population is unsheltered. A total of 503,000 casualties are calculated to occur, including 412,000 fatalities.

FIGURE 4.39
Summary Casualty Data for the First Level of Attack on the Russian Northern Fleet



These calculations demonstrate that for most months of the year, the fallout patterns from the first level of attack would occur over sparsely populated regions. For certain months, notably January, February, and November, fallout would descend over Murmansk and its vicinity, causing the number of civilian casualties to approach 200,000. For the second level of attack against the Russian Northern Fleet—in which an additional 7.4 megatons of nuclear explosive yield was detonated at

FIGURE 4.40
Summary Casualty Data for the Second Level of Attack on the Russian Northern Fleet



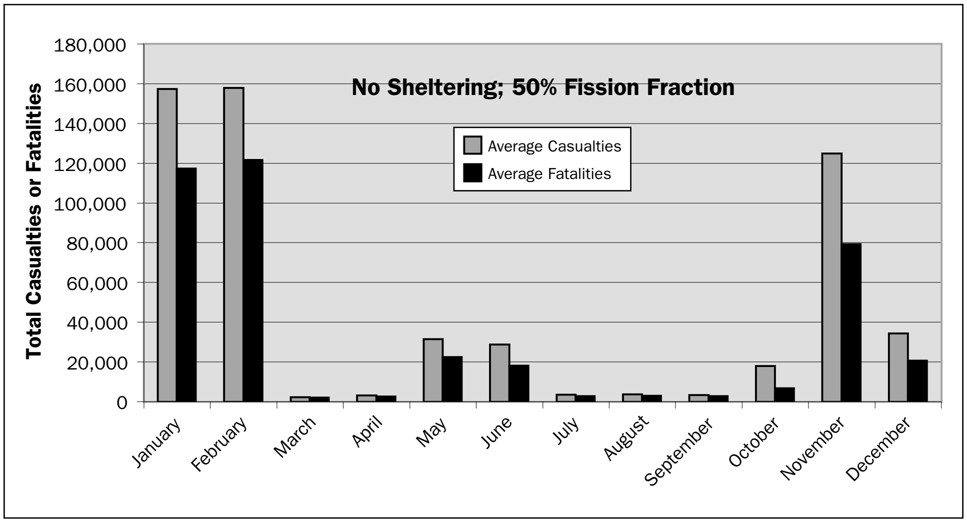


FIGURE 4.41
Casualties and Fatalities as a Function of the Month of the Year for the First Level of Attack against the Russian Northern Fleet
A fission fraction of 50 percent and no sheltering is assumed for this calculation.

18 other naval sites—the range of casualties is computed to be 153,000–466,000, including from 151,000 to 340,000 fatalities. It is notable that the maximum number of civilians threatened by the first level of attack against the Russian Northern Fleet is within the range of the second level of attack, despite the greater number of warheads used and sites attacked.

Figures 4.43 through 4.45 display fallout patterns from the first, second and third levels of attack against the Russian Pacific Fleet. In the first level of attack, in which more than one megaton of nuclear explosive yield is detonated (as surface bursts) at the Rybachiy Naval Base, the most probable wind patterns for all months of the year blow the fallout over the ocean. Figures 4.46 and 4.47 show the summary casualty data for the second and third levels of attack, respectively, against Russian Pacific Fleet targets as a function of warhead fission fraction and population sheltering. Figures 4.48 and 4.49 plot casualties and fatalities by month for the second and third levels of attack.

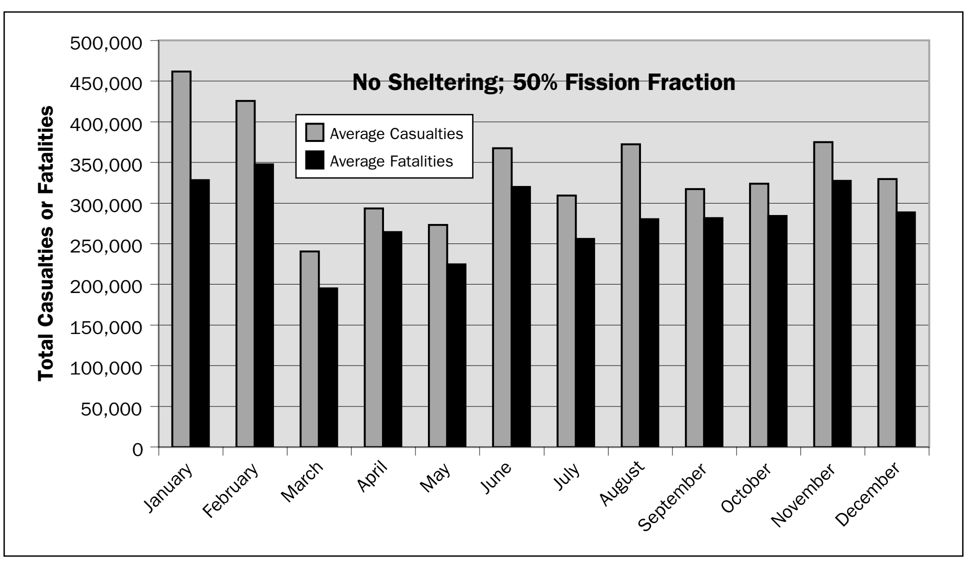
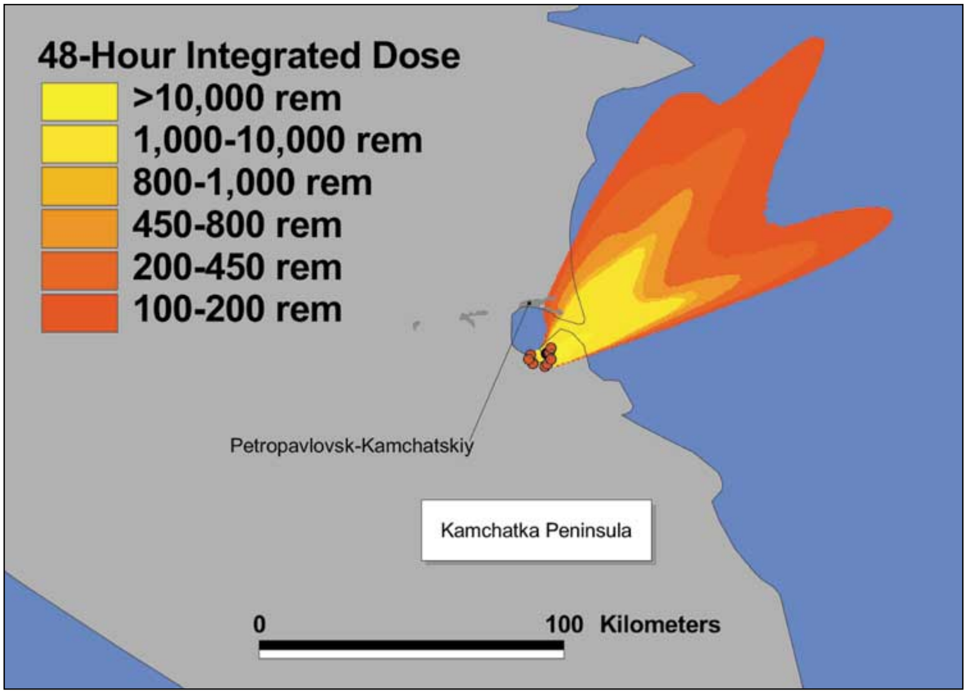


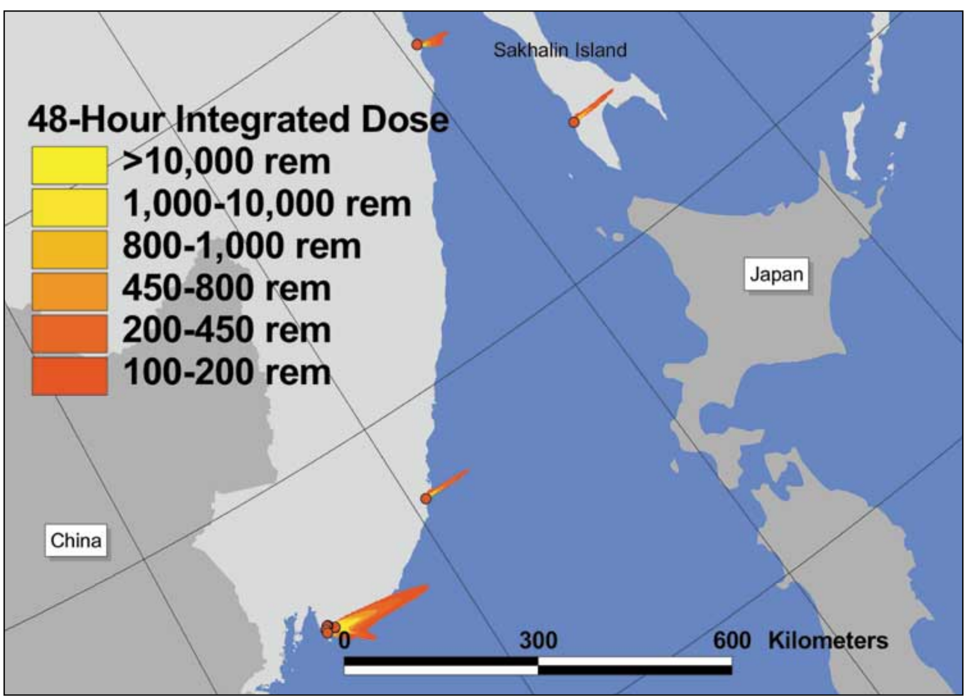
FIGURE 4.42
Casualties and Fatalities as a Function of the Month of the Year for the Second Level of Attack against the Russian Northern Fleet
A fission fraction of 50 percent and no sheltering is assumed for this calculation.

FIGURE 4.43
Fallout Patterns from the Attack on the Rybachiy Naval Base
With twelve W76 ground bursts. The parameters of the calculation are: the most probable winds for the month of January, a warhead fission fraction of 80 percent and an unsheltered population. Because the fallout occurs mostly over the ocean, the number of fatalities calculated is less than one percent of the population of nearby Petropavlovsk-Kamchatskiy.



For the second level of attack against the Russian Pacific Fleet—in which a total of 2.3 megatons of nuclear explosive yield is detonated at eight naval sites (including Rybachiy)—casualties would range from 8,000–44,000, including from 8,000 to 20,000 fatalities. As noted above, this represents a small percentage of the population in the vicinity of these sites. We compute that population centers would lay largely outside the fallout zones because of the prevailing winds. When targets in or very close to

FIGURE 4.44
Fallout Patterns from the Second Level of Attack Against the Russian Pacific Fleet
Using a total of 23 W76 warheads. The parameters of the calculation are: the most probable winds for the month of April, a fission fraction of 80 percent, and an unsheltered population. A total of 149,000 casualties are calculated to occur, including 114,000 fatalities.



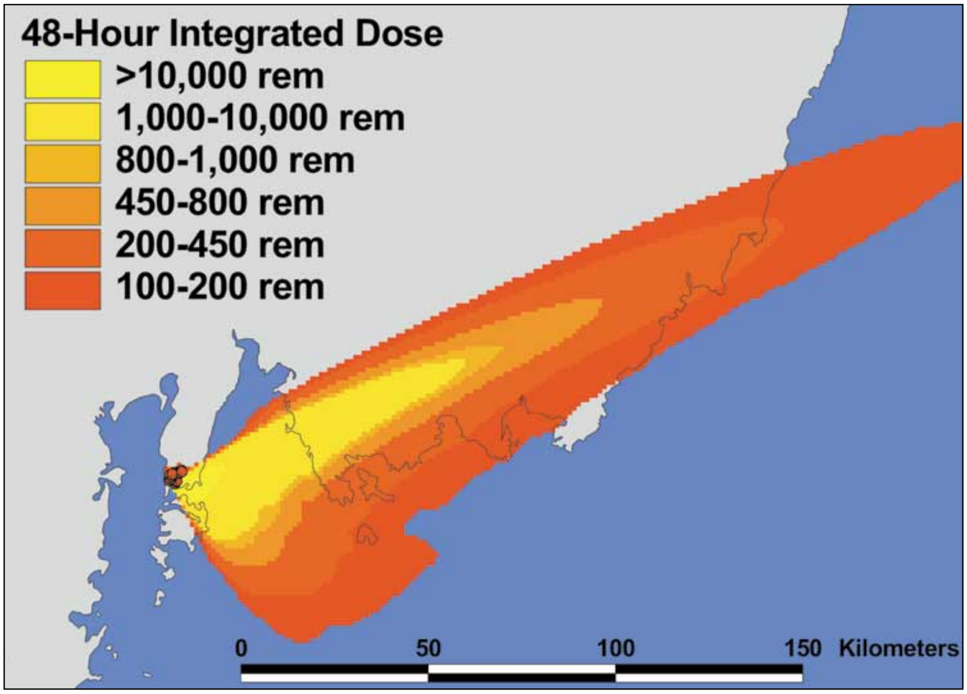


FIGURE 4.45
An Attack on the Vladivostok Harbor, Part of the Third Level of Attack Against the Russian Pacific Fleet
This calculation assumes winds typical of the month of January, fission fraction of 80 percent, and no sheltering. The total casualties calculated for the attack by 18 W76 warheads on the Vladivostok port area are 236,000 and the total calculated fatalities are 158,000.

population centers are included in a nuclear attack, as is the case for MAO-NF's level three targeting against the Russian Pacific Fleet, the computed casualties and fatalities become much less sensitive to the wind parameters. For the third level of targeting against the Russian Pacific Fleet, which includes Vladivostok harbor, the Zvezda plant and Korsakov Naval Base on Sakhalin Island, casualties are computed to approach one-half million.

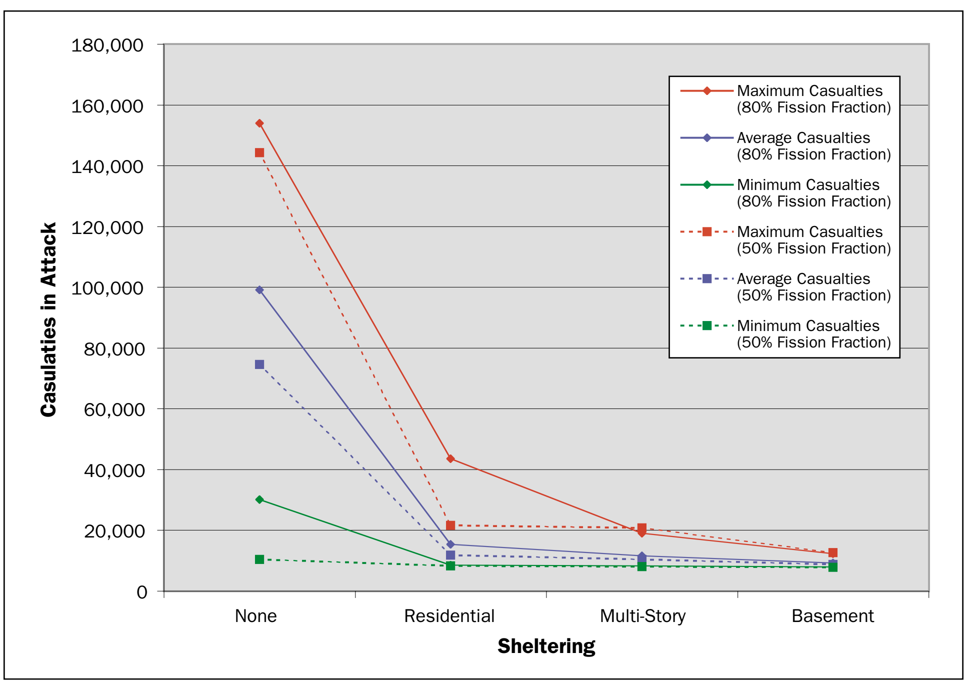


FIGURE 4.46
Summary Casualty Data for the Second Level of Attack on the Russian Pacific Fleet

FIGURE 4.47
Summary Casualty Data for the Third Level of Attack on the Russian Pacific Fleet

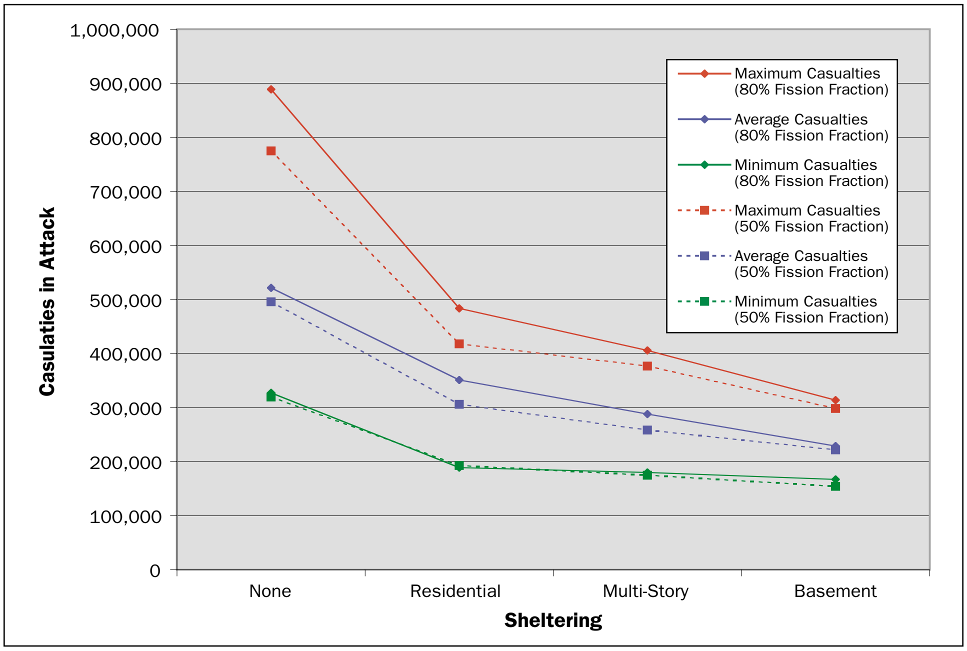


FIGURE 4.48
Monthly Variation in Casualties and Fatalities for the Second Level of Attack Against the Russian Pacific Fleet

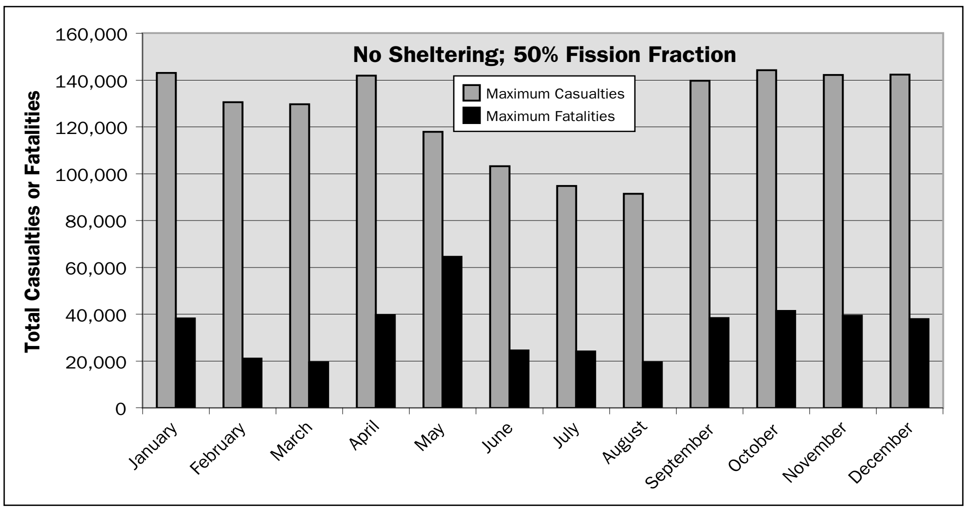
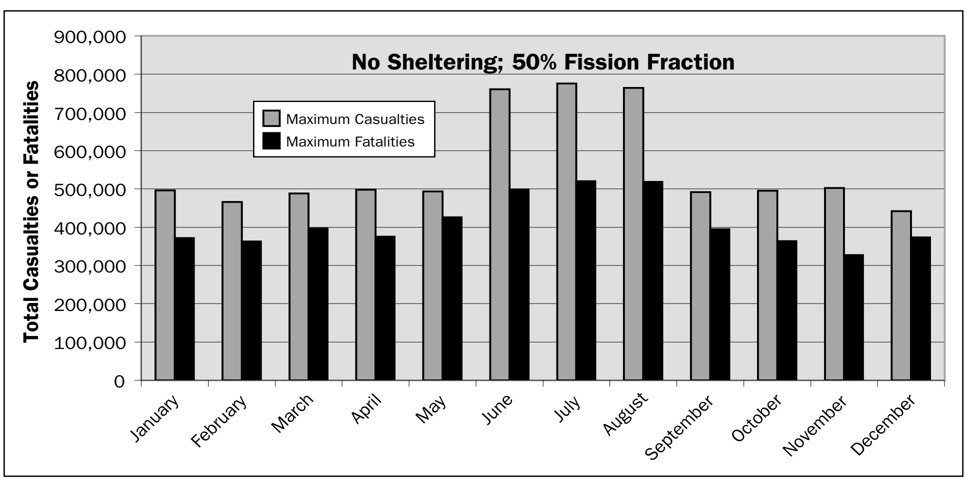


FIGURE 4.49
Monthly Variation in Casualties and Fatalities for the Third Level of Attack Against the Russian Pacific Fleet



LONG-RANGE BOMBER BASES AND FACILITIES

Description of Targets

With the breakup of the Soviet Union, Russian Long-Range Aviation lost key air bases in Estonia at Pyarnu and Tartu; in Ukraine at Uzin and Priluki; and in Kazakhstan at Semipalatinsk, and lost custody of most of its Tu-160 strategic bombers to Ukraine for several years. Long Range Aviation (in Russian *Dalnaiaya Aviatsiya*—DA) was reorganized on May 1, 1998 into the 37th Air Army, with two of its divisions—the 22nd Heavy Bomber Division based at Engels and the 73rd Heavy Bomber Division at Ukrainka—operating long-range bombers.[54] The 182nd Guard Aviation Wing of Tu-95MS heavy bombers, which had been based at Mozdok Air Base since 1962, was disbanded in April 1998, and its 35 bombers were transferred to Engels Air Base.[55]

In the START I MOU dated 31 July, 2000, Russia declared a total of 81 deployed heavy bombers (66 Bears and 15 Blackjack bombers) and 11 test heavy bombers (six Bears and five Blackjacks). Ukrainka Air Base had 21 Bear H16 and 27 Bear H6 bombers and Engels Air Base had 13 Bear H16, 5 Bear H6 and all 15 Blackjack bombers. Figure 4.50 shows a Corona satellite image of Ukrainka Air Base taken on December 6, 1969. Figure 4.51 is a map showing Engels Air Base. The 11 test heavy bombers were at the Zhukovskiy Heavy Bomber Test Flight Center at Ramenskoye Airfield. According to Russian Air Force Major General Dmitry Morozov, 79 percent of long-range aircraft are serviceable.[56]

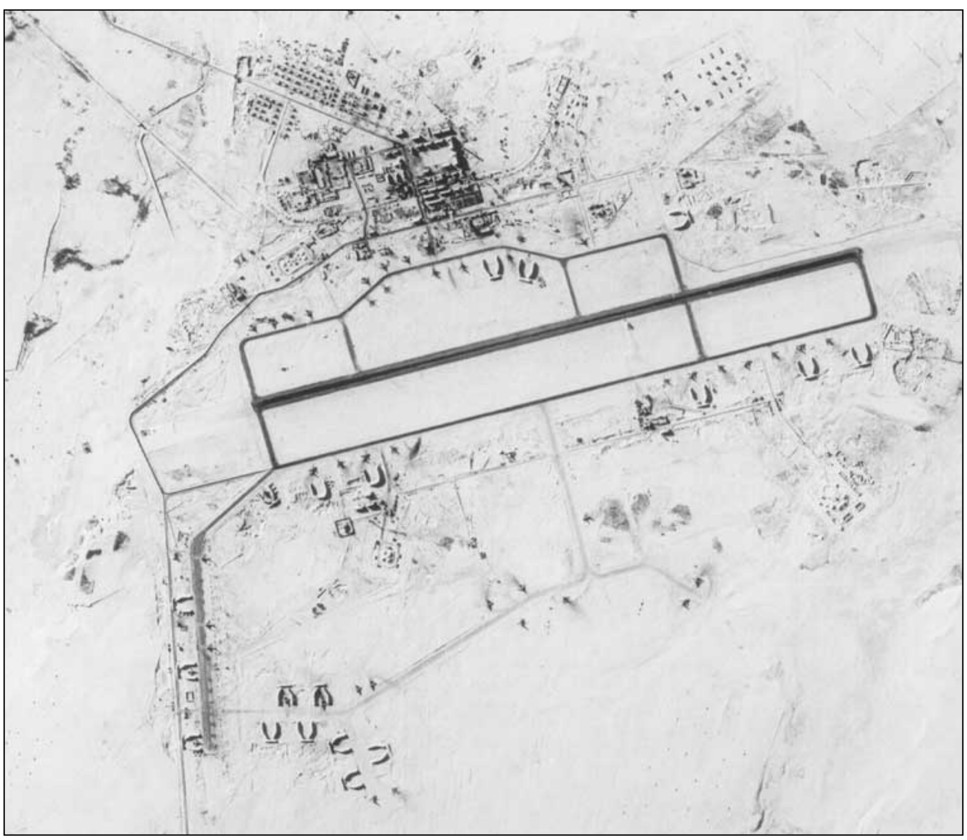


FIGURE 4.50
Corona Satellite Image of Ukrainka Air Base
Taken on December 6, 1969 during mission 1108-1. The Ukrainka Air Base is located in the Russian Far East at 51°10' N, 128°26' E, approximately 1,500 km due north of Seoul, South Korea. Source: Joshua Handler, Princeton University.

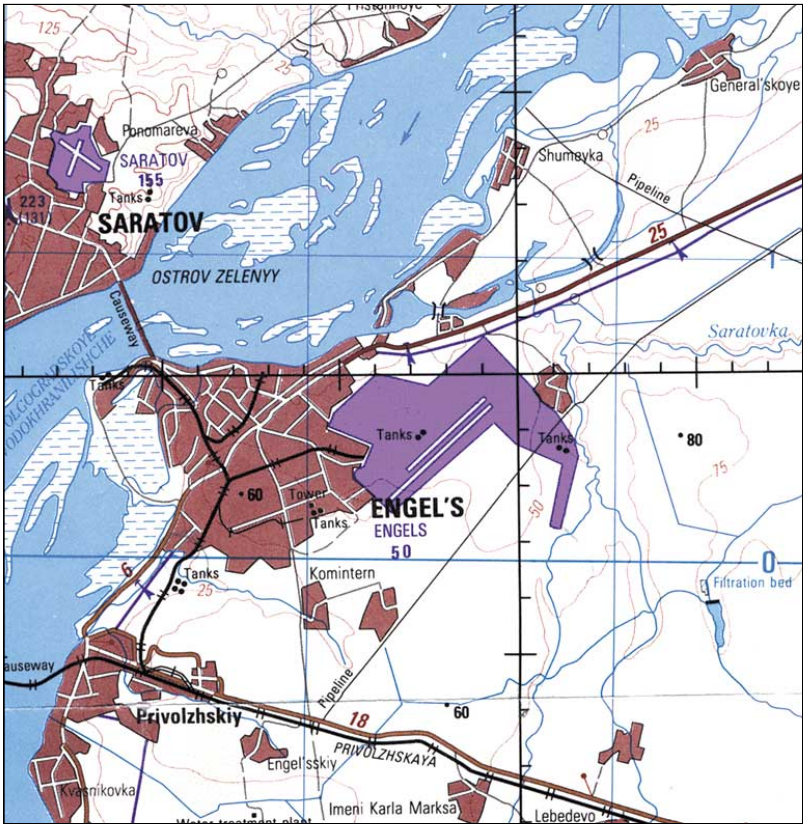


FIGURE 4.51
Engels Air Base, near the City of Saratov
(Population in the 1989 Soviet Census: 904,600). The air base is located at 51°28' N, 46° 11' E, approximately 750 kilometers from Moscow and adjacent to the Tatischevo missile field. Source: U.S. JOG NM 38-3, Series 1501, Edition 2, "Compiled in 1982."

Russia did not declare any new heavy bombers at the Aircraft Production Combines at Kazan' and Kuybyshev. Two Bear G bombers, described as "heavy bombers equipped for nuclear armaments [gravity bombs] other than long-range nuclear ALCMs," were declared to be at Ryazan Air Base, and at the strategic bomber elimination facility at Engels Air Base. The Russian Air Army training center and the major repair plant for bomber aircraft are located at Dyagilevo, near Ryazan.

During the week of September 17, 1999, the Russian Air Force and Navy conducted command-staff exercises in the Far East involving three Tu-95MS aircraft of the 73rd Heavy Bomber Division, based at the Ukrainka airfield. The strategic bombers forward-deployed to Anadyr Air Base in the Chukotskiy Autonomous District (see Figure 4.52 for a map of the base). In late November 2000, Russia moved several Bear bombers to Anadyr, Tiksi, and Vorkuta Air Bases. The threat to the United States posed by Russian bombers lies in the AS-15 Kent air-launched cruise missiles that they carry. (It is generally understood that today the chance of Russian bombers penetrating U.S. air space to drop gravity bombs is near zero.) The AS-15 has a range of 3,520 kilometers.

Warhead Requirements and Aimpoints

The MAO-NF focuses on the following strategic aviation targets: the main air bases at Engels and Ukrainka and the forward air bases where bombers might be dispersed, refueled, or armed. We examine two levels of attack against Russian strategic aviation assets. The first involves targeting the two strategic air bases, Engels and Ukrainka, the training base at Ryazan', the Zhukovskiy Heavy Bomber Flight Test Center, the Kuybyshev and Kazan' heavy-bomber production facilities, and selected forward air bases. The second level of attack adds additional air bases to the target list that could be used for dispersing of strategic bombers, refueling tankers or establishing air bases for potential Russian fighter escorts. Table 4.11 provides a list of all air bases for the two levels of attack. A total of 19 W76 warheads are used in the first level of attack against Russian strategic aviation targets, and an additional 54 W76 warheads are used in the second level of attack.

The objective of the MAO-NF nuclear attack is to destroy strategic bombers and other aircraft on the ground, crater airfield runways, and damage other

FIGURE 4.52
Anadyr Air Base
Located in the Russian Far East region of Chuckchi at 54°48' N, 177°34' E, approximately 800 kilometers from the Alaskan mainland. Source: U.S. JOG NQ 59,60-16, Series 1501, Edition 1, "Compiled April 1969 from best available sources."

long-range aviation assets, such as POL storage and aircraft repair and production facilities. Using the PV system, we assess the vulnerability of Soviet-built aircraft and associated aviation targets to blast effects (see Table 4.12).[57] Of the three types of aircraft, helicopters are the most vulnerable to nuclear weapons, followed by long-range bombers and fighters. A single W76 air burst would damage Bear bombers on the ground over a 21-square kilometer area. Aircraft are judged least vulnerable to blast when directly facing the explosion. Table 4.12 clearly illustrates that it is necessary to detonate a W76 as a ground burst in order to destroy aircraft in concrete arch bunkers, as well POL and conventional ammunition storage.

In hard rock, a W76 ground burst is calculated to produce a crater of radius 41 meters and depth 17 meters. The W76 crater would be about 10 percent smaller in dry soil, and about twice as large if the warhead detonated over wet soil. As a result of the detonation of the W76 over hard rock, radioactive ejecta will be thrown out of the crater. At a distance of 90 meters from ground zero, the ejecta are calculated to have a depth of one meter. The runway at Ukrainka Air Base measures 3,500-meters-long by approximately 70-meters-wide in a geo-referenced Ikonos satellite image taken last year (see Figure 4.53). One W76 ground burst will be sufficient to crater the runway, making it impossible for heavy bombers to take off. Figure 4.53 is a January 17, 2000 Ikonos satellite image of the Ukrainka Air Base showing the runway pattern, revetments, and aircraft. On the satellite image, we have overlaid circles showing the radii for severely damaging the Bear bombers from the surface burst and from adjacent air bursts.

We assume that similar bombing patterns consisting of one surface burst and two air bursts would also be used in the attacks on Engels, Ryazan', and Ramenskoye, but we do not yet have the imagery or other map data to choose the ground zeros in

TABLE 4.11

Summary List of Air Base and Other Strategic Aviation Targets for MAO-NF

Target types include Air Defense Base (ADB), Arctic Staging (AS) Base, Civilian (CIV) Airfield, Strategic Bomber Base (SBB), Heavy Bomber Flight Test Center (HBFTC), Air Force Nuclear Training Center (AFNTC), Naval Aviation (NA), International Airport (IAP), Frontal (for Forward) Aviation Base (FAB), Medium Range Bomber Base (MRBB).

Level of Attack	Target Name	Target Type	Number of W76 Warheads
1	Anadyr'-Ugolnyye Kopi/ Leninka/Ugolny Airfield	ADB, AS, CIV	1
1	Engel's Airfield	SBB	3
1	Kazan State Aviation Plant	Plant, Airfield	2
1	Kuybyshev State Aviation Plant	Plant, Airfield	2
1	Ramenskoye/Zhukovskiy Airfield	HBFTC	3
1	Ryazan'/Dyagilevo Airfield	AFNTC	3
1	Tiksi Airfield	AS	1
1	Ukrainka Airfield	SBB	3
1	Vorkuta Airfield	AS	1
2	Artem N/Vladivostok/ Knevichi International Airport	NA-IAP	1
2	Bada N Airfield	FAB	1
2	Baltiysk Airfield	NA	1
2	Belaya Airfield	MRBB	1
2	Borgoy Airfield	FAB	1
2	Borzya NW Airfield	FAB	1
2	Chernyakhovsk Airfield	NA	1
2	Chita NW Airfield	UNKN	1
2	Chita/Kadala International Airport	FAB-IAP	1
2	Chkalovsk/Proveren/ Kaliningrad International Airport	NA-IAP	1
2	Domna Airfield	FAB	1
2	Galenki NE Airfield	FAB	1
2	Gorelovo Airfield	FAB	1
2	Ing-Puta Yuan-Pugoi NW Airfield	AS	1
2	Irkutsk SE/Ustinov International Airport	MRBB-IAP	1
2	Kamenka Airfield	MRBB	1
2	Khabarovsk NE/Novy/ Khabarovsk Novy International Airport	FAB-IAP	1
2	Khorol E Airfield	MRBB	1
2	Kipelovo Airfield	NA	1
2	Klin Airfield	FAB	1
2	Komsomol'sk South Airfield	FAB	1
2	Korsakov Airfield	NA	1
2	Kraskino SE Airfield	FAB	1
2	Kubinka/Tuchkvo Airfield	FAB	1
2	Lakhta/Kholm Airfield	ADB-NA-AS	1
2	Malyavr/Severomorsk-3 Airfield	NA	1
2	Marinovka Airfield	MRBB	1
2	Morozovsk SW Airfield	MRBB	1
2	Mozdok Airfield	MRBB	1
2	Nikolayevka Airfield	NA	1
2	Nivenskoye/Yezau Airfield	NA-HELO	1
2	Nyangi Airfield	FAB	1
2	Olen'ya/Olenegorsk Airfield	ADB-NA-AS	1
2	Olovyannaya Airfield	FAB	1
2	Ostrov/Gorokhovka (a) Airfield	NA-AS	1
2	Ostrov/Gorokhovka (b) Airfield	NA-AS	1
2	Petropavlovsk-Kamchatsky/ Yelizovo International Airport	NA-IAP	1
2	Romanovka W/Pristan Airfield	NA	1
2	Seshcha/Sesha Airfield	MRBB	1
2	Severomorsk/Severomorsk-1 Airfield	NA	1
2	Shatalovo/Pochinok SE Airfield	MRBB-FAB	1
2	Shaykovka/Gorodische Airfield	MRBB	1
2	Siverskiy Airfield	MRBB	1
2	Smurav'yevo/Gdov Airfield	MRBB	1
2	Sol'tsy Airfield	MRBB	1
2	Sovetskaya Gavan' Airfield	NA	1
2	Ulan-Ude/Mukhino International Airport	FAB-IAP	1
2	Unashi Airfield	FAB	1
2	Verino/Pereyaslavka Airfield	FAB	1
2	Voronezh SW/Voronezh S Airfield	MRBB-FAB	1
2	Vozdvizhenka/Ussuriysk-Vozdvizhenka Airfield	MRBB	1
2	Vozzhayevka NE Airfield	FAB	1
2	Yeysk Airfield	MRBB	1
2	Zavitinsk NE Airfield	MRBB	1

TABLE 4.12

Physical Vulnerability Data for Russian Aircraft and Other Aviation Targets

For aircraft, severe damage corresponds to: "damage which is beyond repair or requires extensive depot level repair consisting of structural failure of wings, control surfaces, fuselage, and main landing gear." For aircraft, moderate damage corresponds to: "damage to aircraft which requires extensive field level repair consisting of structural failure of control surfaces, fuselage components, and other than main landing gear such as nose, outriggers, or tail." The peak blast pressures corresponding to a 50 percent probability of achieving severe damage and the corresponding radii for air and surface bursts are computed for a 100-kiloton explosion, corresponding to the yield of the W76 warhead. Source: *NTDI Handbook,* pp. 550–551.

	VN for Severe Damage	VN for Moderate Damage	Peak Over-pressure or Dynamic Pressure for 50% Probability of Severe Damage in psi (100 kt)	Radius of Severe Damage in Meters (100 kt; burst at one kilometer height of burst)	Radius of Severe Damage in Meters (100 kt; ground burst)
Bear (TU-95) Long-range Bomber, Nose-on	12P0	12P0	10.0 (Over)	2,160	1,517
Bear (TU-95) Long-range Bomber, Random Orientation	09Q0	09Q0	0.8 (Dynamic)	2,831	2,143
Backfire Long-range Bomber, Nose-on	14P3	12P2	12.4 (Over)	1,885	1,357
Backfire Long-range Bomber, Random Orientation	11Q0	10Q1	1.6 (Dynamic)	2,035	1,578
Fishbed (MIG-21) Fighter, Nose-on	15P0	15P0	17.3 (Over)	1,404	1,152
Fishbed (MIG-21) Fighter, Random Orientation	12Q5	11Q3	1.8 (Dynamic)	2,139	1,666
Foxbat (MIG-25) Fighter, Nose-on	13P0	13P0	12.0 (Over)	1,931	1,382
Foxbat (MIG-25) Fighter, Random Orientation	12Q0	12Q6	2.3 (Dynamic)	1,949	1,542
Crusty (TU-134) Transport, Nose-on	12P0	12P0	10.0 (Over)	2,160	1,517
Crusty (TU-134) Transport, Random Orientation	09Q0	09Q0	0.8 (Dynamic)	2,831	2,143
May (IL-38) Antisubmarine Warfare Aircraft, Nose-on	12P0	12P0	10.0 (Over)	2,160	1,517
May (IL-38) Antisubmarine Warfare Aircraft, Random Orientation	09Q0	09Q0	0.8 (Dynamic)	2,831	2,143
Hind (Mi.24) Helicopter, Nose-on	08P0	07P0	4.8 (Over)	3,160	2,249
Hind (Mi.24) Helicopter, Random Orientation	07P0	06P0	4.0 (Over)	3,529	2,458
Aircraft bunker, concrete arch, inside width 11.4 meters (Failure of the arch or frame structure)	28P6	-	127.9 (Over)	—	475
Aircraft bunker, concrete arch, inside width 13.0 meters (Failure of the arch or frame structure)	32P7	-	239.0 (Over)	—	371
Aircraft bunker, concrete arch, inside width 16.0 meters (Failure of the arch or frame structure)	35P9	-	301.7 (Over)	—	340.0
Aircraft bunker, concrete arch, inside width 19.0 meters (Failure of the arch or frame structure)	30P3	-	229.8 (Over)	—	377.0
Aircraft bunker, steel A-frame, inside width 16.0 m (Failure of the arch or frame structure)	16P5	—	15.6 (Over)	1,558	1,210
POL Storage (Rupture of above-ground, exposed, steel, vertical-cylindrical tanks resulting in loss of contents)	21Q9	-	32.1 (Dynamic)	445	775
Conventional ammunition storage (Severe structural damage to munition storage igloos with 0.6 m of earth cover, resulting in light to severe damage to contents)	21P0		51.6 (Over)	122	695
BACK NET radar (Overturn)	12Q8	-	1.4 (Dynamic)	2,336	1,800
BACK NET radar (Distortion of Reflectors)	10Q4	-	0.9 (Dynamic)	2,678	2,037
SIDE NET radar (Structural Failure of Antenna Support)	11Q3	-	1.4 (Dynamic)	2,324	1,792
SIDE NET radar (Distortion of Reflectors)	10Q3	-	1.0 (Dynamic)	2,627	2,002

FIGURE 4.53
Air and Ground Bursts of W76 Warheads at Ukrainka Air Base
Inside the red circles the probability of destroying a Bear bomber (at a random orientation to the explosion) would be greater than 90 percent (assuming a CEP of 183 meters for 100-kt ground and air bursts). Source: spaceimaging.com.

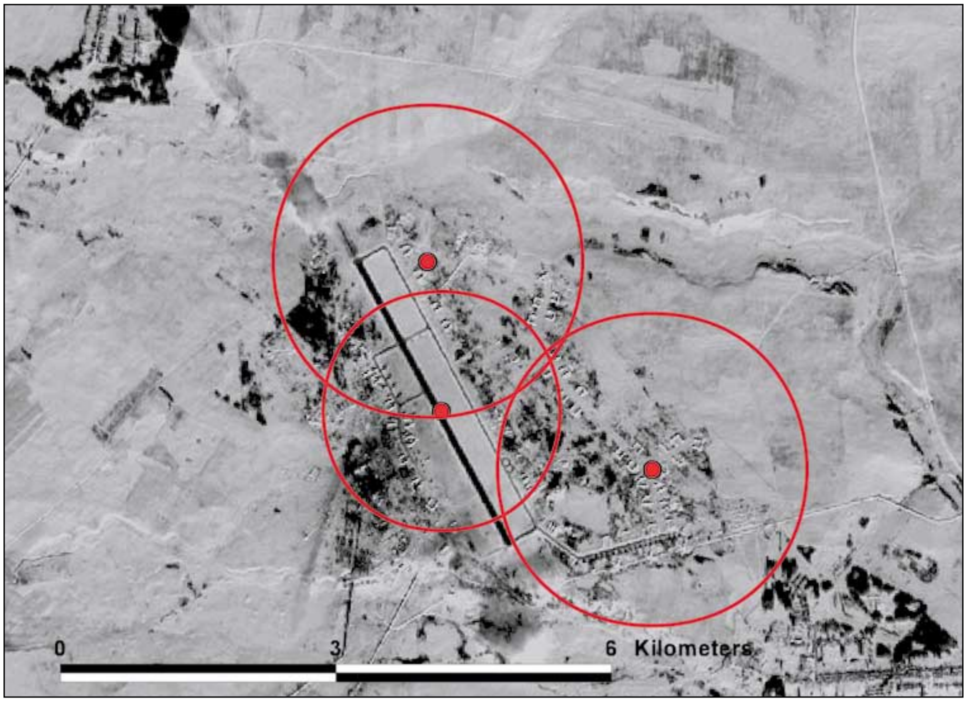


FIGURE 4.54
Kazan State Aviation Plant
Ikonos satellite image taken on April 20, 2000. Source: spaceimaging.com.

detail, as we did for Ukrainka. Both the Kazan and Kuybyshev Aviation Plants lie on the outskirts of major Russian cities. Figure 4.54 shows an Ikonos satellite image of the Kazan plant and adjacent airfield (Kazan North). In NRDC's MAO-NF, we assign a W76 ground burst to each plant and to the airfields adjacent to the plants. For forward and dispersal air bases in MAO-NF, we assign one 100-kt W76 ground burst at the center of each runway to crater it. Aircraft adjacent to the runway will have been destroyed, and since strategic bombers can't land or take off from the damaged airfield, any surviving aircraft would essentially be trapped. Fuel stores associated with the airfield, such as underground tanks, would therefore be rendered useless.

Casualties and Sensitivity Analysis

Figures 4.55 and 4.56 show the summary casualty data for the first and second levels of attack, respectively, against Russian strategic aviation targets as a function of warhead fission fraction and population sheltering. As we will see in the concluding section of this chapter, the attack on this component of Russia's nuclear forces represents the second-greatest threat to civilians, following the attack on Russian ICBM silos. The numbers of computed casualties decreases significantly under the assumption of residential sheltering, but does not continue to decrease substantially for multi-story or basement sheltering. This is due to the fact that most of the MAO-NF strategic aviation targets are quite close to urban areas. Figures 4.57 and 4.58 plot the casualties and fatalities by month for the first and second levels of attack, respectively, against Russian strategic aviation targets. Figure 4.59 maps the fallout patterns for the attack on priority (i.e., first level) Russian aviation targets in the vicinity of Moscow. We calculate an average of one million civilian casualties in the first level of attack and an average of two million civilian casualties in the second level of attack.

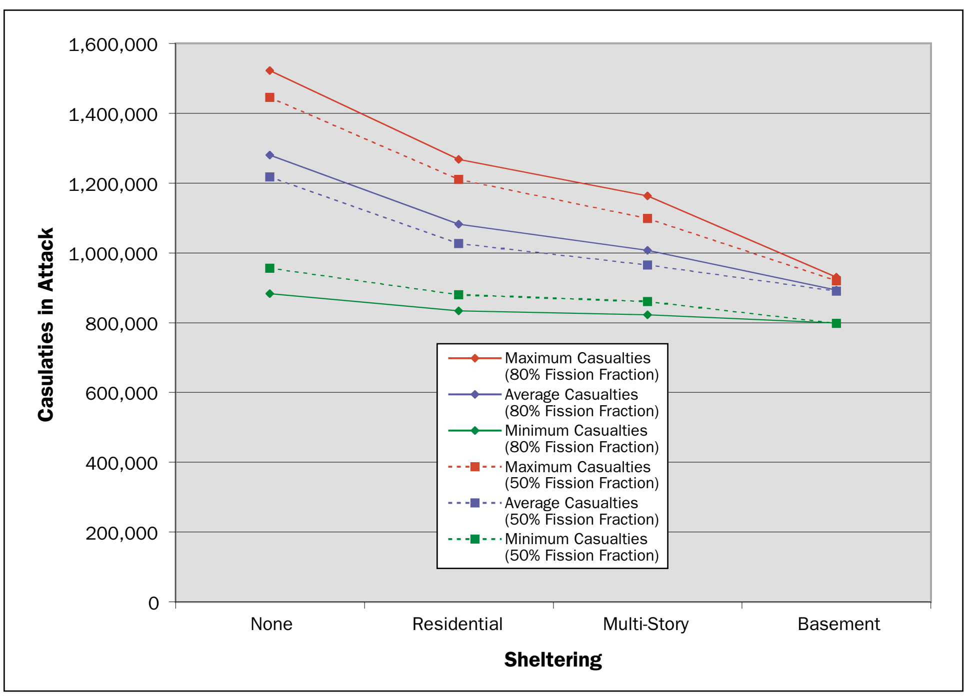


FIGURE 4.55
Summary Casualty Data for the First Level of Attack on Russian Long-Range Bomber Bases and Facilities

FIGURE 4.56
Summary Casualty Data for the Second Level of Attack on Russian Long-Range Bomber Bases and Facilities

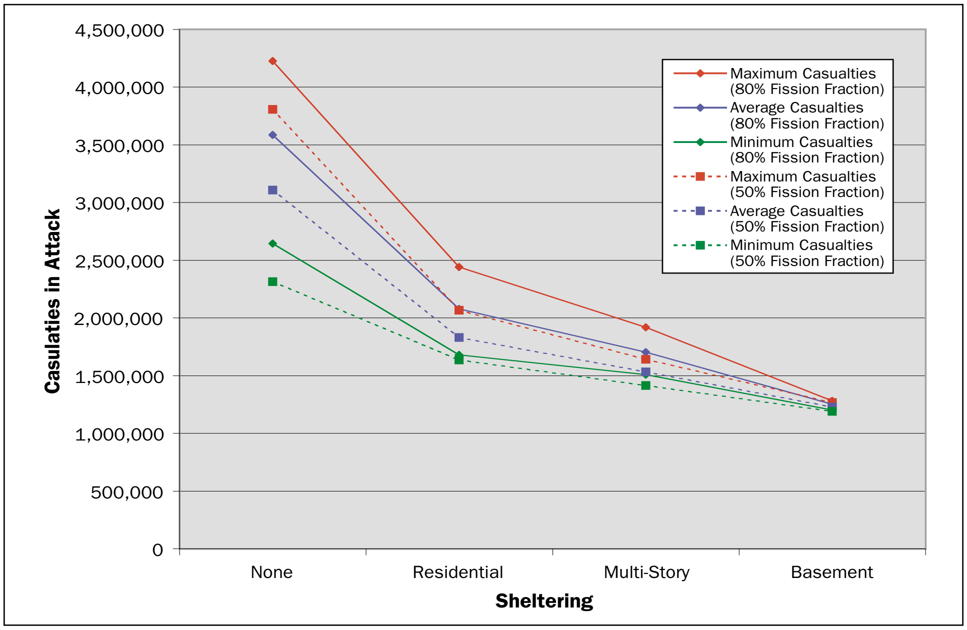


FIGURE 4.57
Monthly Variation in Casualties and Fatalities for the First Level of Attack on Russian Long-Range Bomber Bases and Facilities
Using the assumptions of no sheltering and a warhead fission fraction of 50 percent.

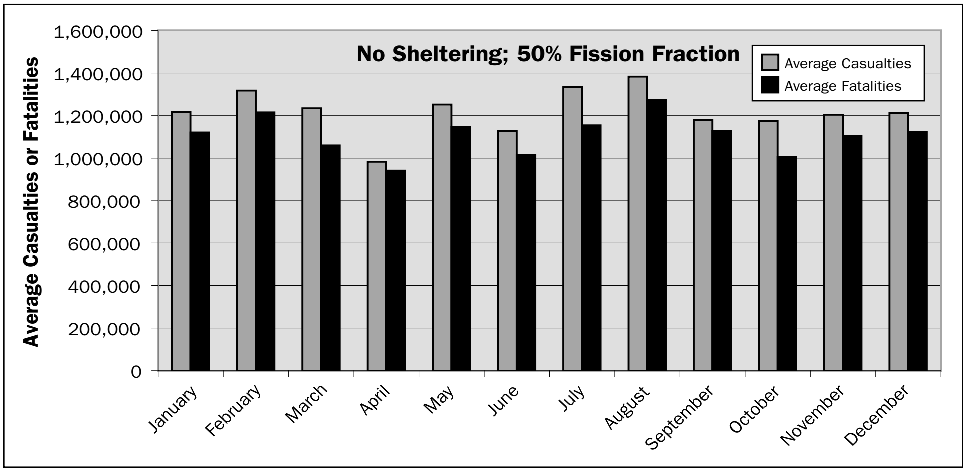
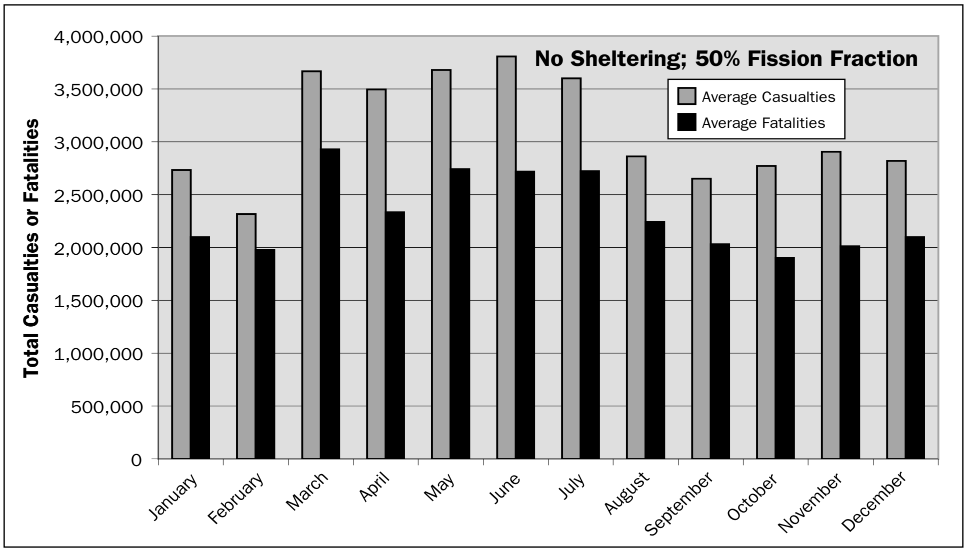


FIGURE 4.58
Monthly Variation in Casualties and Fatalities for the Second Level of Attack on Russian Long-Range Bomber Bases and Facilities
Using the assumptions of no sheltering and a warhead fission fraction of 50 percent.



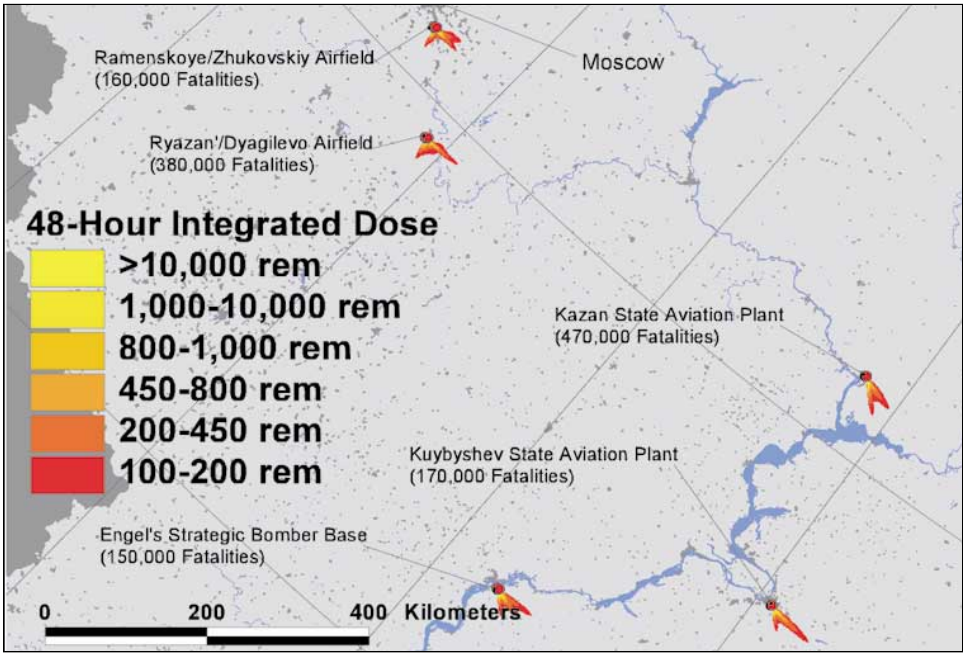


FIGURE 4.59
Fallout Patterns for Strategic Aviation Targets in the Moscow Area
From the first level of attack in NRDC's MAO-NF. This calculation uses the most probable wind patterns for the month of July, and assumes that the attacking W76 warheads have a fission fraction of 80 percent and the population is unsheltered.

NUCLEAR WEAPON STORAGE SITES

Description of Targets

The U.S. government does not know how many intact nuclear warheads are in Russia. The total number of nuclear warheads may be as great as 20,000, 6,000 of which are deployed with strategic forces. The number of non-strategic nuclear warheads is said to be between 6,000 and 13,000, with the actual number more likely near the upper limit.[58] It is not known outside of Russia, at least not by us, how many nuclear warheads are in storage awaiting disassembly.

We also do not know precisely how many nuclear warhead storage facilities Russia has. The U.S.-Russian Cooperative Threat Reduction Program (CTR, also referred to as the "Nunn-Lugar Program") and the Russian press refer to 123 nuclear weapon storage sites.[59] In a report on the CTR effort, *Tass* refers to "guarding the perimeters of 123 nuclear weapons depots, including 50 facilities of the Russian Defense Ministry."[60] A second *Tass* report refers to "123 nuclear weapons stores, [including] 23 Russian Strategic Missile Troops sites and 48 navy and air force facilities."[61] And a U.S. General Accounting Office (GAO) report indicates that, in response to a 1999 request from the Russian Navy, the U.S. Department of Energy is installing security systems at 42 Russian naval sites that store nuclear weapons.[62] While the 12th Main Directorate for Nuclear Weapons (12th GUMO) may have a presence at all nuclear warhead storage sites, these citations suggest that under the Ministry of Defense there are:

50 sites managed by the 12th Main Directorate
42 sites managed by the Navy[63]
23 sites managed by the Strategic Rocket Forces
8 sites managed by the Air Forces
123 sites total

Even if one accepts these numbers, it is unclear from the references how "site," "depot," and "facility" are defined—do these terms refer to a high-security area, one of perhaps several bunkers or buildings within a security area, or a larger site that may contain several such areas? We suspect that in the references above, it is the first: each refers to a high-security fenced area under guard.

The 50 sites managed by the 12th Main Directorate can be further subdivided into:

- National-level storage sites
- Regional level storage sites, also called rocket/repair technical bases (RTBs)
- Storage sites at nuclear weapon assembly/disassembly plants[64]

We are not able to identify all 123 storage sites, but in Table 4.13 and Figure 4.60, we list the 64 sites we have identified through a variety of open sources.

The Russian press recently provided a general description of Russian nuclear weapon storage sites.

> *Such installations are surrounded by two zones: an unprotected general zone and a protected "technical" zone. But that "protection" amounts to three barbed-wire barriers that, as a rule, are not connected to any alarm system. Within the technical zone, immediately surrounding the facility, there is another, "local" zone that's supposed to be secured 24 hours a day. But in reality the alarm sensors function at 50 percent of capacity at best.*[65]

In Figure 4.61, we represent our understanding of the layout of a typical national-level, nuclear weapons storage site managed by the 12th Main Directorate.

The Belgorod-22 (Golovchino) national nuclear weapon storage site is located about 17 kilometers from the Russian-Ukrainian border. Figure 4.62 is a map of Belgorod-22 derived from NRDC's analysis of a 1970 Corona satellite image (courtesy of Joshua

FIGURE 4.60
Known or Presumed Nuclear Weapon Storage Sites in Russia

Handler, Princeton University) and a contemporary U.S. JOG. Snow is visible on the ground in the Corona image except in the forested areas that are nearly identical in shape on the JOG. The Vorksa River flows in an inverted "V" just above a village labeled "Topoli" on the JOG, and the inverted-V-shaped bend in the Vorksa is faintly visible in the Corona image with its snow and ice covering. On the JOG, the road, which runs past Topoli, continues into the forested region and then forms a circle. In the Corona image, five to seven discrete nuclear weapon storage locations are visible as snow-covered patches spaced 300–700 meters apart along this circular road. Interestingly, no troop declarations are given for this area in the CFE data exchange.

Corona satellite images from three additional nuclear weapon storage sites in the Ural Mountains—Karabash (Mission 1115-1 of September 14, 1971), Nizhnyaya Tura (Mission 1016-2 of January 21, 1965) and Yuryuzan (Mission 1115-2 of September 20, 1971)—were also made available to NRDC by Joshua Handler. We geo-referenced these images to the corresponding JOGs using common features such as roads, railroads, streams and lakes. This enabled us to extract an overall length

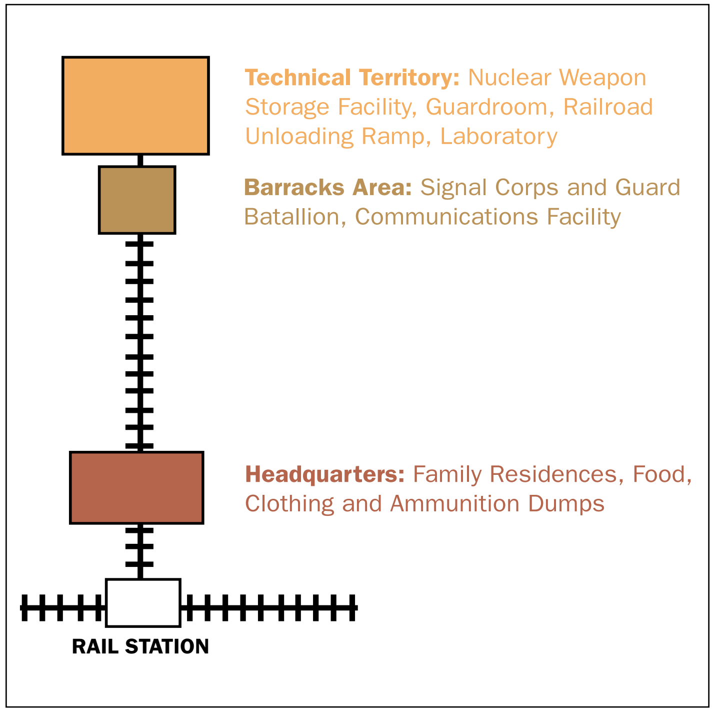
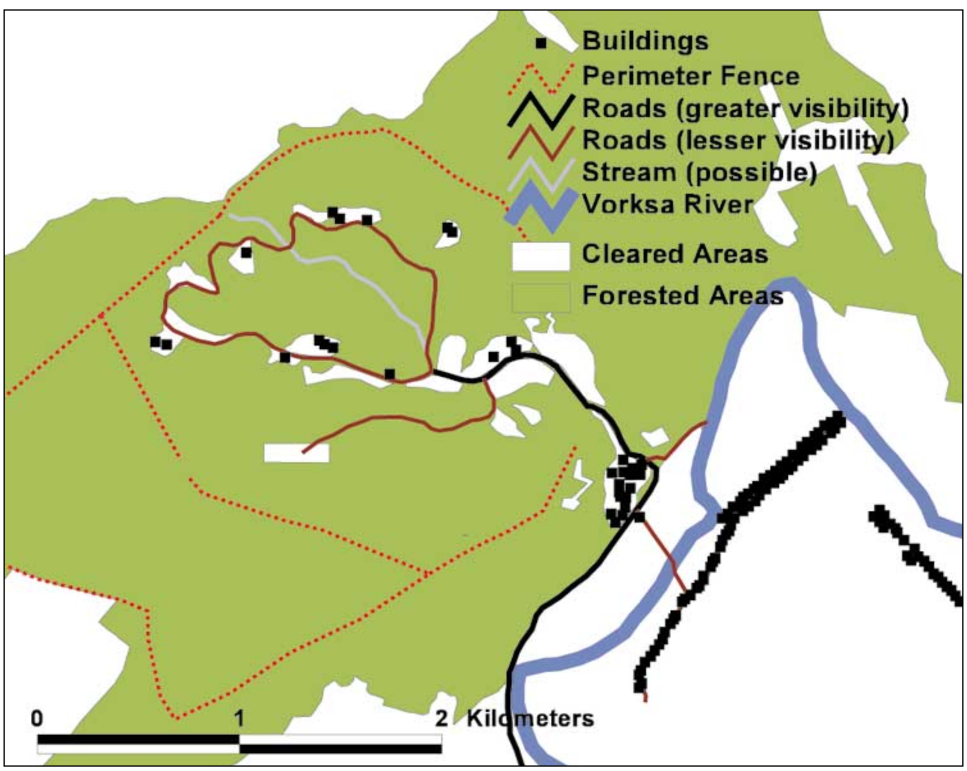


FIGURE 4.61 ▲
General Schematic of a Russian Nuclear Weapon Storage Site



◀ FIGURE 4.62
A Map of the Belgorod-22 Nuclear Weapon Storage Site
Located near the Russian-Ukrainian border.

TABLE 4.13

Known or Presumed Operational Nuclear Weapon Storage Sites in Russia

For four of these nuclea weapon storage sites, marked by an asterisk in the table, we do not yet have accurate coordinates.

Nuclear Warhead Storage Site Name	City, Region	Military District
National Level Storage Sites Maintained by the 12th Main Directorate		
Belgorod-22 Technical Territory	Golovchino, Belgorod region	Moscow
Bryansk-18 (Zhukovka) Technical Territory	Rzhanitsa, Bryansk Region	Moscow
Irkutsk-XX Technical Territory	Zanina (South of Zalari), Irkutsk Oblast	Transbaikal
Karabash/Chelyabinsk-XX Technical Territory	Karabash, Chelyabinskaya Oblast	Urals
Khabarovsk-XX Technical Territory	Khabarovsk, Khabarovsk Kray	Far East
Komsomolsk-na-Amure-XX Technical Territory	Bolon, South of Komsomol'sk-na-Amur, Khabarovsk Kray	Far East
Krasnoyarsk-26 Technical Territory	Dodonovo, Krasnoyarskiy Kray	Siberian
Mozhaysk-XX Technical Territory	Mozhaysk, Moskovskaya Oblast	Moscow
Murmansk-XX (Olenegorsk) Technical Territory	Olenegorsk, (East of) Murmanskaya Oblast	Northern
Nizhniy Tagil-XX (Nizhnyaya Tura) Technical Territory, Site 1	Lesnoy, Nizhnaya Tura, Yekaterinburgskaya Oblast	Urals
Nizhniy Tagil-XX (Nizhnyaya Tura) Technical Territory, Site 2	Nizhnyaya Tura, (Southwest of) Yekaterinburgskaya Oblast	Urals
Saratov-XX (Krasnoarmeyskoye) Technical Territory	Engel's, Saratovskaya Oblast	Volga
Sebezh-XX (Bulyzhino) Technical Territory	Bulyzhino, Pskovskaya Oblast	Northern
Sverdlovsk-XX Technical Territory*	Sverdlovsk, Yekaterinburgskaya Oblast	Urals
Vologda-XX (Chebsara) Technical Territory	Chebsara, Vologodskaya Oblast	Northern
Voronezh-XX (Borisoglebsk) Technical Territory	Borisoglebsk, Voronezhskaya Oblast	Moscow
Yuryuzan Technical Territory	Trekhgornyy, South of Yuryuzan', Chelyabinskaya Oblast	Urals
Sites at Nuclear Weapon Assembly/Disassembly Plants		
Penza-19 Site 1 (Bermed Structures) Nuclear Warhead Storage Facility	Zarechnyy/Seliksa, 13 km East of Penza, Penzenskaya Oblast	Volga
Sarov-Avangard Nuclear Warhead Storage Facility	Sarov, Mordovskaya Republic	Volga
Sites Managed by the Navy or the 12th GUMO		
Konyushkov Bay/Abrek Bay Nuclear Warhead Storage Facility	Tikhookeanskiy; SE of Vladivostok, Primorskiy Kray	Far East
Lakhta/Kholm Airfield Nuclear Warhead Storage Facility	Arkhangel'skaya Oblast	Northern
Olen'ya/Olenegorsk Airfield Nuclear Warhead Storage Facility	Olenegorsk, Murmanskaya Oblast	Northern
Ostrov Airfield Nuclear Warhead Storage Facility	Ostrov, Pskovskaya Oblast	Northern
Primorskiy area Nuclear Warhead Storage Facility*	Unknown	Far East
Rybachiy peninsula/Petropavlovsk area (Military Unit 95051)	Krasheninnikova Bay, Kamchatskaya Oblast Nuclear Warhead Storage Facility	Far East
Severodvinsk Nuclear Warhead Storage Facility	Severodvinsk, Arkhangel'skaya Oblast	Northern
Sovetskaya Gavan' Airfield Nuclear Warhead Storage Facility*	Sovetskaya Gavan', Khabarovskiy Kray	Far East
St. Petersburg Area Nuclear Warhead Storage Facility	St. Petersburg area, Leningradskaya Oblast	Northern
Sites Managed by the Strategic Rocket Forces		
Aleysk-XX RTB	Aleysk, Altayskiy Kray	Siberian
Barnaul-XX RTB	Barnaul, Altayskiy Kray	Siberian
Bershet'-XX RTB	Bershet', Perm' Oblast	Urals
Dombarovsky-XX RTB	Dombarovskiy, Orenburgskaya Oblast	Volga
Drovyanaya-XX RTB	Drovyanaya, Aginski Buryat A. Okrug	Transbaikal
Irkutsk-XX RTB	Irkutsk, Irkutsk Oblast	Transbaikal

Nuclear Warhead Storage Site Name	City, Region	Military District
Kansk-XX RTB	Kansk, Krasnoyarskiy Kray	Siberian
Kartaly-XX RTB	Kartaly, Chelyabinskaya Oblast	Urals
Kostroma-XX RTB	Kostroma, Kostromskaya Oblast	Moscow
Kozelsk-XX RTB	Kozelsk, Kaluzhskaya Oblast	Moscow
Krasnoyarsk-XX (Achinsk) RTB	Krasnoyarsk, Krasnoyarskiy Kray	Siberian
Nizhniy Tagil-XX RTB	Nizhiy Tagil, Yekaterinburgskaya Oblast	Urals
Novosibirsk-XX RTB	Novosibirsk, Novosibirskaya Oblast	Siberian
Tatishchevo-5 RTB	Tatishchevo, Saratovskaya Oblast	Volga
Teykovo-XX RTB	Teykovo, Ivanovo Region	Moscow
Uzhur-XX RTB	Uzhur, Krasnoyarskiy Kray	Siberian
Vypolzovo-XX RTB	Vypolzovo, Tver' Oblast	Moscow
Yoshkar-Ola-XX RTB	Yoshkar-Ola, Mariyskaya Republic	Volga
Yur'ya-XX RTB	Yur'ya, Kirovskaya Oblast	Urals
Sites Managed by the Air Forces or the 12th GUMO		
Belaya Airfield Nuclear Warhead Storage Facility	Mikhaylovka, Irkutsk Oblast	Transbaikal
Engels Airfield Nuclear Warhead Storage Facility	Engel's, Saratovskaya Oblast	Volga
Irkutsk Airfield Nuclear Warhead Storage Facility*	Irkutsk, Irkutsk Oblast	Transbaikal
Kaliningrad/Chernyakhovsk Airfield Nuclear Warhead Storage Facility	Kaliningrad Region	Moscow
Kamenka Airfield Nuclear Warhead Storage Facility	Kamenka, Penzenskaya Oblast	Volga
Khorol East Airfield Nuclear Warhead Storage Facility	Khorol', Primorskiy Kray	Far East
Ryazan/Dyagilevo Airfield Nuclear Warhead Storage Facility	Ryazan', Ryazanskaya Oblast	Moscow
Seshcha/Sesha Airfield Nuclear Warhead Storage Facility	South-East of Roslav', Bryansk Region	Moscow
Shatoalovo/Pochinok SE Airfield Nuclear Warhead Storage Facility	Pochinok, (South of) Smolensk Oblast	Moscow
Shaykovka/Gorodische Airfield Nuclear Warhead Storage Facility	Gorodische, Smolensk Oblast	Moscow
Siverskiy Airfield Nuclear Warhead Storage Facility	Siverskiy, Leningradskaya Oblast	Northern
Smurav'yevo/Gdov Airfield Nuclear Warhead Storage Facility	Gdov, Pskovskaya Oblast	Northern
Sol'tsy Airfield Nuclear Warhead Storage Facility	Sol'tsy, Novgorodskaya Oblast	Northern
Ukrainka Airfield Nuclear Warhead Storage Facility	Vernoye, Amurskaya Oblast	Far East
Voronezh SW/Voronezh S Airfield Nuclear Warhead Storage Facility	South of Voronezh, Voronezhskaya Oblast	Moscow
Vozdvizhenks Airfield Nuclear Warhead Storage Facility	North of Ussuriysk, Primorskiy Kray	Far East
Zavitinsk NE Airfield Nuclear Warhead Storage Facility	Zavitinsk, Amurskaya Oblast	Far East

scale for the images and to assess the likely spacing of bunkers for Soviet-built nuclear weapon storage sites. This process was limited in accuracy of course by the vintage of the satellite images and the reasonable guesses that had to be made regarding identification of bunkers. We also had to make assumptions about the spacing of bunkers and their hardness in order to construct the MAO-NF attack, as discussed below.

Warhead Requirements and Aimpoints

The NTDI Handbook lists target category 604 X0, "assembly and storage facilities for nuclear weapons and components,"[66] and the current U.S. Intelligence Data Handling System lists target categories 604 00, "Nuclear Weapons Storage," and 604 20, "Nuclear weapons storage site, operational," suggesting continuity between them.

The NTDI Handbook describes severe and moderate damage for 13 underground or earth-mounded storage structures, (see Table 4.14). We assume that the "national bunker" structure type refers to the Soviet-built national, nuclear weapon storage sites discussed above. We found an example of a "Type III (Cruciform)" storage bunker in a declassified 1963 CIA Photographic Intelligence Report: "Regional Nuclear Weapons Storage Site Near Berdichev, USSR."[67] This report discusses the similarity between cruciform bunkers near Berdichev in present-day Ukraine, and near Dolon Airfield in present-day Kazakhstan. As the name suggests, the storage bunkers are cross-shaped, earth-mounded, drive-through buildings measuring 60 by 53 meters. The two cruciform bunkers at Berdichev were measured to be 990 meters apart.

Casualties and Sensitivity Analysis

We explore an attack by eight W76 warheads on each of the 17 National-Level nuclear weapon storage sites (136 warhead for a total yield of 13.6 Mt), and take into

TABLE 4.14
Physical Vulnerability Data for Soviet-Built Nuclear Weapon Storage Facilities
A CEP of 130 meters and ground bursts were assumed for the W88 and W76 damage radius calculations. Source for the vulnerability numbers: *NATO Target Data Inventory Handbook* (1989)

Type	VN, Severe Damage	Severe Damage Radius, 475-kt W88 (m)	Severe Damage Radius, 100-kt W76 (m)	VN, Moderate Damage	Moderate Damage Radius, 475-kt W88 (m)	Moderate Damage Radius, 100-kt W76 (m)
National bunker	46P8	299	156	44L8	330	171
Direct support bunker	46P8	299	156	44L8	330	171
Type I (Nuclear Capable)	36L9	649	308	34L9	739	353
Type II (Guitar)	36L9	649	308	34L9	739	353
Type III (Cruciform)	36L9	649	308	34L9	739	353
Type IV (ASM)	36L9	649	308	34L9	739	353
Type V (ASM MOD)	36L9	649	308	34L9	739	353
Type VI	37P9	615	296	31P7	751	398
Type VII (Arys Mod)	34L9	739	353	31L6	679	371
Type VIII	34P7	606	323	30P5	712	397
Type XI (Arys)	44L7	304	163	43L7	324	174
Type VIII (Single Bay)	34P1	468	276	30P5	712	397
Vault	38P1	360	212	34P1	468	276

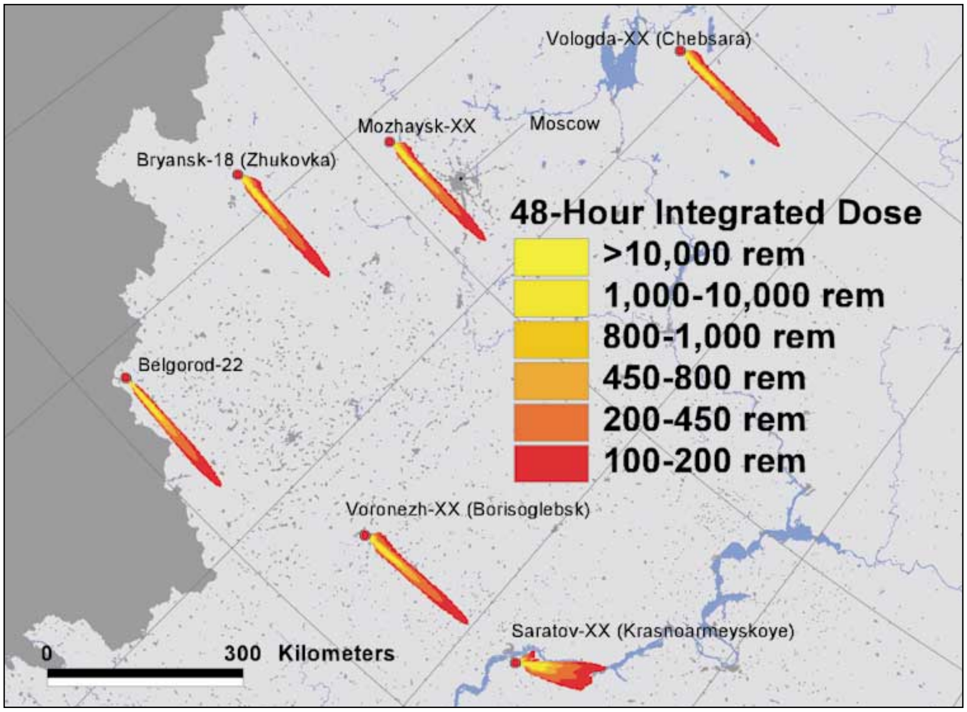


FIGURE 4.63
A Map of the Attack on the National-Level Storage Sites in the Vicinity of Moscow
In this calculation six storage sites are attacked by a total of 48 W76 warheads with a total yield of 4.8 megatons. The most probable winds for the month of November are used in the calculation. We assumes warhead fission fractions of 80 percent and an unsheltered population. A total of 1.4 million casualties are calculated, including 870,000 fatalities.

account seasonal variations in the wind, fission fractions of the weapons, and sheltering of the population. Because of the high weapon requirement for warhead storage sites, and because these targets do not need to be destroyed within an urgent timeframe under the likely guidance in the SIOP, an attack on only 17 sites is probably indicative of the U.S. warhead assignment in the actual SIOP and is what we model in our MAO-NF.

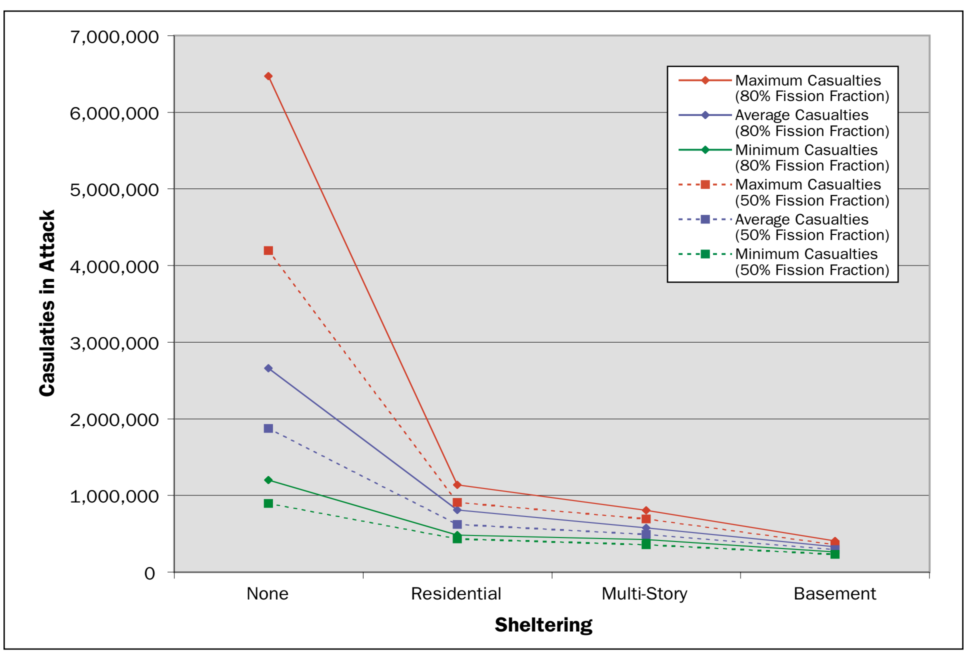


FIGURE 4.64
Summary Casualty Data for an Attack on the Russian National-Level Nuclear Warhead Storage Sites as a Function of Population Sheltering

FIGURE 4.65
Monthly Variation in Casualties and Fatalities for an Attack on the Russian National-Level Nuclear Warhead Storage Sites

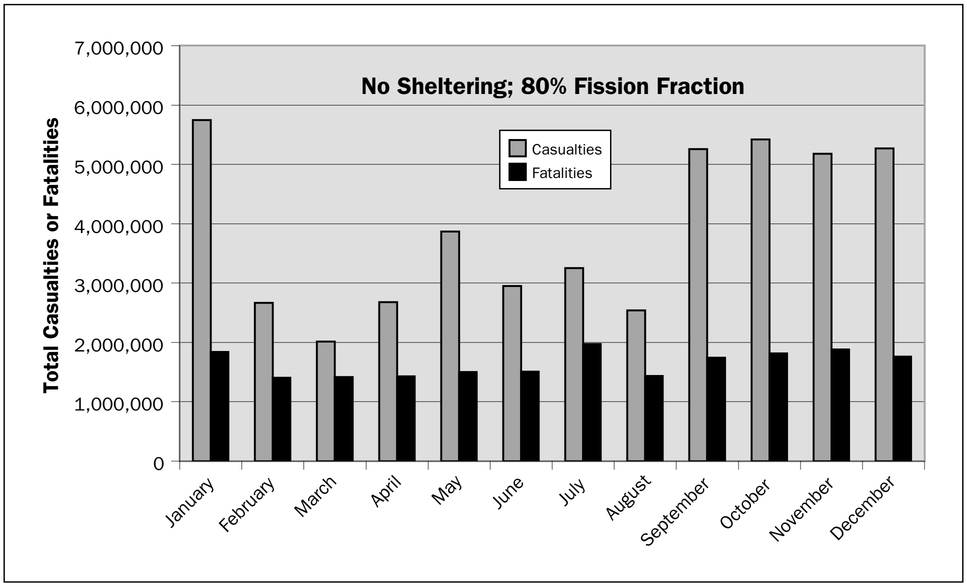


Figure 4.63 displays the nuclear warhead storage targets in the central and southern portions of European Russia, and the associated fallout patterns from the MAO-NF attack. Figure 4.64 provides a summary of the casualty calculations for the attack on the national-level nuclear warhead storage sites. As the figure illustrates, even a minimal level of population sheltering during the first 48 hours after the attack drastically reduces the number of computed casualties. We compute that between 355,000 and 1.1 million civilian casualties result from the MAO-NF attack on Russian national-level nuclear warhead storage sites, including between 290,000 and 740,000 fatalities. As we will see in the concluding section of this chapter, this component of Russia's nuclear forces ranks third in terms of a threat to civilians.

THE NUCLEAR WEAPON DESIGN AND PRODUCTION COMPLEX

Description of Targets

The core of the Russian (and formerly Soviet) nuclear weapon design and production complex is composed of ten closed cities and one open city (see Figure 4.66 and Table 4.15). What transpired at these locations throughout the Cold War was a central security concern for the United States and West Europe for more than 40 years.[68] This complex researched, developed, tested, and produced the nuclear weapons that were provided to Soviet armed forces and that were deployed widely against western militaries. As these secret cities were discovered through U.S. intelligence means beginning in the 1950s, they became some of the highest priority targets of U.S. nuclear forces. No doubt many or all remain on the target list today.

The Russian government continues to operate the complex at a much reduced pace, but with high levels of security. As satellite imagery and declassified U.S. military maps reveal, certain plants are extremely large and most of the facilities have extensive fencing. The ten closed cities that make up the complex have a combined population of three-quarters of a million people, and the population of the

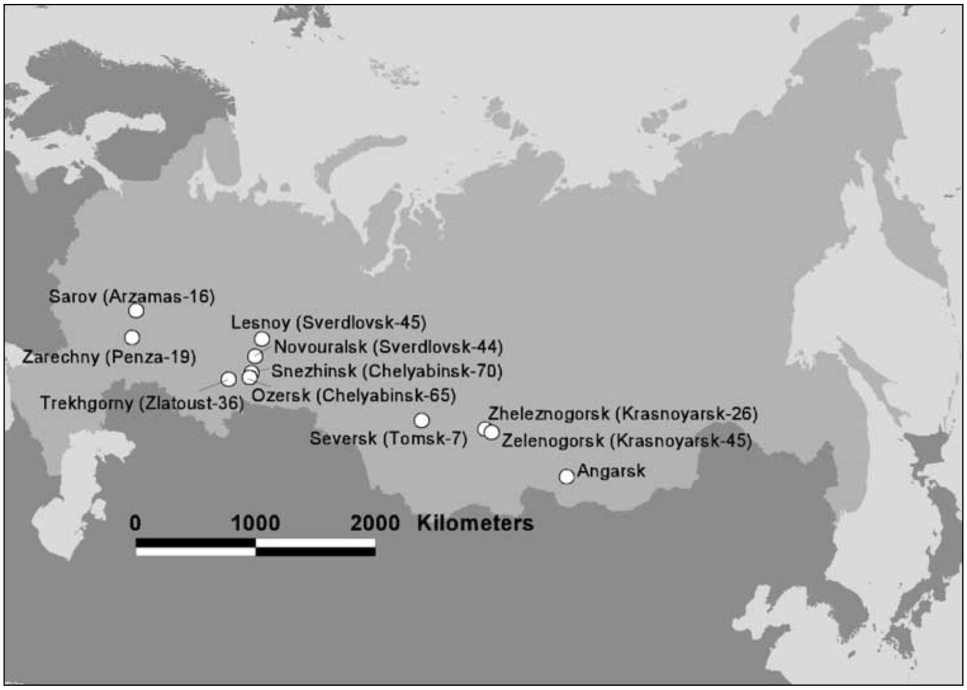


FIGURE 4.66
The Ten Closed Cities and One Open City (Angarsk) of the Russian Nuclear Weapon Design and Production Complex

open city of Angarsk was 286,000 in 1989. Only a fraction of those people, an estimated 67,000, perform nuclear program work and are paid out of the Ministry of Atomic Energy's (Minatom) budget.[69]

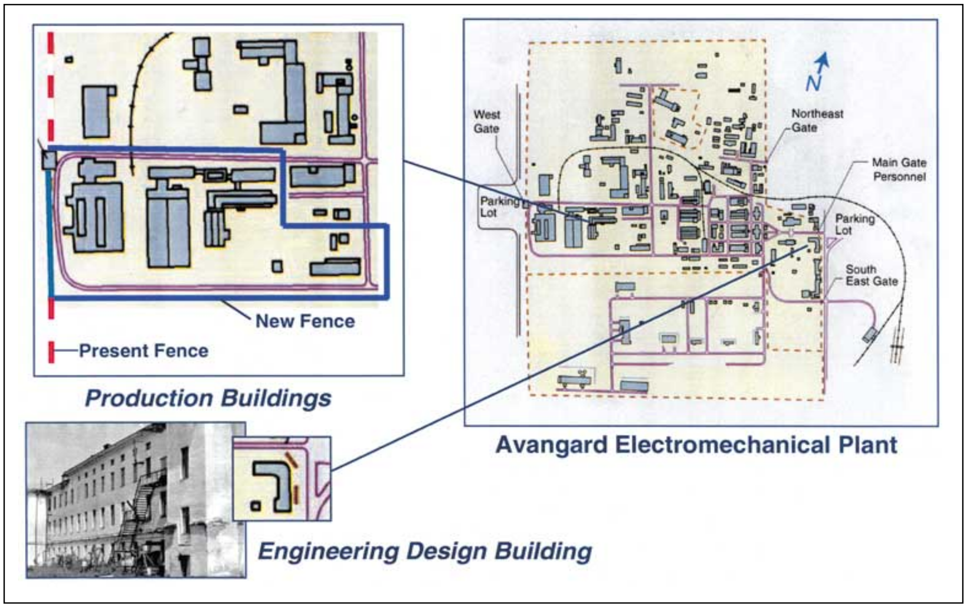
Attacking the complex would destroy key facilities that contribute to the research, development, and production of Russia's nuclear weapons. The goal of an attack on the Russian nuclear weapons complex would be to eliminate any future nuclear weapon design and production capability. The attacked facilities include design laboratories, plutonium and tritium production reactors, chemical separation plants, uranium enrichment plants, warhead assembly, and component plants. It should be said that the level of activity at many of the sites is quite low compared to past decades, and some of the facilities at these sites are shut down.

Warhead Requirements and Aimpoints

Our MAO-NF counterforce attack theoretically does not target cities as such. That there are always attractive military targets in urban areas poses a dilemma for nuclear war planners, whose guidance may be to avoid civilian casualties as much as possible. As we show in the next section, this issue is especially pronounced for attack scenarios that call for hitting command, control, and communication targets, which are often in the middle of cities. In fashioning an attack against the Russian nuclear weapons design and production complex, we are confronted with a similar problem of what facilities to target, and how to target them. With tens of thousands of people living in close proximity to the plants and laboratories, an attack using even a single weapon will result in large numbers of casualties.

For purposes of attacking facilities in the Russian nuclear weapons design and production complex, the NTDI Handbook lists four relevant target categories:

FIGURE 4.67
The Sarov Avangard Warhead Production Plant
This production plant is also the target shown in the lower left corner of Figure 4.68. Source: Los Alamos National Laboratory View-Graph.



▸ Nuclear reactors used for the production of fissionable materials and for the generation of heat
▸ Installations for the production of uranium-235 and lithium, which are used primarily in weapons
▸ Installations that perform research and development, design, and fabrication of fissionable material components and related nuclear components of weapons
▸ Assembly and storage facilities for nuclear weapons and components[70]

The general vulnerability numbers for severe and moderate damage are provided for the third category:

FIGURE 4.68
Sarov
Ikonos satellite image taken on February 26, 2000, and displayed here at 16-meter resolution. The plume in the center of the image originates at the location of the test reactor area of the laboratory, just southeast of the Design Bureau (upper right target) and directly east of the Avangard warhead production plant (lower left target). The inner white circles correspond to the severe damage radii and the outer white circles correspond to the moderate damage radii for a 100 kt warhead at a height of burst of 400 meters. Source: spaceimaging.com.

TABLE 4.15
Targeting Information for the Russian Nuclear Weapons Design and Production Complex

Contemporary Name	Soviet Designation	Function	Workforce[72]	Population[73]	Number of W76 Warheads
Sarov	Arzamas-16	Nuclear Weapons Design; Serial Production of Nuclear Weapons	21,500	83,000	2
Snezhinsk	Chelyabinsk-70	Nuclear Weapons Design	15,000	48,000	4
Lesnoy	Sverdlovsk-45	Serial Production of Nuclear Weapons	10,000	58,000	4
Zarechny	Penza-19	Serial Production of Nuclear Weapons	11,000	64,000	1
Trekhgorny	Zlatoust-36	Serial Production of Nuclear Weapons	6,400	33,000	2
Ozersk	Chelyabinsk-65	Tritium Production (Reactors, Reprocessing, Waste, MOX Fuel Fabrication); Plutonium and Tritium Warhead Component Fabrication	12,000	88,000	4
Seversk	Tomsk-7	Plutonium Production (Reactors and Reprocessing); HEU Production; Plutonium and HEU Warhead Component Fabrication	15,000	119,000	5
Zheleznogorsk	Krasnoyarsk-26	Plutonium Production (Reactors and Reprocessing)	8,300	100,000	2
Zelenogorsk	Krasnoyarsk-45	HEU Production	10,000	67,000	1
Novouralsk	Sverdlovsk-44	HEU Production	15,000	96,000	3
Angarsk	Angarsk (?)	Uranium Enrichment	?	286,000 (1989 Soviet Census)	1

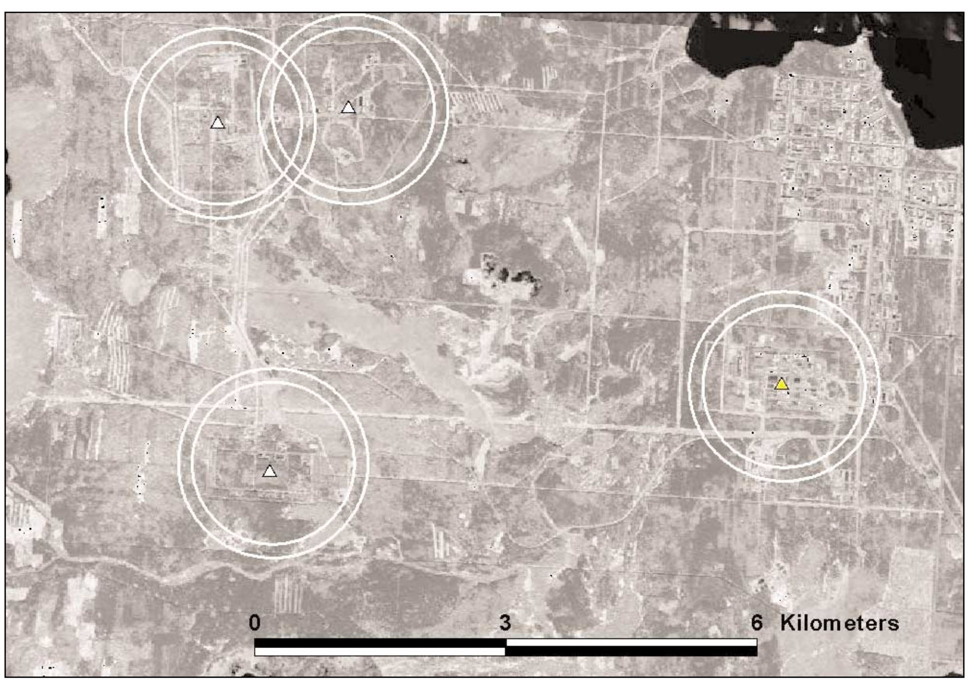
TABLE 4.16
Casualty and Fatality Data for the Attack on the Russian Nuclear Weapons Design and Production Complex

City Name	Population[74]	Casualties, Blast Model	Fatalities, Blast Model	Fatalities, Superfires Model	Number of W76 Warheads
Sarov	83,000	73,000	35,000	89,000	2
Snezhinsk	48,000	6,500	1,600	7,500	4
Lesnoy	58,000	62,000	43,000	58,000	4
Zarechny	64,000	20,000	11,000	21,600	1
Trekhgorny	33,000	7,400	1,700	6,100	2
Ozersk	88,000	11,500	3,400	5,900	4
Seversk	119,000	60,000	26,000	56,500	5
Zheleznogorsk	100,000	1,000	400	1,000	2
Zelenogorsk	67,000	7,000	1,400	8,600	1
Novouralsk	96,000	30,000	16,000	31,000	3
Angarsk	286,000 (1989 Soviet Census)	72,500	7,500	85,000	1
Summary	946,000	350,900	147,000	370,200	29

FIGURE 4.69
Ozersk
Ikonos satellite image taken on February 24, 2000, and displayed here at 16-meter resolution. The frozen lake at the top center-right is Lake Kyzyltash. Targets include the plutonium pit production facility, plutonium production reactors (shut down), tritium production reactors (operating), and fissile material storage areas. The inner white circles correspond to the severe damage radii and the outer white circles correspond to the moderate damage radii for a 100 kt warhead at a height of burst of 400 meters. Source: spaceimaging.com.

VN 19Q7 predicts severe damage to the installation consisting of severe damage to the principal production building, severe damage to machinery and equipment in the building and associated damage generally as follows: severe damage to supplies, parts and assemblies in process and finished products; severe damage to electric switches and circuit breakers; collapse of switchyard frames; collapse of overhead gas mains; and interruption of water supply due to electric power loss.

FIGURE 4.70
Snezhinsk
Ikonos satellite image taken on July 18, 2000, and displayed here at 16-meter resolution. The targets include the Site 20 reactor area, the Site 9 theoretical division (nuclear weapons design) and the Site 10 explosives plant. The inner white circles correspond to the severe damage radii and the outer white circles correspond to the moderate damage radii for a 100 kt warhead at a height of burst of 400 meters. Source: spaceimaging.com.



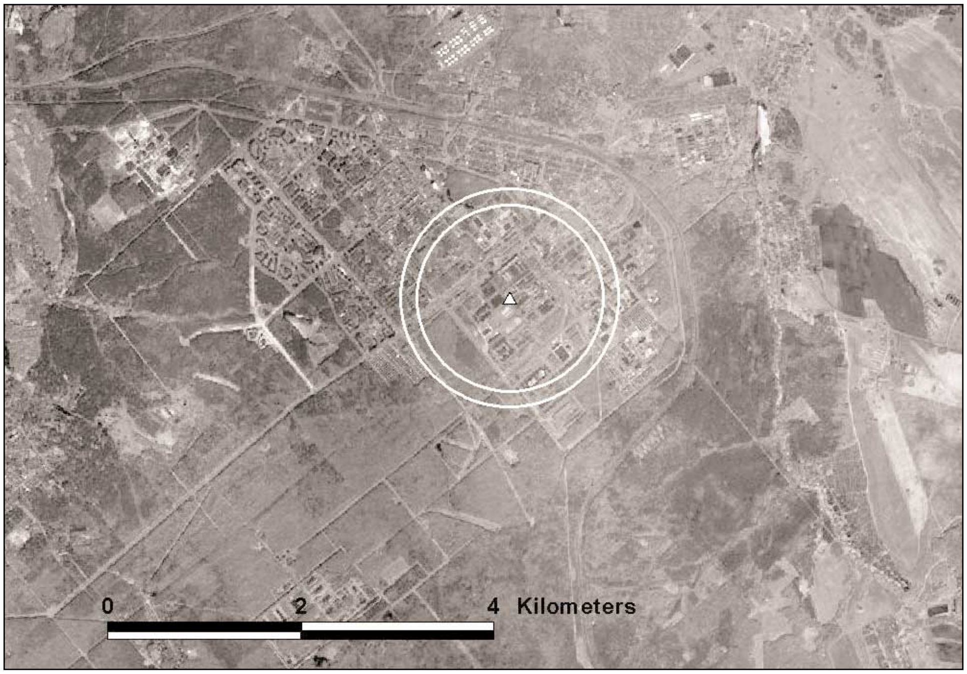


FIGURE 4.71
Zarechny
Ikonos satellite image taken on June 12, 2000, and displayed here at 16-meter resolution. We have targeted the Start Production Association nuclear warhead component fabrication and nuclear warhead assembly plant. The inner white circle corresponds to the severe damage radius and the outer white circle corresponds to the moderate damage radii for a 100 kt warhead at a height of burst of 400 meters. Source: spaceimaging.com.

VN 17Q7 predicts moderate damage to the installation consisting of at least moderate structural damage to the principal production building, moderate damage to machinery and equipment in the building and associated damage generally as follows: moderate to severe damage to supplies, parts and assemblies in process and finished products, severe damage to electric switches and circuit breakers; collapse of switchyard frames; collapse of overhead gas mains; and interruption of water supply due to electric power loss.[71]

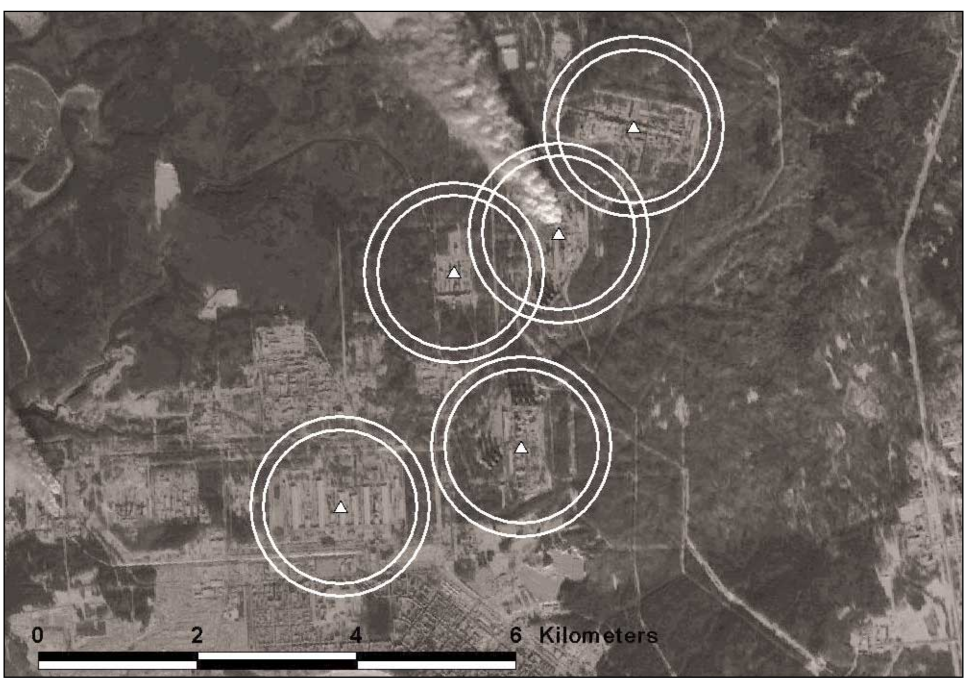


FIGURE 4.72
Seversk
Ikonos satellite image taken on July 10, 2000, and displayed here at 16-meter resolution. Note the plume from the plutonium production reactor. We have targeted the Siberian Chemical Combine. The inner white circles correspond to the severe damage radii and the outer white circles correspond to the moderate damage radii for a 100 kt warhead at a height of burst of 400 meters. Source: spaceimaging.com.

FIGURE 4.73
Angarsk
Ikonos satellite image taken on February 19, 2000, and displayed here at 16-meter resolution. The inner white circle corresponds to the severe damage radius and the outer white circle corresponds to the moderate damage radius for a 100 kt warhead at a height of burst of 400 meters. Source: spaceimaging.com.

We have chosen the 100 kt W76 warhead to attack the key facilities at the eleven cities. The optimum height of burst for a W76 warhead attacking a target with a vulnerability number of 19Q7 is 400 meters. The corresponding severe damage radius is calculated to be 1.05 km, and the moderate damage radius is calculated to be 1.23 km. Figure 4.67 shows a diagram of the Avangard nuclear weapons production plant, one of the two targets near the city of Sarov. Figures 4.68 to 4.73 show the specific choices of targets and damage radii superimposed on 16-meter-resolution satellite images of the Russian nuclear weapons design and production complex that were taken in 2000. Table 4.15 summarizes the targeting information for the Russian nuclear weapons design and production complex.

Casualties and Sensitivity Analysis

With respect to the civilian casualties, a thermal flux of 10 cal/cm^2 (the expected zone of mass fires) would occur at 4.5 km from ground zero, a peak overpressure of 12 psi (where 98 percent of the population are expected to be fatalities in the OTA model) would occur at 1.4 km, a peak overpressure of 5 psi (50 percent fatalities) would occur at 2.4 km, and a peak overpressure of 2 psi (5 percent fatalities) would occur at 4.4 km from ground zero. For a yield of 100 kt and a height of burst of 400 meters, there would be no local fallout. Table 4.16 provides summary casualty and fatality data for the attack on the Russian nuclear warhead design and production complex. We contrast results from the two models for computing casualties (blast versus superfires). Total casualties from the blast model are 350,000 and total fatalities are 147,000. Total fatalities from the superfires model are 371,000.

COMMAND, CONTROL, AND COMMUNICATIONS

Description of Targets

In the actual U.S. SIOP, we assume that degrading communications between the Russian political-military leadership and Russian nuclear forces in the field would be a high priority. Further disruption of Russian command and control of nuclear forces is pursued in MAO-NF by targeting regional nuclear forces headquarters.

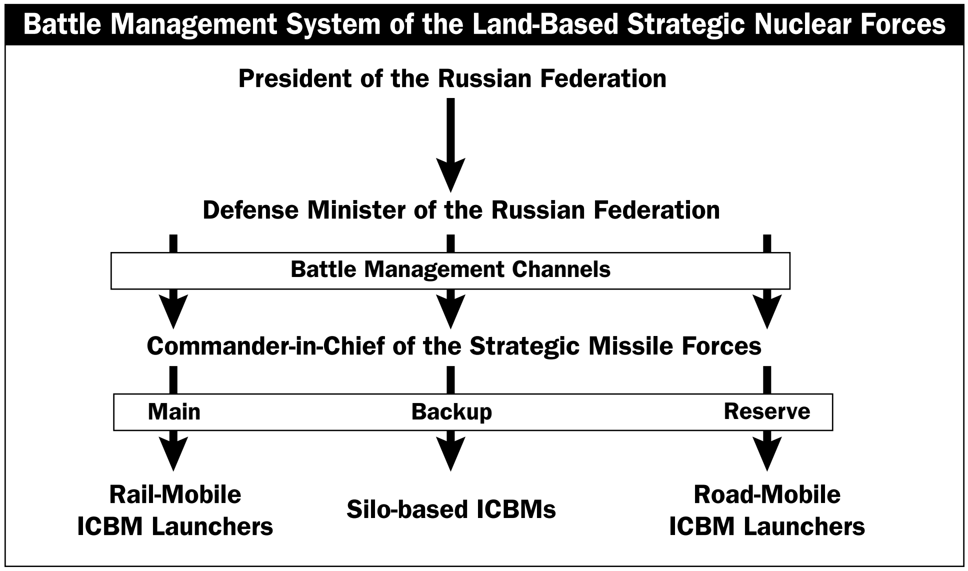
A complete targeting solution for command, control, and communications, or C^3, would include a detailed analysis of how communications flow between the Russian leadership and deployed nuclear forces in a time of crisis. A recent Russian-government publication includes a diagram of the communication pathways between the president and deployed nuclear forces (see Figure 4.74). Below a certain level of command, three parallel paths exist, and evidently serve to provide redundancy in the event of a U.S. attack. Nonetheless, it is likely that destroying a sub-set of all C^3 targets would effectively degrade communications, because a critical sub-set of all C^3 targets probably serves as principal nodes in the system when viewed as a whole. We do not have sufficient data to perform such a nodal analysis. Rather, we have collected open-source information on Russian C^3 assets in order to get a first glimpse at the effects of this component of MAO-NF.

In the NRDC Russian target database, there are currently 362 records for the class of Leadership-C^3 (L-C^3). The categories of targets in this category include (with the number of targets in each category given in parenthesis):

- National government leadership/support (10)
- National-level civilian leadership/support (43)
- National-level military leadership/support (24)
- National-level war support industry leadership (25)
- Intermediate-echelon strategic leadership (13)
- Intermediate-echelon non-strategic nuclear leadership (33)
- Intermediate-echelon non-nuclear leadership (12)
- Intelligence leadership (4)
- Leadership policy, planning and training institutes (2)
- Non-communication electronic installations (21)
- Satellite and space communications (44)
- Telecommunications and electronic warfare (116)

We assume that the categories of intermediate-echelon strategic leadership, non-communication electronic installations (e.g., early-warning radars), satellite and space communications and telecommunications and electronic warfare would be appropriate for MAO-NF, in which there are 194 entries (mapped in Figure 4.75).[75] A selection of targets from some of the other L-C^3 categories would be appropriate for a major attack option specifically directed at national-level leadership in which targeting cities is permitted in the guidance. For example, 87 of the 362 L-C^3 class entries in the NRDC database are located in the city of Moscow and five are located in the city of St. Petersburg.

FIGURE 4.74
Russian Strategic Communication Pathways
Source: *Russia's Arms and Technologies: The XXI Century Encyclopedia*, Volume 1, *Strategic Nuclear Forces* (Moscow, 2000).



Russian satellite systems include the following functional categories: communications[76], navigation[77], meteorology[78], early warning[79], electronic intelligence, photo-reconnaissance, remote sensing, geodesy, radar calibration, space station activity, and scientific activity. A total of 44 geographically distinct satellite earth stations associated with these functions are listed in Table 4.17.

Targeting all satellite earth stations under MAO-NF is probably consistent with the SIOP logic for two reasons. First, about five years have passed since Russia began to commercialize a portion of its telecommunications system. Thus government/military and commercial telecommunications assets are likely still to be

FIGURE 4.75
Intermediate-Echelon Strategic Leadership, Satellite and Space Communications, and Telecommunications and Electronic Warfare Entries in the NRDC Russian Target Database

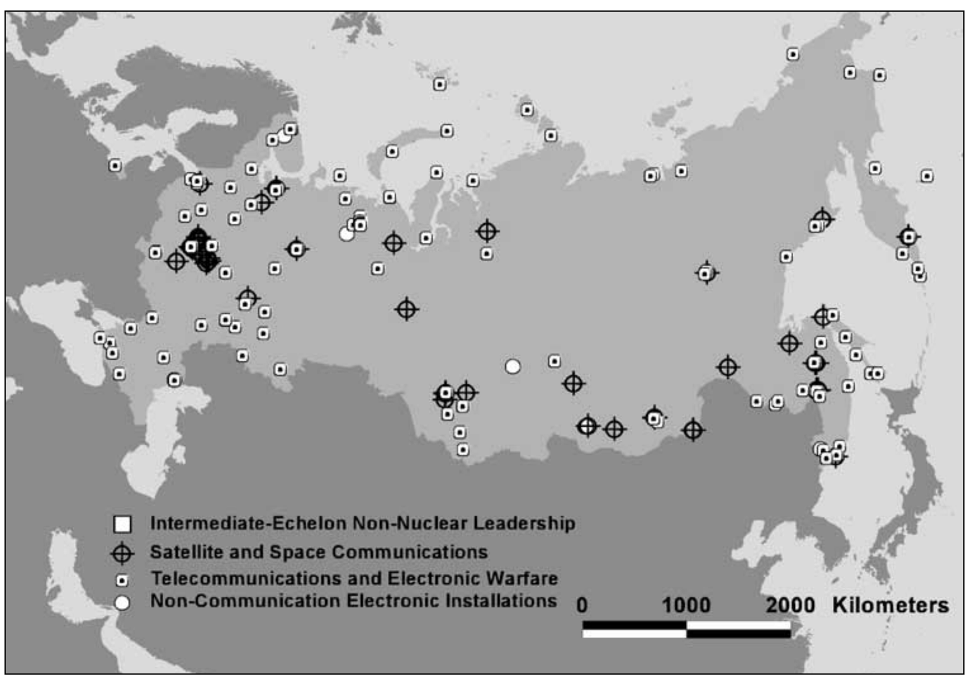
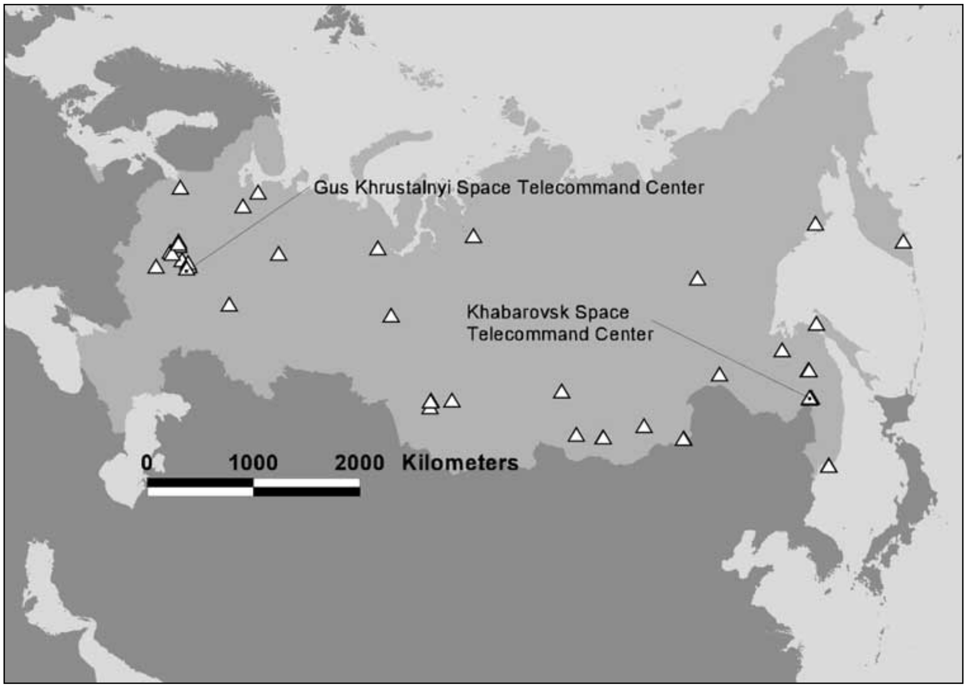


TABLE 4.17
Geographically Distinct Russian Satellite Earth Stations and Their Functions

Station Name	Aeronautical	Fixed-Satellite System	Space Telecommand	Space Research Service	Coast	Space Tracking Station	Meteorological Satellite	Space Telemetering	Earth-Exploration Satellite
ARKHANGHELSK		X							
ARKHANGHELSK	X				X				
DUBNA 1		X							
DUBNA 2,3,4		X							
DUDINKA		X		X		X			
GUS KHRUSTALNY 1,2,3		X							
GUS KHRUSTALNYI		X	X	X					
YAKUTSK		X							
IRKUTSK		X							
KEMEROVO		X							
KHABAROVSK		X	X	X		X	X	X	X
KHABAROVSK		X							
KHABAROVSK 2		X							
KOMSOMOLSKAMUR		X							
KOMSOMOLSKAMUR		X							
KRASNOKAMENSK		X							
MAGADAN		X							
MOSKVA		X					X		
MOSKVA		X		X					
MOSKVA 1		X							X
NAKHODKA	X				X				
NAKHODKA 1		X							
NAUKA		X							
NIKOLAEVSK NA AMURE		X		X					
NIKOLAEVSK NA AMURE1		X							
NOVOSIBIRSK		X							
NOVOSIBIRSK		X							
NOVOSIBIRSK							X		X
PETROPAVLO KAM		X							
PETUSHKI 1,2		X							
S PETERBURG		X							
SALEKHARD		X							
SKOVORODINO		X							
SURGUT		X							
SYKTYVKAR		X							
TAT 1B		X							
TCHITA		X							
TCHITA		X		X		X			
ULAN UDE		X							
VLADIMIR		X							
ZAIARSK		X							

FIGURE 4.76
Russia's Two Space Tele-Command Centers and 45 Earth Satellite Stations



located together. Second, it is also likely that Russia would rely on civilian communication facilities to a certain extent under normal circumstances (as does the U.S.), and as a backup during the crisis that would precede a nuclear exchange. The Russian satellite earth stations and the two space-telecommand centers are mapped in Figure 4.76.

Radio-frequency communication bands are usually divided into categories depending on transmission frequency: extremely low frequency (ELF), very low frequency (VLF), low frequency (LF), medium frequency (MF), high frequency (HF), very high frequency (VHF), ultra-high frequency (UHF), super-high frequency (SHF), extremely high frequency (EHF), and infra-red (IR). Table 4.18 shows the frequency bands commonly associated with these categories, as well as statistics from the International Telecommunications Union database on Russian transmissions.

Given the long propagation range of VLF and LF radio waves, and the ability of VLF waves to penetrate tens of meters into seawater to reach submerged submarines, we plot the location of non-public VLF and LF stations (see Figure 4.77). The figure highlights and labels the five stations that broadcast over all bands, and therefore are likely to be key nodes in the ground-based communications network.

Warhead Requirements and Aimpoints

We do not have a quantitative understanding of vulnerability of these C^3 targets to nuclear weapons effects. It is likely that 100-kt or higher-yield ground bursts would be required to attack the intermediate-echelon leadership targets, and 100-kt air bursts would be sufficient to destroy many of the satellite earth stations and VLF and LF radio-frequency transmitters. In total, we find 175 targets probably suitable to C^3 targeting under MAO-NF.

TABLE 4.18
Electromagnetic Frequency Bands and Statistics for Russian Transmission Stations
The ITU database lists 3,579 geographically distinct Russian radio transmission stations. Range restricted to line of sight is denoted by LOS.

Band Name	ITU Bnd	Frequency Range	Wave Form Name	Propagation	Range (km)	# Stations per Band	# Open to Public
ELF		< 3 KHz					
VLF	4	3-30 KHZ	Myriametric	Surface Wave	10^3–10^4	24	0
LF	5	30-300 KHZ	Kilometric	Surface Wave	10^3–10^4	91	18
MF	6	300-3000 KHZ	Hectometric	Sky Wave		603	194
HF	7	3-30 MHZ	Decametric	Sky Wave		1069	842
VHF	8	30-300 MHZ	Metric	Direct Wave	LOS	2276	29
UHF	9	300-3000 MHZ	Decimetric	Direct Wave, Scatter	LOS	788	23
SHF	10	3-30 GHZ	Centimetric	Direct Wave, Scatter	LOS	33	2
EHF	11	30-300 GHZ	Millimetric	Direct Wave	LOS	3	0
(IR)	12	300-3000 GHZ	Deci-millimetric				

Casualties and Sensitivity Analysis

While we do not have sufficient information to perform a detailed targeting analysis for this component of Russian nuclear forces, our database does reveal how many of these targets occur in major urban areas, and thus would be withheld under guidance that precludes attacking Russian cities. Figure 4.78 is a histogram plot of the number of potential C^3 targets for which the given range of people live within a

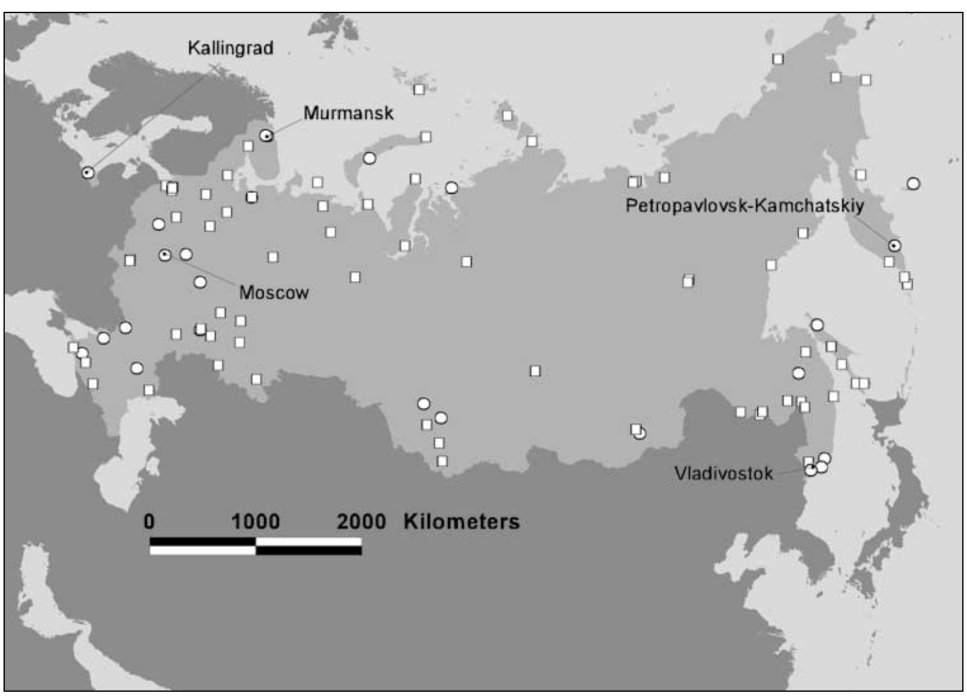
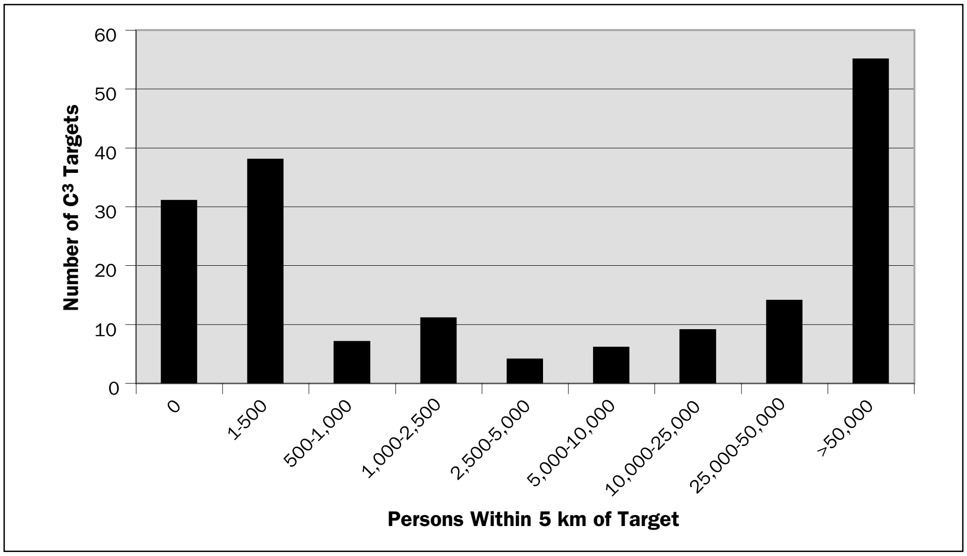


Figure 4.77
Russian Radio Transmission Stations
VLF (circle) and LF (square) non-public radio transmission stations. Five stations, which transmit in all bands, are labeled.

FIGURE 4.78
Histogram of the Number of Potential C³ Targets for which the Given Range of People Live within a 5-kilometer Radius

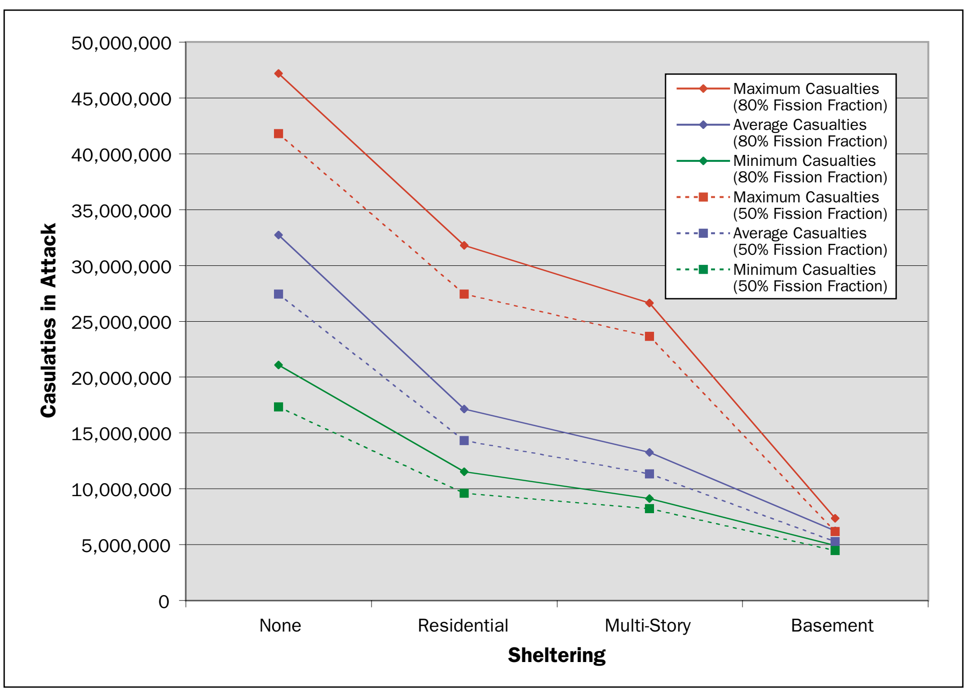


5-km radius (the outer radius for prompt effects of a W76). If the withhold against attacking cities in the guidance can be interpreted as a withhold on attacks for which there are more than 10,000 persons within a 5-km radius, then 97 of the C^3 targets could still be attacked, potentially threatening 86,000 people.

CONCLUSION

We have considered in detail the U.S. warhead requirements and Russian casualties for an attack against Russian nuclear forces. Drawing on the most comprehensive

FIGURE 4.79
Summary Casualty Data for MAO-NF



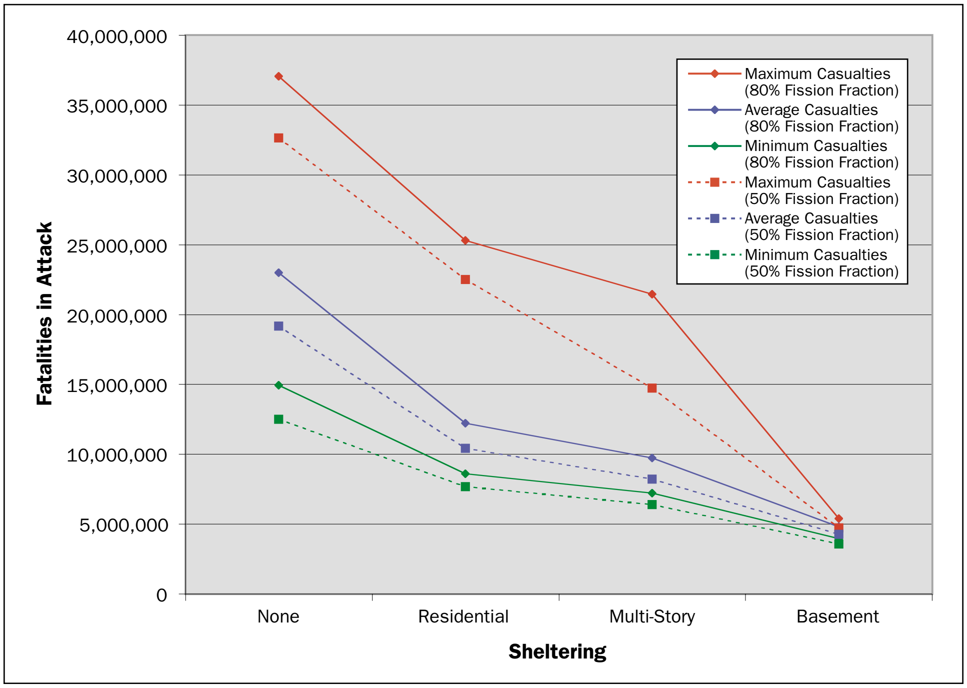


FIGURE 4.80
Summary Fatality Data for MAO-NF

levels of targeting for Russian aviation and naval sites, the total number of warheads used was 1,289, including:

- 500 W87 warheads, representing all of the single-warhead MM III ICBMs
- 220 W88 warheads, representing half of all W88 warheads, or the equivalent of 1.1 fully-loaded SSBNs
- 569 W76 warheads, the equivalent of three fully-loaded SSBNs

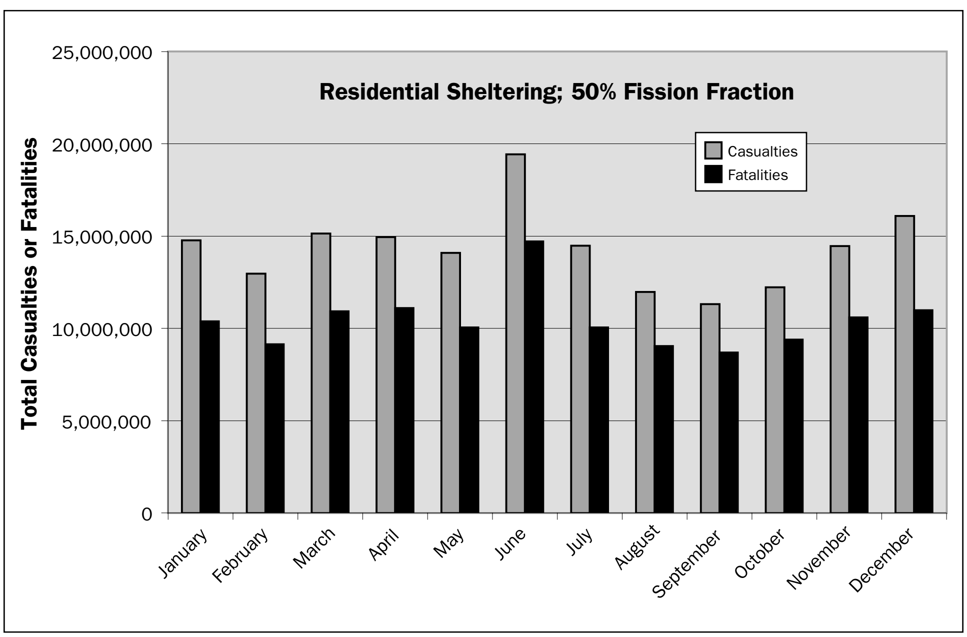
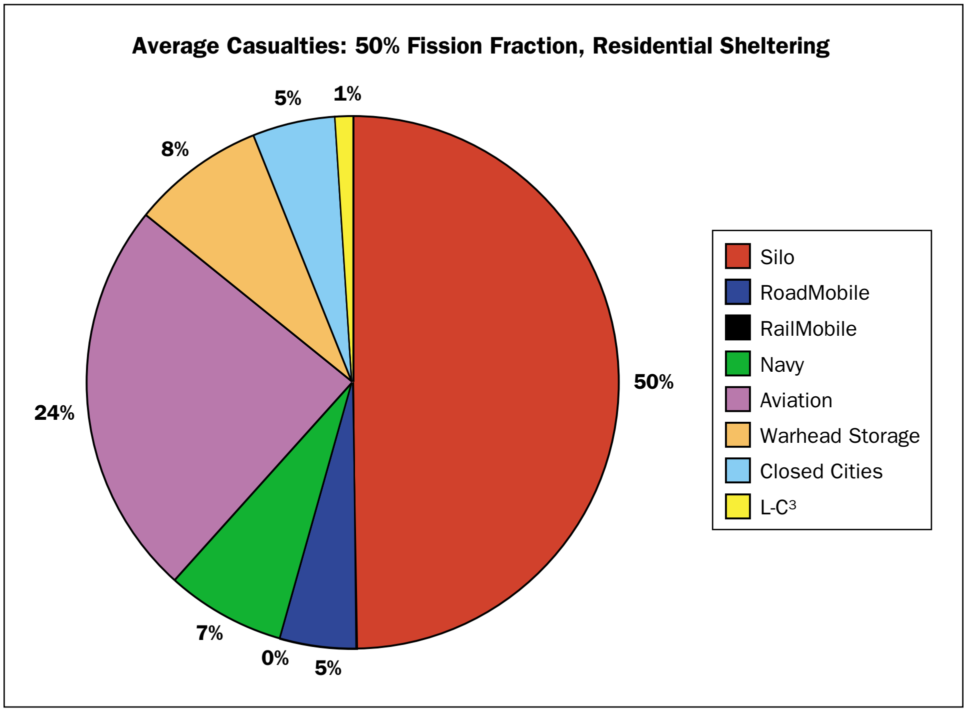


FIGURE 4.81
MAO-NF Casualties and Fatalities as a Function of Month of the Year
Assuming a weapon fission fraction of 80% and a population sheltering corresponding to residential dwellings.

FIGURE 4.82
MAO-NF Casualties Separately Evaluated for the Eight Components of Russia's Nuclear Forces



This works out to be almost one half the number of U.S. nuclear weapons on high alert today and essentially all of the weapons on high alert in a future START II force.

The attack, which would last a total of 30 minutes, would result in the following:

- More than 90 percent of Russian ICBM silos would be severely damaged
- All fifty SS-25 garrisons and bases would be destroyed
- All three SS-24 bases would be devastated by air bursts
- All Russian Northern and Pacific Fleet naval sites would be radioactive ruins, and any SSBNs that had been in port would become blasted pieces of metal on the bottom of the bays
- More than 60 important air fields would have their runways cratered and any strategic bombers caught at the air bases would be severely damaged
- Seventeen nuclear warhead storage sites would have their 136 bunkers turned into radiating holes
- The entire Russian weapons production and design complex would be blasted apart, killing in the process a large fraction of the nuclear workers
- Communications across the country would have been severely degraded

Within hours after the attack, the radioactive fallout would descend and accumulate, creating lethal conditions over a land mass with an area exceeding 775,000 square kilometers—larger in size than France and the United Kingdom combined. The key to survival in the first two days after the attack would be staying indoors, preferably in the upper stories of high-rise apartment buildings or in basements. Figure 4.79 plots the casualties and Figure 4.80 plots the fatalities for

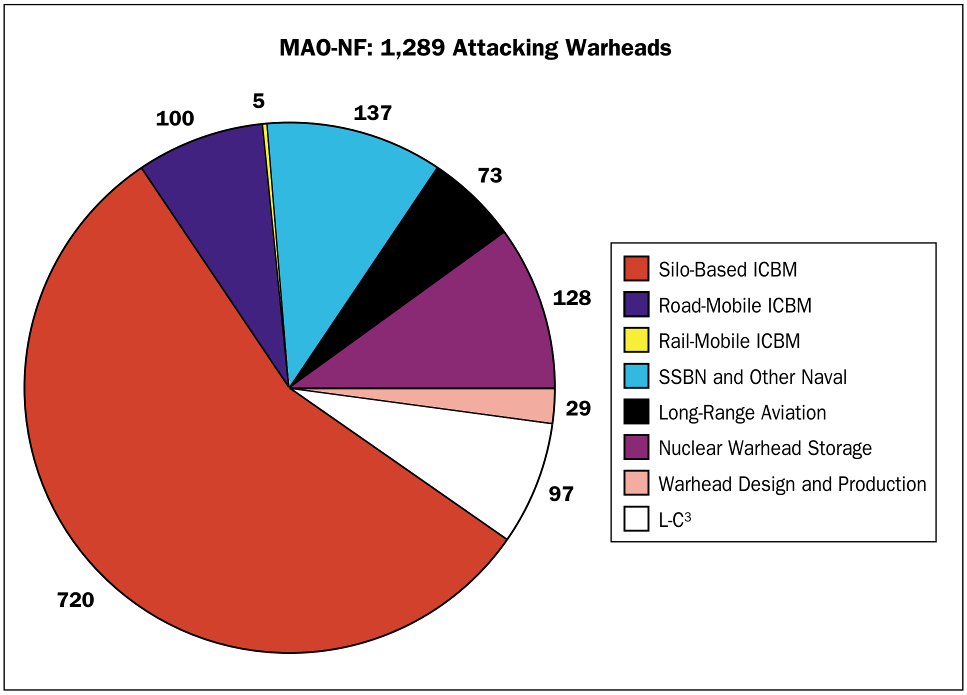
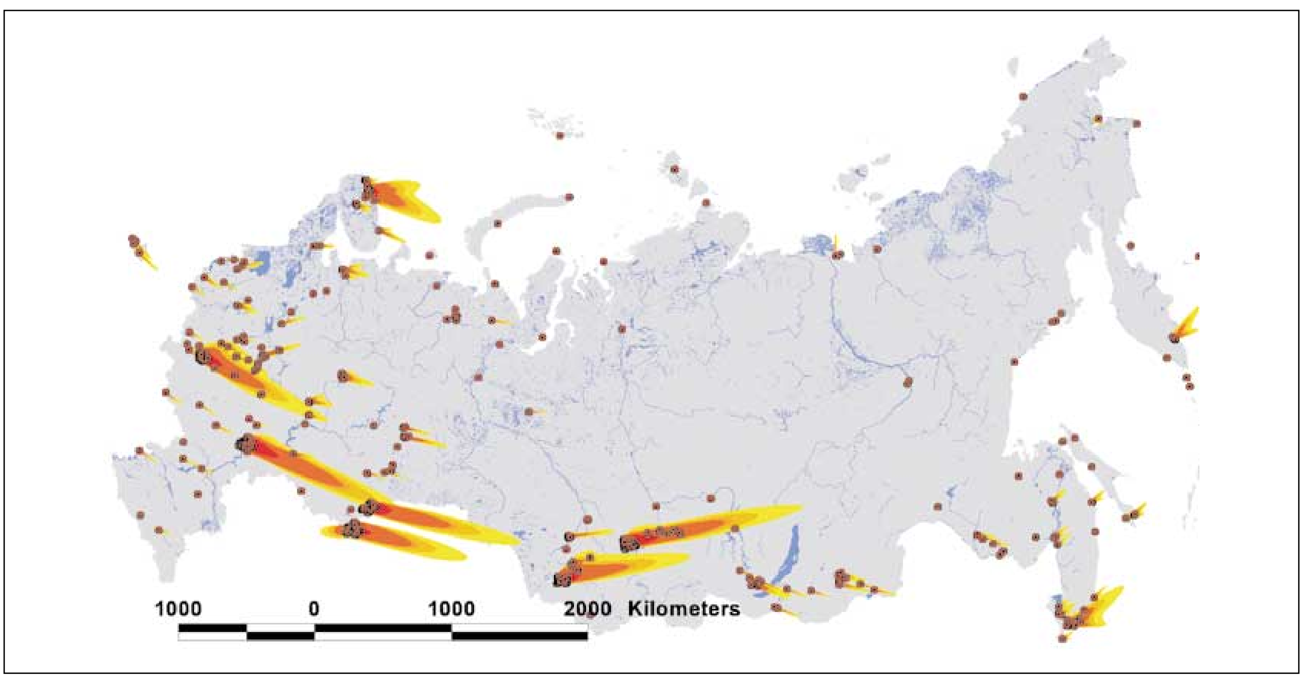


FIGURE 4.83
The Allocation of U.S. Warheads to the Eight Categories of Russian Targets in NRDC's MAO-NF

MAO-NF as a function of population sheltering. Figure 4.81 plots the casualties and fatalities as a function of month for an assumption of 80 percent fission fraction and a population sheltered in residential (single-story) dwellings. Figure 4.82 shows how the casualties in MAO-NF rank among the eight categories of targets we have considered in this study. Figure 4.83, to be contrasted with Figure 4.82, illustrates how NRDC allocated attacking U.S. nuclear weapons to the eight components of

FIGURE 4.84
Fallout Patterns from MAO-NF Across the Russian Landmass ▼



Russia's nuclear force under MAO-NF. Finally, Figure 4.84 displays the fallout patterns across Russia for MAO-NF.

Considering the monthly variation in wind parameters, the likely bounding values of 50 percent and 80 percent fission fraction, and the likely bounding values of residential and multi-story sheltering, we find that the casualties resulting from MAO-NF would be between 11 and 17 million people, including between 8 and 12 million fatalities.