Modeling a U.S. nuclear attack on Russia requires (1) data on the likely targets of such an attack; (2) data on the number and capabilities of U.S. weapons; (3) a plan that allocates weapons to targets; and (4) formulas for estimating the likely results of the attack. Two other crucial issues in nuclear targeting are the problem of nuclear “fratricide” and the question of whether Russia would be able to launch a retaliatory attack before U.S. weapons arrived at their targets. THE TARGETS: RUSSIA’S STRATEGIC NUCLEAR FORCES The highest priority targets in a U.S. nuclear attack on Russia would be the long-range weapons that Russia could use to retaliate. Other targets would be hit as well: for example, nuclear storage sites, short-range nuclear forces, conventional military forces, and command and control sites.24 Russia’s strategic nuclear forces can be divided into four categories. The first comprises 258 ICBMs deployed in silos that have been hardened enough that each must be targeted individually.25 The second leg is Russia’s 291 mobile long-range missiles. If alerted, these missiles would disperse across large patrol areas, making them difficult to destroy. Normally, however, they are kept in shelters inside forty garrisons.26 The third leg comprises 78 long-range bombers that are normally deployed at two air force bases. Seven other airfields are used for training and exercises, so they too are primary targets. In addition, fifty-four other airfields have a connection to Russia’s bomber force and are included on the target list.27 The last leg is Russia’s submarine force. Russia has 12 SSBNs, although only 9 are currently in service; and it has dramatically reduced the frequency of routine patrols. In fact, Russia usually has no SSBNs at sea, relying instead on a dock-alert system in which a submarine in port is on alert.28 Russia’s SSBNs are deployed at three main bases; several dozen other naval facilities are occasionally visited by submarines, however, and would also have to be attacked.29 Finally, we target 127 nuclear weapons storage, production, assembly, and disassembly sites.30 Table 1 summarizes the current Russian strategic force and estimates the number of aimpoints that would have to be targeted to destroy each leg of that force. FORCES FOR A U.S. NUCLEAR FIRST STRIKE The United States currently fields 500 ICBMs, 14 SSBNs, and 77 strategic bombers. The size of this arsenal is bigger than these numbers suggest because most U.S. missiles, submarines, and bombers carry multiple warheads. For example, a single U.S. SSBN carries (on average) 144 warheads. Each B-2 bomber can carry 16 nuclear bombs, and the B-52 bombers have room for 20 nuclear-armed cruise missiles.31 Not all of these forces, however, are typically available for a first strike. During normal conditions, approximately 95 percent of U.S. ICBMs are prepared to launch, but the other legs of the triad are kept at lower alert levels. Typically only 4 SSBNs are on routine patrol, and no U.S. bombers are kept on alert for nuclear operations.32 The United States could take steps to surreptitiously increase the size of the alert force. For example, although there are usually only 4 U.S. SSBNs on patrol, occasionally there are submarines (1) traveling to replace those on station, (2) returning to port after a patrol, and (3) training at sea for an upcoming deployment. The United States could secretly order SSBNs heading home from patrol to return to their launch areas, order the submarines on patrol to remain on station after their replacements arrive, and send submarines undergoing pre-deployment training to launch areas. If timed cleverly, the only sign of the “surge” in U.S. naval activity would be a submarine or two returning late from patrol. In the model below, we assume a temporary surge of 8 SSBNs at sea. The U.S. strategic bomber force would be easier to alert quietly. Given the small number of aircraft involved, the United States should be able to perform preflight maintenance and load the planes with bombs and cruise missiles without taking externally visible steps. In the model, we assume that the United States can quietly alert 75 percent of the small bomber force (58 bombers plus tankers for aerial refueling). To estimate the number of nuclear warheads that the United States could launch against an adversary, one additional calculation is required: the reliability of U.S. delivery systems (i.e., missiles, submarines, and aircraft). Our model uses the standard estimate of 80 percent reliability for U.S. nuclear weapon systems;33 we vary this assumption in our sensitivity analysis. Table 2 provides a snapshot of the U.S. strategic force with information on weapon yield and accuracy. Weapon yields are widely reported, but there is greater uncertainty about accuracy. Our estimates of accuracy use publicly available data; when sources conflict, we generally use the most recent estimates because key components of these weapons are occasionally updated to improve performance. assigning weapons to targets and estimating effects In assigning U.S. weapons to Russian targets, we follow three principles: (1) the most accurate weapons are assigned to the hardest targets; (2) the fastest-arriving weapons are assigned to the targets capable of responding most quickly;34 and (3) except for the nuclear storage sites, each target must be hit by at least one fast-arriving weapon. The goal is to ensure that each target is at least damaged in the initial, surprise wave of warheads; follow-on waves would arrive minutes later to ensure that virtually every target is destroyed. Finally, the attack we model leaves the United States with a reserve of more than 350 strategic nuclear warheads ready to be fired immediately after the U.S. first strike; the number of available strategic warheads would rise quickly to more than 1,000 as bombers returned and reloaded; and the submarines that did not attack (because they were in port) pushed out to sea.Following the targeting criteria described above, we allocate U.S. nuclear weapons to Russian forces as follows: Russian silo-based ICBMs: • initial attacks: stealthy cruise missiles, B-2 strikes, and SLBM warheads • follow-on attacks: land-based ICBMs Russian mobile missile garrisons: • initial attacks: multiple SLBM warheads • follow-on attacks: ICBM warheads Russian strategic aviation: • initial attacks: SLBM warheads used for airbursts over airfields • follow-on attacks: cruise missiles and ICBMs to crater runways Russian naval facilities: • initial attacks: multiple SLBM warheads against naval targets • follow-on attacks: cruise missiles and ICBMs Nuclear storage sites: • initial attacks: no fast-arriving warheads • follow-on attacks: ICBMs against storage facilities Table 3 presents a list of targets in the hypothetical U.S. counterforce attack, the number of aimpoints for each target, and the number of warheads assigned to each aimpoint. To calculate the expected outcome of this attack, we use variations of two simple formulas. The first uses the yield of a warhead and the hardness of a target to calculate the lethal radius (LR), that is, the maximum distance from the detonation at which the target would be damaged or destroyed. Once the LR is calculated, the second formula uses a given delivery vehicle’s accuracy to calculate the odds (the “single-shot probability of kill,” or SSPK) that it would deliver its warhead within the lethal radius.35 (For details regarding these calculations, see appendix 1.) Two clarifications about these calculations are necessary. First, this analysis assumes that Russia is unable to launch its missiles before the first wave of U.S. warheads arrive on target. For reasons described below, this assumption is realistic. Second, the model assumes that Russia’s 9 deployed SSBNs are in port (or that one submarine is at sea but is being tracked) and that their mobile ICBMs are in garrison. For reasons described above, this assumption is also realistic. NUCLEAR TARGETING AND “FRATRICIDE” Historically, analysts have assumed that only 2 nuclear warheads could be used in a short time frame against any target because of a problem called “fratricide.” Assigning multiple warheads to a target requires precise timing to prevent one incoming warhead from destroying others. Furthermore, a nuclear detonation near ground level (which is ideal for destroying hardened silos) would create a debris cloud that could destroy other warheads heading to the same target. As a result, analysts have typically assumed that targets will be hit with a single airburst (which would create little debris) and a single ground burst.36 Concerns about fratricide were justified during the Cold War, but they no longer prevent planners from allocating multiple warheads to each target. The fratricide problem was serious during the Cold War because missiles did not have the pinpoint accuracy that they do today. Under those circumstances, at tacks on an enemy’s ICBM field would produce many near misses (i.e., warheads that detonated too far from the silo to destroy it, but close enough to create a debris cloud that would shield it from the next wave of attacks). Today U.S. missile accuracy is so good that virtually all misses would result from delivery-vehicle malfunctions rather than accuracy limitations; the key point is that malfunctioning delivery vehicles (e.g., boosters that fail to ignite or defective guidance systems) would rarely deliver the warhead close enough to the intended target to create a local debris cloud and a serious fratricide risk.37 As a result, U.S. war planners can assign a large number of warheads to each Russian target. If the delivery system for the first weapon functions properly, the target will likely be destroyed. If the first delivery vehicle malfunctions, it will probably not create a debris cloud over the target, and the next incoming warhead—if its delivery vehicle functions properly—can still succeed. ATTACK TIMING: CAN THE RUSSIANS LAUNCH UNDER ATTACK? A critical issue for the outcome of a U.S. attack is the ability of Russia to launch on warning (i.e., quickly launch a retaliatory strike before its forces are destroyed). It is unlikely that Russia could do this. Russian commanders would need 7–13 minutes to carry out the technical steps involved in identifying a U.S. attack and launching their retaliatory forces. They would have to (1) confirm the sensor indications that an attack was under way; (2) convey the news to political leaders; (3) communicate launch authorization and launch codes to the nuclear forces; (4) execute launch sequences; and (5) allow the missiles to fly a safe distance from the silos.38 This timeline does not include the time required by Russian leaders to absorb the news that a nuclear attack is under way and decide to authorize retaliation. Given that both Russian and U.S. early warning systems have had false alarms in the past, even a minimally prudent leader would need to think hard and ask tough questions before authorizing a catastrophic nuclear response.39 Because the technical steps require 7–13 minutes, it is hard to imagine that Russia could detect an attack, decide to retaliate, and launch missiles in less than 10–15 minutes. The Russian early warning system would probably not give Russia’s leaders the time they need to retaliate; in fact it is questionable whether it would give them any warning at all. Stealthy B-2 bombers could likely penetrate Russian air defenses without detection. Furthermore, low-flying B-52 bombers could fire stealthy nuclear-armed cruise missiles from outside Russian airspace; these missiles—small, radar-absorbing, and flying at very low altitude— would likely provide no warning before detonation. Finally, Russia’s vulnerability is compounded by the poor state of its early warning system. Russian satellites cannot reliably detect the launch of SLBMs; Russia relies on ground-based radar to detect those warheads.40 But there is a large east-facing hole in Russia’s radar network; Russian leaders might have no warning of an SLBM attack from the Pacific.41 Even if Russia plugged the east-facing hole in its radar network, its leaders would still have less than 10 minutes’ warning of a U.S. submarine attack from the Atlantic, and perhaps no time if the U.S. attack began with hundreds of stealthy cruise missiles and stealth bombers.42 Table 4 presents the results of the modeled attack on Russian nuclear forces. The first row of results, the “base case,” uses expected values for the accuracy and reliability of U.S. weapons and the hardness of Russian targets. In each row, the top number is the expected number of targets that survive; the bottom numbers reflect the range of targets that might survive (with a 95 percent confidence interval). The model suggests that the Russian strategic nuclear force is extremely vulnerable. Using base-case values, zero Russian silo-based ICBMs, zero mobile missiles, zero bomber bases, and zero Russian SSBNs are expected to survive. The range of plausible outcomes is even more striking: the likelihood of a single ICBM silo, mobile missile shelter, runway, or submarine surviving the attack falls outside the 95 percent confidence interval. The other rows in Table 4 present the results of sensitivity analysis. The row below the base case indicates expected outcomes if the accuracy of all U.S. nuclear weapons is 20 percent worse than expected (i.e., CEP is increased by 20 percent). The next row shows the impact of reducing the reliability of U.S. weapons from 80 percent to 70 percent. The final row assumes that Russian ICBM silos are 50 percent harder than expected. None of these changes significantly reduces the vulnerability of the Russian nuclear force.