detonation systems are disengaged. This structure of the command and control system precludes the accidental transmission of the launch command or the delivery of an unauthorized command. The use of the command and control system to transmit an authorized order for launch of nuclear weapons is discussed in the next section.

Use of Strategic Nuclear Forces

Virtually any scenario involving the use of strategic nuclear forces implies that the decision to use them will be preceded by a serious international crisis that could reach the stage of an armed conflict involving conventional arms or tactical nuclear weapons. Therefore, plans for the use of strategic forces and the procedures for the delivery of a strategic strike are based on the assumption that each side will be able to put strategic forces and battle management systems on high alert.[26]

The only scenario that does not include exercising this capability is a surprise strategic nuclear strike. The probability of an unprovoked nuclear strike was minimal even when relations between the Soviet Union and the United States were characterized by extreme tension. Nevertheless, the structure of strategic forces, their operations, and the structure of the battle management system were designed to secure the capability for a strategic strike even under the most unfavorable case of a surprise nuclear attack.

If the development of a particular crisis situation suggests that a strategic nuclear strike might be delivered by any side in the conflict, strategic forces can be put on high alert. High-alert status can increase the survivability of strategic systems and the stability of command and control systems considerably. In particular, after this higher state of readiness has been declared, land- and rail-based mobile missile systems can be dispersed, missile-armed submarines in port can be sent out to sea, and bombers can be loaded with nuclear weapons. Measures to enhance the stability of command and control systems may include the activation of reserve command centers and reserve communication channels and the deployment of mobile relay stations for the transmission of commands to submarines and bombers.

The establishment of communications between the military leadership and the national leadership and the engagement of the Supreme High Command mechanism would be essential in the enhancement of the capability of the command and control system to withstand an attack. This would entail, among other measures, the arrival

of the supreme commander at the central or reserve command center and his official assumption of the command of the armed forces. In this case the General Staff would be the executive body of the Supreme High Command. Putting the troops on high alert probably would be accompanied by the transfer of the battle management system from regular combat duty to combat mode. The supreme commander could then use the command and control system to give the necessary orders for a nuclear strike.

The determination of the necessary level of readiness of the troops and the choice of the specific steps to raise this level should be based on an analysis of the current situation and the plans drawn up in advance. The declaration of the high-alert status is a potentially destabilizing move because it can be interpreted as a signal of the willingness to use strategic force and could escalate a crisis or conflict, and this is an important consideration in making the decision to move to high alert. For this reason, the institution of these measures probably would require an order from the supreme commander and should be preceded by a thorough analysis of the possible consequences of this move. Some of the steps required to raise the level of readiness could also be taken on orders from the General Staff.[27]

A surprise strategic strike would eliminate any opportunity to raise the level of readiness of the armed forces. Consequently, if a strategic strike should become necessary under those conditions, all missions would have to be undertaken by the forces that were already on alert at the time of the attack. Nevertheless, even this would entail efforts to disperse the troops, so that they could serve as the basis for a reserve force in the delivery of a retaliatory strike. In addition, measures to enhance the stability of the command, control, and communications system following a surprise attack would increase the feasibility of a retaliatory strike.

After the strategic forces have been put on high alert in response to a crisis situation, the need to deliver a strategic strike must be addressed with a view to that situation and the development of the crisis or conflict. The main strategic option envisaged in Soviet military doctrine was the delivery of the counterstrike or launch-on-warning strike. The decision to use nuclear weapons would thus be made only in response to the delivery of a nuclear strike against the USSR.[28] The counterstrike is also the main option envisaged in Russian military doctrine. The provisions of Russian military doctrine, however, specifically envisage the possibility of delivering a first strike. In particular, the delivery of a first strike can be considered, under Russian military doctrine, in the case of an attack on key elements of the early warning system or the command, control, and communications system.[29]

The principal event determining the need to deliver a strategic nuclear strike, therefore, is the start of an attack by an enemy. The determination that an enemy has initiated a is made based on the detection of launches of ballistic missiles aimed at national territory. The Russian missile attack early-warning system can record launches of ICBMs from U.S. territory and launches of SLBMs from certain parts of the world's oceans. The "missile attack" signal is transmitted from the command center of the early-warning system to the central air defense command post and the central command post of the General Staff.

The "missile attack" signal generated by the space-based early-warning system probably would have to be confirmed at the central command post of the Air Defense Forces and the central command post of the General Staff. If the number of indications of an attack were to exceed a certain minimum, confirmation of the signal might not be required, and it might be transmitted automatically to the highest levels of the command and control system. The duty officers of the corresponding command posts would then use all available information, including early-warning satellite imagery, to assess the signal's credibility. In addition, a report of the detected event would be sent to the Krokus terminals of the highest military officers, which would display information about the scale of the possible attack and the projected impact area of the warheads. The military command would then use this information to assess the credibility of the signal and the scale of the possible threat.

The "missile attack" signal generated by the space-based early-warning system probably would play a more important role in a surprise attack. In that case, this signal would activate the Kazbek communications system, with terminals in the offices of the supreme commander, the minister of defense, and the chief of General Staff, and would facilitate the transfer of the battle management system from regular combat duty to combat mode. (If this status change has been effected in advance, for example, in response to a crisis, the satellite signal may not play such a significant role.) In any of the possible scenarios, the supreme commander would have to make decisions about further action on the recommendations of the minister of defense and chief of General Staff after the warning of the possible attack has been transmitted. In the event of a surprise attack, the equipment of the Kazbek system would be used to establish direct communications between the supreme commander and the military leadership and to transmit all of the supreme commander's orders and commands.

It is precisely during this stage that the decision would be made to put strategic forces in a full state of readiness. If this decision were made, the supreme

commander would issue a so-called preliminary command, which is necessary for further actions that could lead to the delivery of a strategic strike. During the execution of the preliminary command, all of the links of the battle management system would be connected, so that the system would be ready to transmit the main launch command and the launch authorization codes, if necessary. As noted in the last section, because of safeguards built into the system, the command to launch delivery vehicles for a nuclear attack probably could not be issued without the execution of the preliminary command.

If the troops were transferred to the high-alert status, the preliminary command could be issued even in the absence of a signal from the early-warning system. In this case, the preliminary command, which still could be issued only by the supreme commander, could be carried out at the same time as the measures to raise the level of readiness. The decision to issue the preliminary command before an actual incoming attack probably would be made on the basis of an analysis of the situation. As noted earlier, when the preliminary command was executed by the personnel on alert and all of the duty crews, measures would be taken to guarantee the execution of a main launch command if one were to be issued.

One of the distinctive features of the system for the command and control of strategic forces in the Soviet Union was that the supreme commander could issue the order to launch strategic vehicles and the authorizing codes only after the transmission of a "missile attack" signal from the early-warning system. In the absence of this signal, the order to launch strategic vehicles could not be given. The system was set up in this way probably to eliminate the possibility of an erroneous decision to launch a strategic strike. This arrangement, however, did not and does not exclude the possibility of a first strike, as described below.

The "missile attack" signal is transmitted after the space-based early-warning system has detected ballistic missile launches by the enemy and the early-warning radars have confirmed those launches. Radar detection and tracking of targets is required to confirm the attack. Because the space-based early warning system does not register missile launches from all possible launch sites, a "missile attack" signal can be transmitted even if it is based only on data reported by radars. In that case, the criteria for the reliable identification of targets could be somewhat stricter and the tracking time somewhat longer than for missile launches detected directly by the satellite system.

After receiving the "missile attack" signal, the supreme commander would make decisions, relying on the recommendations of the minister of defense and chief of General Staff, on whether to deliver a strategic strike and, if so, on the specific type of strike to be delivered. Information transmitted by the early-warning system on the probable number of attacking missiles and the main regions to be attacked would be used to assess the potential scale of the attack. If the supreme commander were not in one of the command posts of the highest command and control link the decision to deliver a strategic strike had to be made, he would have to use his Kazbek terminal to transmit the preliminary command and the launch order. The supreme commander's order would be transmitted to the central command post of the General Staff, which would then issue the launch order to be transmitted through the chain of command to the strategic delivery vehicles. The launch order, which would include a unique code to confirm its authenticity, as well as the code of the chosen mode of operations and the release codes, would be sent through the chain of command of the battle management system and numerous backup communication channels to the missile launchers and to the relay stations transmitting the order and the authorizing codes to missile-armed submarines and bombers.

As discussed above, the command and control system is set up so that a "missile attack" signal is required to enable the order for a strategic launch to be given and the authorization codes to be transmitted. Since in the case of a first strike, the early-warning system would not register an enemy attack (because one was not occurring) and would not transmit such a signal, the "missile attack" signal required for the issuance of the launch command would have to be generated manually at the central command post. In the event of a decision to deliver a first strike, the supreme commander and the minister of defense would order this signal to be generated. This arrangement enables the military leadership to prevent a situation in which the decision to deliver a first strike is made by the supreme commander alone.

A launch-on-warning counterstrike puts exceptionally high demands on the readiness of troops and on the stability and reliability of the command and control system. As noted above, in the event of a surprise attack, the country's top leaders will have only a few minutes to assess the situation and choose a response. The possibility of delivering a launch-on-warning or retaliatory strike could be threatened if key elements of the command, control, and communications system are attacked during the early stages of a conflict. The highly centralized

decision-making mechanism that was a distinctive feature of the command and control system in the Soviet Union could also preclude a launch-on-warning or retaliatory strike if the central command post and the top leadership are eliminated.

To guarantee the capability of delivering a retaliatory strike, the battle management system envisages the possibility of issuing an order to use nuclear weapons and the authorization codes in the absence of a direct command from the supreme commander. This requires the fulfillment of several conditions, however. First of all, the equipment of the battle management system must confirm the absence of communications with the supreme commander. Second, the nuclear attack identification system, which apparently includes various detectors recording seismic signals and other effects of nuclear explosions, must record nuclear explosions within national territory. Third, the supreme commander must have given preliminary authorization to deliver this type of retaliatory strike to the central or reserve command center. This authorization probably would be issued at a fairly early stage of the conflict, most probably at the same time as the preliminary command put strategic forces in a state of maximum readiness. If all of these conditions are fulfilled, the central command center or the reserve command center can launch strategic vehicles using its own authorizing codes.

The problem of the vulnerability of the central command center and the top leadership is also solved by deploying a network of reserve command centers, which could deliver a retaliatory strike if necessary. In particular, airborne and rail-based mobile command centers could be deployed in times of crisis. If there is enough time, members of the top leadership could also move to a hardened central command station in the Moscow region.

In addition, the Soviet Union began contruction of a reserve command station of the General Staff, a superhardened command center in the Yamantau Mountain. Located underground, this command center is intended to secure the control of the strategic forces after the destruction of the main command centers.[30] It is quite possible that this command center is supposed to take the necessary steps to deliver a retaliatory strike if the top leadership is eliminated.

In addition to securing the possibility of issuing the order to use strategic force, the battle management system must provide the possibility of transmitting the order to the delivery systems of the nuclear weapons. The possibility of delivering a retaliatory strike is highly dependent on the existence of reliable communications, because the central command center of the command and control system and the lines of communication must continue to be operable even under the effects of enemy nuclear weapons. It is highly probable, however, that the destruction of

elements of the command and control system, which would be among the first targets of the attack, could also complicate the delivery of a launch-on-warning strike.

The stability of the communications system is secured with the aid of numerous backup channels and the use of a variety of devices and frequencies to transmit orders. The stability of this system can also be enhanced considerably by using satellite communication channels and by deploying mobile relay stations, including airborne stations, that can escape destruction during an attack and secure the transmission of the use signal and the authorization codes to ICBM launchers, submarines, and strategic bombers.

One of the reserve communication channels created in the Soviet Union is the Perimeter system, which has been integrated into the battle management system.[31] The Perimeter system includes command rockets for the transmission of commands directly to strategic missile launchers. After the appropriate command has been received by the Perimeter system command post, the command rockets would take off and transmit the launch order and authorization codes continuously in flight over the missile position areas for a period ranging from 20 to 50 minutes. This signal would make the launch of delivery vehicles possible even if all other lines of communication between the launcher and the outside world have been damaged. Silo missiles could be launched automatically, without any participation by the combat duty personnel of the regimental command station. The relay stations transmitting commands to submarines and bombers probably can also receive the signal from the command rockets of the Perimeter system, and the submarines and bombers probably can receive the signal directly as well.

A distinctive feature of the Perimeter system is the possibility of activating it before a nuclear attack is detected. When the system was being designed, it was assumed that the supreme commander might issue the command to activate it after a warning of the first signs of a nuclear attack. According to the original plan, later rejected, if the command station of the Perimeter system was activated in advance and did not receive an order to stop the combat algorithm within a certain period of time, the launch of the command rockets and the transmission of the order to deliver a retaliatory strike would be automatic. This was supposed to guarantee the delivery of a retaliatory strike in the event of the elimination of the top leadership while reserving the possibility of the cancellation of the order in the event of a false signal.

By all indications, the Perimeter system was never deployed in the configuration that allowed such an automatic launch of the command rockets. The decision to

deploy the system took into account the chance that the work of the combat algorithm could not be stopped and that the operation of the system in the automatic mode would therefore be potentially dangerous. At this time the Perimeter system is supposed to serve as a reserve communication channel, and the command rockets can be launched by a human order either from the central command center or from one of the reserve command centers, in accordance with the regular procedure for a retaliatory strike. The guaranteed launch feature of the Perimeter system may have been one of the functions reserved for the superhardened command center.

18. Most of the work of the General Staff was performed by the Main Operations Directorate. In addition, the General Staff set up a Treaty and Legal Directorate in the mid-1970s, and it was also actively involved in the commission's work. In the Ministry of Foreign Affairs most of the work was performed by the U.S. and Canada Department. S. F. Akhromeyev, who occupied various positions on the General Staff (chief of the Main Operations Directorate, then first deputy chief of General Staff, and later chief of General Staff in 1984–1988), and G. M. Korniyenko, who headed the U.S. and Canada Department in the Ministry of Foreign Affairs and then became first deputy minister in 1977, played a particularly prominent role in the commission's work. See Savelyev and Detinov, *Big Five*, p. 61.

19. Ibid., p. 115.

20. The decree on the start of a development project usually stipulated the dates of the main stages of the work, down to the quarter (the completion of the blueprints, the beginning of tests, and the start of series production), named the head developers of the system and its components (including the name of the chief designer of the system) and the organizations participating in the project, and instructed various agencies to take the necessary measures for the creation of the system (the construction of various facilities, the appropriation of territory, and the resolution of any social problems arising from the creation of the system, such as relocation of residents, construction of housing, etc.).

21. The static overpressure created in the front of the nuclear blast shock wave is not necessarily the main factor causing the destruction of the target. Nevertheless, the level of protection is usually expressed in terms of overpressure, because the intensity of the other destructive factors involved in the explosion usually correlates with that quantity.

22. The kill radius can be estimated by means of the equation $R = kq^{1/3}$, where R is the radius in kilometers, q is the yield of the blast in megatons, and k is the coefficient of target hardening. For urban structures (protection level of 0.3 atmospheres), $k = 4$, and in the case of hardened silos (100 atmospheres), $k = 0.4$. See, for example, Ye. B. Volkov, *MBR SSSR (RF) i SShA* (ICBMs of the USSR (Russian Federation) and the United States) (RVSN, 1996), p. 21.

23. CEP and ME are connected with root-mean-square deviation σ, describing the probable deviation of the warhead from the initial aiming point, with the following correlative relationships: CEP = 1.18σ, ME = 2.7σ.

24. For example, if CEP is equal to the kill radius, it would take six warheads to destroy targets with a probability greater than 0.98.

25. The kill radius increases in proportion to $q^{1/3}$, where q is the yield of the weapon. This means that the yield has to be eight times as great to double the size of the kill radius.

26. There is almost no information about the Russian command and control system. The description in this chapter is a review of the system's operating principles based on a few reports in unclassified literature. The information about the work of the command and control system have been taken from B. G. Blair, *Global Zero Alert for Nuclear Forces* (Brookings Institution, 1995), which is the most complete description of the Russian battle management system available today in the open literature. In addition, some of the information used here was cited in the following works: V. Ye. Yarynich, *Otsenka garantii* (Guarantee Assessment) (MGIMO, 1994); V. Yarynich, "Yadernye strategii i faktor upravleniya" (Nuclear strategies and the factor of command and control), *Segodnya*, 30 March 1994,

p. 9; Steven J. Zaloga, "Russia's Doomsday Machine," *Jane's Intelligence Review* (February 1996), pp. 54–56.

27. In the few cases in which the Soviet Union took measures to put the nuclear forces on high alert, these actions were taken on a limited scale and were not detected by U.S. intelligence. See, for example, B. G. Blair, *The Logic of Accidental Nuclear War* (Brookings Institution, 1993), pp. 23–26.

28. In the 1970s the Soviet Union started working on an extensive program to secure the possibility of a launch-on-warning strike. In 1982 the Supreme Soviet officially announced the policy of no first use of nuclear weapons. It is significant, however, that this did not preclude the delivery of a first strike in response to the use of tactical nuclear weapons by the enemy, and particularly in response to the use of tactical weapons to destroy targets within the territory of the Soviet Union.

29. The basic provisions of Russian military doctrine include the following statement: "Deliberate actions by an aggressor to pose a threat to strategic nuclear forces, the missile attack early-warning system, nuclear power plants, and facilities of the atomic and chemical industry could increase the probability of the escalation of a conflict involving the use of conventional arms into a nuclear conflict." "Osnovnye polozheniya voennoy doktriny Rossiiskoy Federatsii" (The basic provisions of the military doctrine of the Russian Federation), *Rossiyskiye vesti*, 18 November 1993.

30. This command center, known as "Installation Beloretsk-15," is located in Bashkiria, near the settlement of Tatly, 35 kilometers from Beloretsk. The command post buildings are situated far underground, deep within Yamantau Mountain. M. Safarov, ". . . komu bunker?" (Who gets the bunker?) *Komsomolskaya pravda*, 14 March 1992, p. 2. Construction of the installation had apparently not been completed as of 1997. V. Mikheyev, "Khochesh mira—roi bunkery" (If you want peace, start digging), *Izvestiya*, 3 April 1997, p. 3.

31. The Perimeter-RTs system, which includes modified RT-2PM (SS-25) missiles, is now in use. Previosly the system included command missiles that were modified Pioneer (SS-20) and MR UR-100 (SS-17) missiles. V. Pappo-Korystin, V. Platonov, and V. Pashchenko, *Dneprovsky raketno-kosmicheskiy tsentr* (The Dneprovsk Space Rocket Center) (PO YuMZ KBYu, 1994), p. 105; Blair, *Global Zero Alert*, p. 52.

Chapter 3. The Nuclear Weapon Production Complex

1. The history of the nuclear weapons program is discussed in detail in the following publications: A. K. Kruglov, *Kak sozdavalas atomnaya promyshlennost v SSSR* (How the Soviet Atomic Industry Was Created) (TsNIIatominform, 1995); V. N. Mikhailov, A. M. Petrosyants et al., eds., *Sozdaniye pervoi sovetskoi yadernoi bomby* (Creation of the First Soviet Nuclear Bomb) (Energoizdat, 1995); E. A. Negin, G. D. Kulichkov et al., *Sovetskii atomnyi proekt* (Soviet Atomic Project) (Nizhni Novgorod, 1995); David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939–1956* (Yale University Press, 1994); T. Cochran, R. S. Norris, and O. Bukharin, *Making the Russian Bomb: From Stalin to Yeltsin* (Westview, 1995); R. Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (Simon & Shuster, 1995).

2. According to Rhodes (*Dark Sun*, p. 40), the decision to establish the commission was prompted by a letter from Vernadsky to the Academy of Sciences about a *New York Times*