Director's

Series

on

PROLIFERATION

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Director's Series on Proliferation

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Contents

1

Nuclear Proliferation: Myth and Reality

*Roger Baleras**

Some recent developments in nuclear proliferation have been cause for alarm; namely, the confused situation regarding the nuclear weapon complex of the former Soviet Union that resulted from the fall of the Eastern Bloc, and the surprising discovery of Iraq's nuclear program despite its being a signatory to the Nuclear Non-Proliferation Treaty (NPT). These phenomena not only reinforced a climate of worry during preparation for renewal of the NPT, but also led the United States to develop plans for a major new program in counterproliferation, including a program of missile defense (a revision of the previous Strategic Defense Initiative).

Certainly, conditions that favor nuclear proliferation have increased. It should not necessarily be concluded, however, that these conditions will inevitably lead to a plague. A reasonable analysis of the situation is required. Specifically, two key questions must be answered: (1) Should nuclear proliferation be considered as the major danger of the future? and (2) What is the danger exactly? To respond, the following must be addressed:

- New factors contributing to proliferation must be identified and their credibility adjudged.
- The means and difficulties of producing each major type of weapon must be outlined so that an *a priori* assessment of the probability of a proliferant actually producing it can be made.
- The motivations and options of proliferant nations must be identified so that the probability that one might actually mobilize the resources and the will to achieve a nuclear weapon capability can be estimated.

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Elements That Can Contribute to an Increase in Proliferation

Expectations of the 1960s that the number of countries with nuclear weapons would increase have not been realized. Today the number of threshold nations has actually decreased. We must recognize, however, that the evolution of the geopolitical scenery has produced new elements that could make proliferation easier.

Spread of Knowledge

Sensitive scientific information pertinent to nuclear weapons has been jealously guarded by the laboratories of the five declared nuclear weapon states. Even so, as a result of activities, such as publication of theoretical papers and declassification campaigns (especially in the United States), the principles for making a primitive nuclear weapon are well enough known. Such tools as computers and computer codes with dual uses are easily accessible (microcomputer capability is enough to design a primitive weapon).

Given the critical situation at the Russian laboratories, it is plausible that some experts could be co-opted by proliferating nations, but it is clear that the Russians are aware of this problem and are watching out for it. It would be more difficult to control the sale of sensitive documents, however. Conversion of the laboratories of the former Soviet Union to nonweapon work could prevent the movement of experts to proliferating countries, but might also contribute to a diffusion of weapons knowledge.

Uncontrolled Nuclear Materials

The key to controlling proliferation is to control nuclear materials such as plutonium and enriched uranium. Control is facilitated by the fact that production of these materials requires advanced technology, major facilities, and highly qualified people, and therefore a lot of money. It would be very difficult to carry out such a clandestine program for a long time, although a uranium program would be easier to hide than a plutonium one.

In reality, there have been cases for which clandestine programs have not been readily discovered. In the case of Iraq, there was a lack of vigilance and too much reliance on inspections by the International Atomic Energy Agency (IAEA). The inspectors focused only on the civil fuel cycle and did not look for a parallel, clandestine cycle based on enriched uranium. In North Korea, the IAEA went to the actual site where waste was stored, but the inspectors were fooled by camouflage and obfuscation, so they did not take samples when they could have.

Two lessons can be drawn from the above experiences:

- The usefulness of inspections is limited by their ability to intrude, and therefore on-site inspections cannot absolutely prevent deception.
- The experience in Iraq shows that production of nuclear material for weapons requires large facilities and years of work. Despite Iraq's effort, it was apparently unable to produce enough material for a nuclear weapon. (In the cases of Pakistan and South Africa, one can assume these countries have been helped.)

There is also the problem of international traffic in nuclear materials, an issue, largely raised by the press, that creates worry and sensitizes the world's police. Keeping track of nuclear materials is tricky because it requires continuously following these materials in all their forms in operational and reserve weapons, laboratory material, fabrication, scrap, etc. It would be impossible to have a continuous accounting of nuclear material in every location where it is used—research, manufacturing, and stockpile. Today the best guarantee against theft or diversion remains the inspection of entrance and exit quantities at each center where special nuclear materials are used.

Until now, the nuclear material traffic reported by the international press has not been sufficient in quality or quantity for a nuclear device. It is not in the interests of the nuclear nations, especially Russia, to permit such traffic. It is possible, but highly unlikely, that such movements could take place without the deliberate intent of one of the five declared nuclear weapons states, but that is an issue outside the scope of this analysis.

Although it may be possible to divert material from commercial nuclear power reactors, such an attempt has never been discovered. The NPT does not permit development of nuclear power without rigorous control of the associated nuclear fuel cycle. Most reactor fuel is low enriched and is inadequate for weapons. (One could argue about research reactors that use highly enriched fuel but they are low-power reactors producing very little plutonium and are subject to inspection.) Spent fuel reprocessing requires large and sophisticated facilities, which must be under international inspection. To separate plutonium from by-products is very complicated, much more so than the isotopic separation of uranium. Even if the Iraqi nuclear complex had not been discovered early, it is noteworthy that the IAEA inspections prevented weapons use of material from Iraqi nuclear facilities under safeguards.

The Means of Nuclear Proliferation

Radiological Weapons

A radiological weapon is an explosive device designed to disperse aerosolized radioactive material. It is a terrorist weapon; the desired effect is above all psychological and aims at terrorizing the civilian population. The principal effect is to contaminate an area for some period of time. Despite its apparent simplicity, such a weapon requires a lot of explosive and a large amount of radioactive material, which is difficult to obtain. Fabrication of the device would present nontrivial problems, such as manipulation of highly radioactive materials and assembly of components inside a case for delivery. The precautions necessary during manufacture of such an awkward radioactive device could easily be detected. Chemical and biological weapons are much easier to make, more discrete, and deadlier. The use of chemical weapons in the Tokyo subway by the Japanese religious sect, Aum Shinrikyo, demonstrates the point.

First Generation Nuclear Weapons

A "primitive" nuclear weapon is a pure fission device—like those used on Hiroshima and Nagasaki. Such a device can be developed without a nuclear test, but therefore has a band of uncertainty in yield between 10 and 50 kt. Safety is a delicate matter, and it depends on the nature and the mass of the nuclear material involved, becoming more of a problem as the mass increases. The basic principles of device design are well known. Production is nonetheless difficult and requires an effort roughly equivalent to that of the first US, UK, or French programs.

The Iraqi program, even though uncompleted, demonstrates the extensive resources that must be assembled:

- Five to ten thousand people.
- An annual budget of at least $1 billion.
- Training of experts in neutronics, explosives, metallurgy, numerical modeling, and production technologies.
- Design and construction of enrichment facilities.
- Production of weaponized neutron sources.
- Creation of high explosive test sites and the development of sophisticated diagnostics such as radiography.
- Construction and organization of other specific facilities, nuclear and non-nuclear.

Only a country having the will to pursue a nuclear weapons program, sufficient resources, and the capability to sustain a large effort for many

years could undertake such a program. A group of terrorists is unlikely to be able to do so. Compounding the problem, it is necessary that the program be hidden. Such a huge program would probably be detected or at least suspected before completion. The Iraqi case, which escaped international vigilance for many years, has little chance of happening again.

Modern Strategic and Tactical Weapons

The five declared nuclear powers possess modern strategic and tactical nuclear weapons, most of which are thermonuclear. They are miniaturized for ease of delivery and, consequently, are often sophisticated. Development of such weapons requires a large number of nuclear tests and is quite beyond the means of most proliferants. Only certain major industrial powers have the means to launch such a program. The absence of nuclear tests translates into weapons with poor performance and reliability. Programs for such advanced design weapons are much larger than those for first generation weapons and would require testing (which would profoundly upset the geopolitical scene) or detailed help from a nation that itself has tested.

Motivation for Nuclear Proliferation

As discussed, a massive effort is required to develop nuclear weapons. Such effort can only be supported by high motivation and steady will, which can be analyzed as a function of the same classes of weapons described above.

Radiological Weapons

The threat of radiological weapon use generally accompanies blackmail, which could be from ethnic groups, religious sects, fanatics, or highly determined opposition groups. Motivation can be very high. In all cases, however, alternative weapons are available that are simpler, easier to acquire, more reliable, and more efficient. Explosive, chemical, and biological weapons are better suited, less detectable, and easier to produce, and therefore are more likely. In a case of blackmail, if the radiological device can be located, there are countermeasures that have been developed to limit the effects of contamination.

First Generation Weapons

This issue of first generation weapons is important for most of the threshold nuclear nations, and the motivations can be diverse:

- *Legitimate concerns about national security* stemming from geopolitical or historical antagonisms. This is the case for nations surrounded by hostile neighbors or larger powers and, consequently, wanting to assure the sanctity of their national territory.
- *The search for cost effectiveness,* given the high cost of a sophisticated conventional capability, which must be continually upgraded and is a heavy burden for some nations to bear. A nuclear weapons capability will always remain very attractive and unequaled in its efficiency.
- *The search for gain in international prestige,* which can motivate political hegemony. With nuclear weapons, nations could hope to dissuade the international community from opposing their policy of expansion.
- *Internal pressures* from an autocracy in a country under military rule. The ruling class can gain a feeling of legitimacy in the exercise of national sovereignty.

Modern Strategic and Tactical Weapons

Modern strategic and tactical weapons are within the reach of only the large industrial powers with major scientific establishments. The drive to attain the status of a large nuclear power can only be motivated by a desire to defend economic or political interests on a regional or global scale. However, such proliferation will give rise to mistrust from potential adversaries. The probability that additional nations will develop such weapons is low, but cannot be excluded, especially if the political balance is disturbed in a major way.

The Balance Sheet on Proliferation

The fact that there has been an unexpectedly low level of nuclear proliferation over the last fifty years can be attributed both to the difficulties in making nuclear weapons, as discussed above, and to the restrictions on exports of nuclear technologies. Until now, the breakup of the USSR and the Gulf War have not had the consequences feared. On the contrary, in the last five years we have witnessed—aided by external pressure, but nonetheless real—renouncements of the nuclear programs by Brazil, Argentina, South Africa, and South Korea. We have seen an energetic restraint of Iraq. Nevertheless, international controls, no matter how rigorous, will always have limits, and the great effectiveness of nuclear weapons will always attract interest. The most important obstacle to nuclear proliferation remains the vast program that must be put in place without the rest of the world knowing.

The degradation of the Soviet nuclear complex can potentially raise the risk of proliferation through the spread of knowledge, the movement of experts, or the loss of nuclear material (although so far no nuclear terrorism has resulted). Although less frequently mentioned, the degradation of the Soviet military complex also may result in other types of proliferation:

- *Proliferation of conventional weapons,* drawn from the large Warsaw Pact stockpiles and sold at bargain prices, has contributed to some fatal confrontations, and the worst may not be behind us. No embargo on conventional weapons has been effective.
- *Chemical weapons* have proliferated despite international accords. The Aum Shinrikyo sect in Japan is an example. Chemical weapons are easy to make, and the necessary materials are available in the open market. There is nothing special about these materials, and it is practically impossible to control them. The simplicity permits chemical weapons to be developed and produced in secret.
- *Ballistic missiles,* which can be a common factor with the four other types of proliferation, have themselves proliferated during recent years. The Scud missile has spread around the globe. A collaboration between proliferant nations has been established to increase the performance and range of these delivery systems. Ballistic missile proliferation, which does not require many specific technologies, acts as a powerful catalyst to the development of weapons of mass destruction. More recently, the danger of proliferation linked to the technology of cruise missiles has appeared, and this is perhaps even more worrisome. Stealth technology is also spreading. Cruise missiles can easily be modified to enhance performance and carry chemical or biological packages, and even small unmanned aerial vehicles or light airplanes operated in a drone mode could be effective as cruise missiles.

Conclusion

The proliferation of weapons other than nuclear has been responsible for events in which a large number of people were killed, but no nuclear conflict has taken place, and no nuclear terrorism has been noted. Thus, nuclear proliferation has not only expanded less than other types of proliferation in the past few years, it has actually diminished. The upheaval in the East and the Gulf War have resulted in a great—perhaps exaggerated—sensitivity to the problem of nuclear proliferation.

The stress given by the United States to the problem of nuclear proliferation could be perceived by other countries as a desire for hegemony. They may see the United States as wanting to retain the power of US conventional weapons, while remaining the guardian of the nuclear fire by virtue of its lead over other nations in the nuclear area.

One must recognize that the US geographical position is unique, far away from unstable areas where future conflicts could arise. This is not the case for the other declared nuclear weapons states.

At present, new nuclear proliferation risks are likely to arise only from limited, known regional cases. Furthermore, such proliferation would not necessarily lead to large geopolitical perturbations, such as would occur if the proliferants were industrial powers that could undertake a program without assistance. Thus, nuclear proliferation cannot be excluded, but will not attain gigantic proportions because the difficulties of the process, compounded by the need for secrecy, are simply too great.

Although it is possible that destabilization may yet occur, it appears that renewal of the NPT and an active program for the surveillance of nuclear proliferation should be sufficient to assure international stability. Maintenance of the special status of the five declared nuclear powers and their nuclear deterrents assures restraint against not only emerging or improving nuclear capabilities, but against other weapons of mass destruction threats as well. Such a pragmatic approach seems preferable to that of looking for a total disappearance of nuclear weapons, as if one could disinvent the atom.

2

Problems of Enforcing Compliance with Arms Control Agreements

*Jozef Goldblat**

In general, states may be assumed to enter international treaties in good faith, intending to abide by their obligations. However, when such vital matters as national security are involved, special assurances are needed that the signatories will not engage in violating or circumventing their contracted commitments. The possibility of verifying compliance is an important criterion to be taken into consideration when states decide whether to conclude or accede to an arms control agreement.

The Role and Functions of Verification

For some politicians, verification is chiefly a means to clear away suspicions of aggressive intent of other states, irrespective of arms control obligations. For others, verification is tied specifically to the relevant arms control agreement because the form and modalities of verification depend on the nature, scope, and military significance of the agreed constraints. There is consensus, however, that verification is necessary to deter cheating. A government contemplating a violation may refrain for fear that detection might bring about an unwelcome response from the cheated state or states and perhaps even provoke a damaging reaction in its own country. On the other hand, deterrence of violations presupposes the ability to detect them. Timely detection is vital to enable the injured party to redress the situation, especially in cases constituting an immediate military threat.

Verification also has an important confidence-building function. By providing evidence that the parties are fulfilling their obligations and by

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confirming that the prohibited activities are not taking place, verification helps to generate an international belief in the viability of the arms control measures and to instill trust in participating states that their interests are protected. In addition, the existence of a verification mechanism makes it easier for a party unjustly accused of a breach to demonstrate its innocence. Charges that have not been disproved and misunderstandings that have not been clarified may negatively affect the international climate, weakening confidence in treaties and casting a shadow on arms control endeavors.

It is usually postulated that verification must be adequate, appropriate, or effective. The meanings attached to these terms differ. Most people take the view that there will always be a limit to detecting violations, but that the threshold should be low enough to make the significance of undetected breaches negligible. The reasoning behind this pragmatic approach is that what matters most is not the fact of noncompliance but the effect of noncompliance; and that, to make a difference that would alter the military balance between states, cheating would have to be practiced on such a scale as to render detection inescapable. Others, however, consider any deviation from the contracted obligations to be an offence that cannot be tolerated, regardless of its military significance, and insist on total verifiability. The reasoning behind this legalistic approach is that the principle *pacta sunt servanda* (contracts should be adhered to) must be observed unconditionally, under the threat of abrogation, even at the risk that disputes over trivial matters might undermine the treaty. Since foolproof verification of a treaty is in fact not achievable, and complete absence of violation can never be proved, only the first of the two approaches makes the conclusion of an arms control agreement possible. The parties must be prepared to take risks and judge whether the threat posed by undetected violations—even those that are militarily significant—is greater than that posed by totally unconstrained military activity. In other words, each party must decide for itself how much cheating it can tolerate—the degree of tolerable uncertainty being a judgment made by state authorities, based on the impact that a violation could have on national security.

Responses to Violations

However well-intentioned governments are when they sign an arms control agreement, they may at a later stage change their mind and be unable to resist temptations to engage clandestinely in outlawed activities. A government determined to derive military advantages from

noncompliance may take the risk that its felony would be detected through verification. Once a breach has been established, it is up to the cheated party or parties to react. Responses may differ depending on the extent to which a breach is considered serious by those affected by it. They may range from deliberately overlooking certain occurrences for overriding political or security reasons (for example, the unwillingness to reveal the source of information) to abrogation of the treaty, followed by punitive action. Between these extremes there exists a possibility of using diplomacy to effect a change in the behavior of the guilty party. This has often proved useful, particularly in dealing with controversial US–Soviet/Russian compliance issues.

Many multilateral arms control treaties provide for the United Nations (UN) and/or another international organization to be formally notified when a suspected or committed violation occurs. The event would thus become publicly known. As no government likes to be pilloried as a violator of legal obligations, publicity may be helpful as an instrument of sanction—more in democratic countries, which are sensitive to public disapproval, than in nondemocratic ones. A reported violation may also lead some states to take actions, such as the recall of ambassadors, the reduction of embassy staffs, and even the severance of diplomatic relations. In addition, international organizations may pass condemnatory resolutions. However, all these steps may not suffice to make the violating state rectify its behavior.

Possible UN Action

Once a competent body has made a definitive finding that a state has violated an arms control agreement, the UN Security Council may, if so requested, consider the matter. The Council is not expressly authorized by the UN Charter to take action against violators of arms control agreements, but if it finds that the situation brought about by the violation could lead to international friction it may, under Chapter VI of the Charter, recommend to the state or states concerned "appropriate procedures or methods of adjustment." The Council may also decide that a specific violation, or a certain type of violation, constitutes a threat to the peace. It could then, under Chapter VII of the UN Charter, call on UN members to apply sanctions—complete or partial interruption of economic relations and of rail, sea, air, postal, telegraphic, radio, and other means of communication. It could also recommend to the UN General Assembly the suspension of the rights and privileges of UN membership or even expulsion from the organization. Finally, the Council may decide that military sanctions should be taken, including demonstrations,

blockades, and other operations by the air, sea, or land forces of UN members. Thus, the Security Council possesses the means to restore international peace, which has been broken as a result of arms control violations. The determination to resort to these means was expressed in the 1992 statement by the President of the Security Council, on behalf of the members of the Council, to the effect that proliferation of weapons of mass destruction would constitute a "threat to international peace and security," and that appropriate action would be taken to prevent it. Significantly, such action would affect all states breaking the rule of nonproliferation—not only parties to relevant agreements—even though the ban on proliferation of nuclear, chemical, or biological weapons is not yet a rule of customary international law binding on all states alike. However, a statement by the President of the Security Council does not have a binding legal effect. To have such effect, it would need to be converted into a formal decision of the Council. Also the term *proliferation*, which lends itself to different interpretations, would have to be unambiguously defined; only then would the Council be entitled to take coercive measures.

In practice, it may be hard to gain approval for the drastic measures described above from the Security Council members not directly affected by a treaty violation or opposed to the treaty itself. Even with the requisite two-thirds majority, the Council may prove unable to act, if any of its permanent members threatens to use the right of veto—which it enjoys under the UN Charter—to defend its own interests or those of its allies. This is what recently happened when China refused to go along with the majority of the Security Council in coercing North Korea to abide by its nuclear nonproliferation commitments. The planned expansion of the Security Council, including its permanent membership, will further reduce the likelihood of adopting binding resolutions on arms control issues.

The problem of reconciling the right of veto with the proper functioning of arms control treaties was recognized as early as in 1946, when the United States put forward the Baruch Plan for the creation of an international atomic development authority. At that time, the US Government stressed the importance of immediate punishment for infringements, maintaining that there must be no veto to protect violators of international treaties—a proposition that the Soviet Union categorically rejected.

In connection with several arms control agreements, the Security Council has been granted functions that have the appearance of

sanctions. Thus, according to Security Council Resolutions 255 of 1968 and 984 of 1995, parties to the 1968 Non-Proliferation Treaty (NPT) received a pledge of assistance in the event they were aggressed or threatened to be aggressed with nuclear weapons. However, these so-called positive security assurances (and the associated statements made by the nuclear powers) did not add to, but simply reaffirmed, the existing obligation of the United Nations to provide assistance to a country attacked or threatened with an attack, whatever the weapon used. Only technical, medical, scientific, or humanitarian assistance is envisaged by the above-mentioned resolutions. The Security Council may recommend "appropriate" procedures regarding compensation under international law from the aggressor for loss, damage, or injury sustained as a result of the aggression, but since all measures provided for in the above resolutions must be taken "in accordance with the UN Charter," the rule of great-power veto will apply.

Similarly, in the 1972 Biological Weapons Convention and the 1977 Convention prohibiting the hostile use of environmental modification techniques, states undertook to provide or support assistance to any requesting party if the Security Council decided that such a party had been harmed (or was likely to be harmed) or exposed to danger as a result of a violation. Under the 1993 Chemical Weapons Convention, the Conference of the Organization for the Prohibition of Chemical Weapons may, in particularly grave cases regarding compliance, bring the issue to the attention of the Security Council. However, here again, the relevant provisions of the UN Charter would apply, and these, as mentioned above, may turn out to be inoperative.

It is true that Iraq, which had violated the NPT, was forced under the 1991 Security Council Resolution 687 to dismantle or destroy the key elements of its nuclear weapon development program. However, these sanctions were imposed chiefly because Iraq had committed aggression against Kuwait in violation of the UN Charter.

The General Assembly is another principal organ of the United Nations to which complaints of treaty violations can be addressed. Its actions are not subject to veto; only a two-thirds majority is required for a recommendation concerning international peace and security. However, considering the present composition of the Assembly of 185 states, obtaining such a majority may not be easy. And even when it is duly adopted, a resolution of the Assembly, unlike that of the Security Council, is not binding on UN members.

Possible IAEA Action

Another intergovernmental organization capable of dealing with breaches of arms control obligations is the International Atomic Energy Agency (IAEA). As envisaged in its Statute, cases of noncompliance with nuclear safeguards agreements are to be reported to the UN Security Council and the General Assembly. If corrective action is not taken within a reasonable time, the IAEA Board of Governors may direct curtailment or suspension of assistance provided by the Agency or a member state, and call for the return of materials and equipment made available to the transgressing member. A noncomplying state may also be suspended from exercising the privileges and rights of IAEA membership. (The Chemical Weapons Convention envisages similar action.) Since no country enjoys the right of veto in the IAEA Board of Governors, adoption of decisions to apply such sanctions cannot be ruled out, but, as explained below, their strength and effectiveness are doubtful.

The IAEA provides very little direct assistance to states, and that which is provided is not for their nuclear power programs. A Board decision regarding possible curtailment of assistance provided by states is not as unambiguously mandatory under the IAEA Statute as are decisions of the UN Security Council under the UN Charter. Even if all the deliveries of nuclear items were actually cut off to penalize the offending state, that state might not feel significantly disadvantaged in a world in which no country is exclusively dependent on nuclear power, and in which nuclear supply exceeds demand. Withdrawal of materials and equipment already supplied is not a realistic measure, because it would require voluntary cooperation of the state being penalized, which is unlikely. Moreover, the return of nuclear supplies may be both exceedingly expensive and dangerous, and the supplier may be unwilling to take them back. Suspension of IAEA membership does not seem to be an effective measure either. In concrete terms, it would involve, (1) withdrawing the right to receive Agency assistance, which, as explained above, is not an important sanction; (2) barring access to Agency information, which is available to members and non-members; and (3) being excluded from Agency meetings, which is not particularly hurtful. Expulsion from the Agency is not provided for.

The weakness of the IAEA enforcement mechanism is best illustrated by the case of North Korea, which was able to refuse international inspection of suspect facilities without provoking immediate and effective sanctions.

Other Collective Action

Collective international sanctions against a violator of a multilateral agreement may be taken even in the absence of an enforcement provision. Such sanctions, when applied, are usually related to the nature of the particular offence. Thus, the breach by India of its undertaking under international cooperation agreements to use nuclear energy exclusively for peaceful purposes prompted a number of countries to restrict the supplies of nuclear materials and equipment, and thereby reinforce the nuclear nonproliferation regime. Iraq's use of chemical weapons during its war with Iran, in violation of the 1925 Geneva Protocol, went unpunished, but a group of industrialized countries banned all exports of chemicals that could be used in the manufacture of chemical warfare agents. In-kind sanctions may not be sufficient, among other reasons, because the number of countries able and willing to apply such sanctions may be too small to produce the desired effect. Coercive measures must be proportional to the gravity of the offence, but they do not need to conform qualitatively to the offence. In other words, a variety of collective sanctions for violating arms control agreements, whether or not approved by the United Nations, may be agreed by the parties and inflicted upon the violator. They could include economic measures, such as the cancellation of economic assistance, the imposition of trade restrictions, and even the termination of vitally needed supplies unrelated to the breach. It is clear that the larger the number of countries imposing sanctions, the greater their effectiveness.

The Chemical Weapons Convention provides for collective measures, in conformity with international law for cases in which serious damage to the object and purpose of the Convention may result from activities prohibited by the Convention. A recommendation to take such measures may be adopted by the Conference of the Organization for the Prohibition of Chemical Weapons, either by consensus or by a two-thirds majority. This, however, may be difficult to achieve. Moreover, the nature of the envisaged measures has not been specified.

Abrogation

All major arms control agreements contain a clause permitting a party to withdraw from the agreement if it decides that extraordinary events have jeopardized its supreme interests. The withdrawing party must give advance notification and, according to most treaties, explain the reasons for its action, but the term *extraordinary* may mean different things to different countries. A violation could justify withdrawal, even

though it would not always endanger the security of the treaty-abiding parties to the point of requiring the abrogation of the treaty.

In bilateral relations, the threat of withdrawal is the primary means of enforcing a treaty, for it may deprive the violating nation of the advantages it has gained from entering it. Alternatively, the party injured by a violation may respond by taking the same prohibited action as the offender without repudiating the agreement as a whole. Such a tit-for-tat interplay—which would be equivalent to informally modifying the terms of the treaty—is conceivable only as long as the main purpose of the treaty has not been perverted. However, the United States did not resort to such responses when the breach of the Anti-Ballistic Missile (ABM) Treaty by the Soviet Union was established and admitted. It preferred exerting pressure on the violator to make it take corrective action. Indeed, the collapse of the ABM Treaty would have harmed not only the interests of the Soviet Union but also those of the United States and its allies.

In multilateral relations, withdrawal from a treaty in response to a violation, or retaliation with a similar prohibited action, would in most cases be self-defeating. It could lead to the unravelling of the treaty, to the detriment of all other parties. This is why the violation of the Biological Weapons Convention, again by the Soviet Union, did not provoke withdrawals from the Convention.

According to the law of treaties, even in the absence of a withdrawal clause, a material breach of a bilateral treaty by one of the parties—which may be a repudiation of the treaty or a violation of a provision essential to the accomplishment of its object or purpose—entitles the other to invoke the breach as grounds for terminating the treaty or suspending its operation. A material breach of a multilateral treaty by a party entitles all other parties—but only by unanimous agreement—to suspend the operation of the treaty or to terminate it, either in the relations between themselves and the defaulting state or as between all parties. A party especially affected by the breach may invoke it as grounds for suspending the operation of the treaty in the relations between itself and the defaulting state. Any party other than the defaulting state has the right to invoke the breach to suspend operation of the treaty with respect to itself if the treaty is of such nature that a material breach of its provisions by one party radically changes the position of all parties with respect to the further performance of their obligations under the treaty. Most arms control agreements are of this nature. The above rules do not apply to provisions relating to the protection of human beings that are

contained in treaties of a humanitarian character, in particular to provisions prohibiting any form of reprisal against persons protected by such treaties.

Conclusion

The traditional responses to violations are in most cases ineffective. To improve the situation, important modifications would have to brought about in the structure and working of the main organs of the United Nations as well as of other international organizations. The force of the UN General Assembly resolutions would have to be enhanced, the right of veto in the UN Security Council circumscribed, the prerogatives of the executive bodies of the arms control implementing organizations widened, and their decisions rendered mandatory. However, the implications of such radical changes would go well beyond the field of arms control. They would certainly be regarded by many states as politically undesirable and, therefore, not feasible in the foreseeable future.

For a response to an unequivocally established violation of a multilateral obligation to be effective, all or most parties must act with no delay and in solidarity with the state or states hurt by the violation. Significant solidary action is not always possible, because many countries are opposed to applying sanctions that have not been decided by competent international bodies. If collective enforcement measures against a culprit state were to be applied without the requirement that an international decision must be taken in each individual case, the nature of such measures would have to be agreed before a violation has been committed, not after.

In devising responses, a distinction must be made between different violation types. Violations can vary from inaccurate or incomplete reporting to nonobservance of procedural clauses, to offences resulting from misunderstanding or misinterpretation of the terms of the treaty, up to obstruction of the control system and material breaches of bans on possessing certain weapons, on deploying armed forces and armaments in certain areas, or on engaging in dangerous military activities. Violations can be committed by governmental authorities, by nongovernmental institutions, or even by individuals (with or without the consent or knowledge of the authorities). Further differentiation is necessary between intentional and unintentional breaches. The latter, which is usually easier to remedy, may result from sheer negligence or inadvertence. Some breaches may be reversible, others may not be.

A Proposal

It is proposed here that responses to possible violations of arms control agreements be made part and parcel of the complex of obligations contracted by the parties, with the exception of the use of force, which may be decided solely by the UN Security Council. The responses—different for different treaties—could be listed in the text of the treaty or in a protocol signed simultaneously with the treaty or later. They may be grouped according to the type of violation, and graduated from mild to severe so as to increase pressure on the violator over time and eventually force it to mend its ways. The conditions for transition from one response to another would also have to be agreed in advance.

The very existence of a list of envisaged sanctions, which does not need to be definitive (it could be periodically revised), would, no doubt, fulfill the function of deterrence. Moreover, a government refusing to take action against a violator, and abstaining, thereby, from upholding the validity of the arms control agreement to which it is party, would expose itself to both international censure and domestic criticism. A first attempt to draw up a list of enforcement measures could be made in the committee that will be charged with preparing the next NPT Review Conference.

Under the proposed scheme, no country would be immune from deserved penalties. It is clear that the stronger and the richer the violating country, the easier it may be for it to resist outside pressure. Nonetheless, it is essential to establish a principle that perpetrators of arms control violations shall not get away with impunity. Since the general public tends to equate such violations with immediate threats to national security, reactions of the complying states must be predictable. Otherwise, verification may lose its *raison d'être.* Violators must fear detection.

3

The Unreliability of the Russian Officer Corps: Reluctant Domestic Warriors

*Deborah Yarsike Ball**

As Russia's fragile democracy continues to be tested, a key question is whether the Russian officer corps is loyal to the central government in Moscow. This question is even more salient given that the military's reliability was tested and found wanting in the breakaway region of Chechnia, where several generals disobeyed orders: Eduard Vorobyev, first deputy commander in charge of the ground forces, refused to lead his troops into battle because he believed the soldiers were ill-prepared to fight; Ivan Babichev, commander of three Russian divisions, halted his column's advance toward Grozny because he did not think it was appropriate to "to use tanks against the people."[1] Is the disobedience to Moscow displayed by such senior officers representative of the sentiments of the officer corps as a whole or were these acts of insubordination isolated incidents?

A survey of 600 field-grade officers conducted throughout Russia in May and June 1995 suggests that unreliability within the officer corps is pervasive. For missions such as quelling separatist rebellions or arbitrating political disputes between the President and Parliament, President Yeltsin and the central government cannot count on the military to execute their orders.

The issue of military reliability is important for at least three reasons. First, the military can be a decisive factor in the outcome of domestic political disputes, as was demonstrated in the 1991 coup that led to the

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[1]See, respectively, Michael Specter, *The New York Times*, January 20, 1995, p. 10; and Lee Hockstader, *The Washington Post*, December 16, 1994, p. 1.

demise of the USSR, and the 1993 conflict between President Yeltsin and the Parliament. Second is the issue of secession. Some have suggested that Moscow's inability to resolve the military's economic woes could lead the military to transfer its loyalty from central civilian authority to regional leaders. General Shaposhnikov, former head of the Commonwealth of Independent States' forces, has already warned of "the growing influence on the army of the leadership of the subjects [regions] of the federation, who now present themselves in the role of saviors of the military garrisons and units." Stephen Sestanovich contends that it is not difficult "to conjure up military formations independent of headquarters, serving regional rather than national interests."[2]

A third reason why the reliability of the officer corps is important pertains to the custody and control of nuclear weapons. The Russian military physically controls the nuclear weapons. If a region where nuclear weapons are stationed declared independence and Moscow could not count on the officers stationed in that region to use force to bring the rebellious region back under central authority, then Moscow could lose custody of the nuclear weapons stationed in that region.

Methodology

To assess the reliability of the Russian officer corps, a survey (the Ball survey) of 600 field-grade officers (majors, lieutenant colonels, and colonels) was conducted in 12 regions of Russia in May and June 1995 (Figure 1). Nuclear weapons are stationed in 9 of these 12 regions.[3] The regions were chosen according to economic, political, geographical, and demographic criteria. In selecting the regions, every effort was made to choose regions that were dissimilar in order to discount, to the extent possible, regional effects on the attitudes of the officers. Seven of Russia's eight military districts were covered; the Caucasus was excluded because it was too politically volatile a place to send interviewers.

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[2]On Shaposhnikov, see *Segodnia*, June 24, 1994, p. 9; and Stephen Sestanovich, "Russia Turns the Corner," *Foreign Affairs*, January/February 1994, p. 87.

[3]The regions are: Kaluga, Moscow City, Voronezh, Saratov, Nizhnii Novgorod, Murmansk, Mari El, Sverdlovsk, Krasnoyarsk, Tuva, Chita, and Primorye. Moscow City, Voronezh, and Tuva do not contain nuclear weapons. The anti-ballistic missile sites are in Moscow Oblast. See, *Nuclear Successor States of the Soviet Union*, The Carnegie Endowment for International Peace and Monterey Institute of International Studies, December 1994.

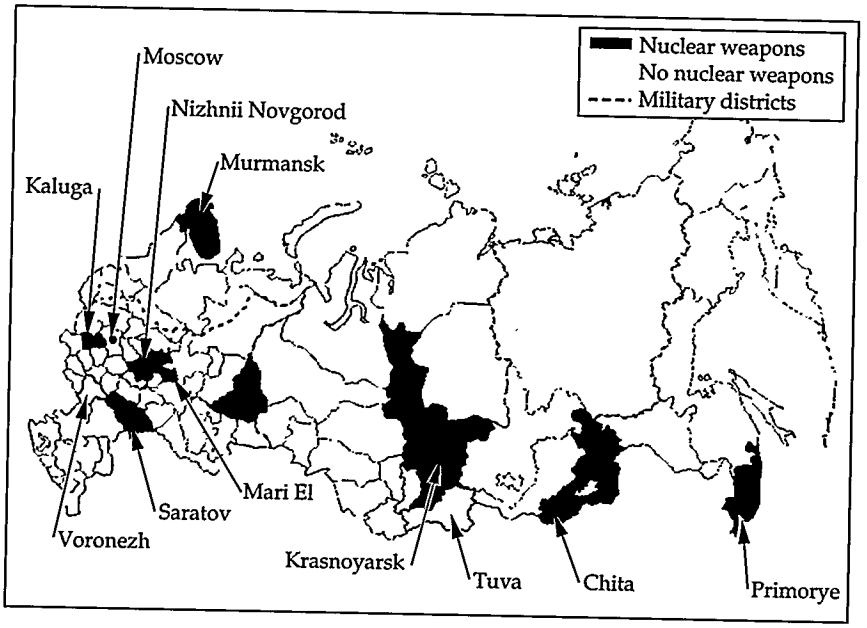


Figure 1. Regions where field-grade officers were interviewed.

The surveys, conducted by Russian Public Opinion and Market Research (ROMIR), a highly regarded Moscow-based survey research firm, were face-to-face interviews at the officers' respective bases.[4] All officers were active members of the Russian armed forces; no retired or reserve officers and no officers from the border guards or internal troops were interviewed. The officers were selected according to four criteria: service, rank, military assignment (command or staff), and branch of service. Those interviewed in the survey constituted a representative sample of the Russian military: their breakdown by service, rank, assignment, and branch was approximately equal to their actual proportion in the Russian military with the exception of the Air Defense Forces (Table 1).

[4]The refusal rate was 7.8%.

Table 1. The Ball survey of 600 field-grade officers: a representative sample.

	%	Number interviewed
Service		
Ground forces	53	320
Air force	14	84
Navy	16	97
Strategic missile forces	15	89
Air defense	2	10
Rank		
Colonel	20	122
Lt. Colonel	33	200
Major	46	278
Military assignment		
Command	56	333
Staff	44	267
Branch		
Combat arms	67	403
Combat—support	33	197

The Military's Perception of Its Role in Society

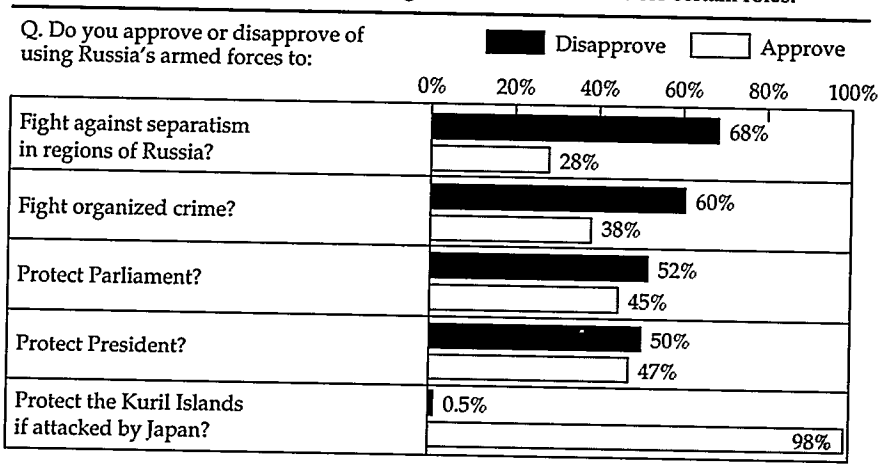
Most Russian officers do not want the military used for domestic political purposes. When asked whether they approved of using military force to fight against separatism, fight organized crime, protect the Parliament, or protect the President, the majority of officers disapproved of using the military for such purposes (Table 2).

Quelling Separatism

The officers were particularly adamant in their opposition to using the military to quell a separatist rebellion in one of the regions of the Russian Federation. Two-thirds of the respondents stated that they disapproved of using the armed forces to fight against separatism in the regions of Russia. Only 7% unreservedly approved of using the military for such purposes.

Given the arduous struggle the military faced in the secessionist region of Chechnia, there was a possibility that the officers' views might be temporarily tainted by these events and that once Chechnia became

Table 2. Approval or disapproval of using Russia's armed forces for certain roles.



a distant memory, they might have a different perspective on using the military to quell separatist rebellions.

To test the effects of Chechnia on the respondents' attitudes, data from the Ball survey were compared with those from a poll commissioned by the German Social Democratic Party's Friedrich Ebert Foundation and conducted in the summer of 1994 before the situation in Chechnia became critical. The Ebert Foundation asked precisely the same question: "Do you approve or disapprove of using Russia's armed forces to fight against separatism in regions of Russia?" The results were similar.[5] In both surveys, the majority disapproved of using Russia's armed forces to fight separatism.[6] The main difference between the two surveys' results concerns the "don't knows"—the undecided. In the Ebert Foundation questionnaire, 22% stated that they did not know whether they approved of the use of armed forces to quell separatism, whereas in the Ball survey, only 4% expressed this uncertainty. The principal effect of Chechnia was that it solidified officers' views, enabling

[5]The Ebert Foundation study used a slightly different sample, interviewing lieutenant colonels through generals, retired officers, officers from the border guards, and internal troops (MVD). In comparing the answers to this question, this author looked at only those officers in the Ebert Foundation study that fit within the sampling specifications.

[6]The findings of this study are consistent with a poll conducted by *Izvestia's* analytical service between December 1994 and March 1995 of junior and mid-level officers (lieutenants through majors). The vast majority of officers stated that the military should not be used as an instrument of domestic policy. See, "Za kogo progolosuet leitenant Ivanov?" [For Whom Will Lieutenant Ivanov Vote?], *Izvestiia*, April 21, 1995, p. 4.

fence sitters to make up their minds. Once stark and recent images of a real separatist rebellion gave reality to a hypothetical question, it became easier for the officers to formulate an opinion.

Officers could easily disapprove of using the military for a specific purpose, such as quelling separatist unrest, and yet still obey orders to perform the task. As Defense Minister Pavel Grachev stated, "We are professional military men, and when we receive an order we must carry it out."[7] This view is encoded in the Armed Forces Service Regulations, which state that "discussion of an order is impermissible, and disobedience or other nonexecution of an order is a military crime." This provision is nothing extraordinary; it is the *modus operandi* of militaries everywhere.

Such professionalism does not, however, appear to be the *modus operandi* of the current Russian officer corps. Data indicate that there is a serious breakdown in discipline among field-grade officers. The Ball survey specifically inquired whether the officers "would follow orders if one of Russia's regions declared independence, and the Russian government ordered troops to take over the region's government administration" (Table 3). Of the field-grade officers, 39% (236 respondents) admitted that they probably or definitely would *not* follow orders. It is unusual for a highly trained, professional officer corps to admit to the possibility of disobeying a lawful order. And yet, two-fifths of the officers interviewed did just that. What is especially interesting is that ROMIR had advised against asking this question, arguing that the highly professional Russian officers corps would take offense and refuse to complete the questionnaire. Yet, the vast majority of officers—90%—answered the question; only 4% refused to answer and 6% were undecided.

Although 39% admitted they would disobey orders to put down a separatist rebellion, the actual percentage is probably considerably higher. The 4% who refused to answer may have done so because they did not want to admit that they would disobey an order. Some of those who were undecided probably fit into this category as well. It was surprising to see that only 17% stated that they would "definitely follow orders," while 34% said they would "probably follow orders." Some percentage of this latter group who said they would "probably follow orders" probably would not actually follow orders but were worried

[7] *Kommersant-Daily*, 1 March 1995, translated in *Current Digest of the Post-Soviet Press* 47, March 29, 1995, p. 6.

Table 3. Responses to the question: Would you follow orders to put down a separatist rebellion?

Response	%
Definitely follow orders	17
Probably follow orders	34
Probably not follow orders	24
Definitely not follow orders	15
Refused to answer	4
Undecided	6

about admitting to such a flagrant violation of military law.[8] A total of 83% of the officers declined to say that they would definitely follow orders. This suggests a serious breakdown in discipline in the Russian officer corps.

Protecting the President

Another surprise was that the officers did not view positively their role as protector of the President who, according to the Russian constitution, is also the commander in chief. The officers' opposition to protecting the President is probably attributable to a general reluctance to see the military enmesh itself in domestic political disputes. Given the military's past experience in this regard, such views are not surprising. In both 1991 and 1993, the military was called on to protect the President of Russia. The result was that the military was criticized for becoming involved in a domestic dispute. There were numerous instances during President Gorbachev's tenure when the military was castigated for becoming involved in domestic disputes. When Gorbachev sent troops to Vilnius, Lithuania, in January 1991 and civilians were killed, the military bore the brunt of the blame. Militaries have long institutional memories, and the Russian military is no exception; protecting the President conjures up images of bitter domestic embroilment and public criticism.

Rightful Role

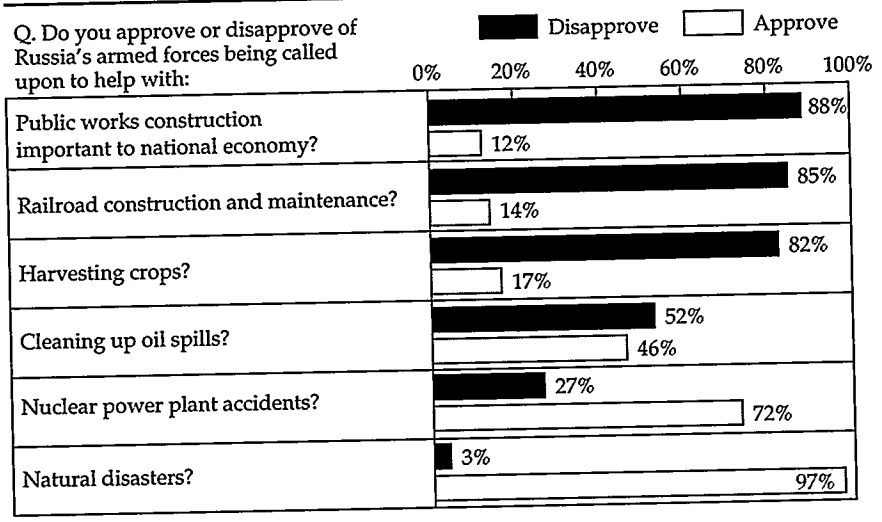
The military feels that internal troops should take care of the country's "internal" problems, and that the military should be responsible for protecting the nation against external threats. And, indeed, in this latter

[8]Russian military doctrine explicitly states that the armed forces may be used to counter separatism, which is one of "the main internal sources of military threats." See "Voennaia doktrina Rossii" [Russia's Military Doctrine], *Rossiiskie vesti*, November 18, 1993, p. 1.

area, the officers exhibit exceptional reliability. When asked whether they would obey orders to defend the Kuril Islands against a hypothetical attack by Japan, 98% of the field-grade officers said they would.

Moreover, the officers believed that the military had a legitimate role in helping the country cope with domestic problems such as natural disasters. Thus, it is not domestic duty *per se* to which the officers object, but rather domestic assignments that they deem political or mundane. They are more than willing to help out with national disasters. They do not want to harvest crops, construct roads, or perform other public works, but when a real disaster strikes, such as an earthquake, flood, or nuclear power plant accident, the vast majority approve of using the armed forces for such purposes (Table 4).

Table 4. Approval or disapproval of Russia's armed forces being called upon to help with certain tasks.



Factors Affecting the Reliability of the Officer Corps

Two variables had a significant effect on officers' attitudes: the region where they are stationed, and the service to which they belong.

Regional Effects

In designing the survey, this author assumed that where the officers were stationed would have no effect on their attitudes. The majority of officers serve in a region for only two to four years. The hypothesis was that, given how frequently officers move, the culture of military life

would provide their formative experience and not the regions where they were stationed. The data indicate otherwise.

Two questions that measure reliability were examined for regional effects. The first is the question discussed above on whether officers would obey orders to put down a separatist rebellion. The second question asked whether the officers would have followed orders to attack the Parliament in October 1993 if they had been stationed there. The answers to these questions varied by region (Table 5).

Table 5. Reliability depends on the region where officers are stationed.

	Would disobey orders to attack separatists (%)	Would have disobeyed orders to attack Parliament in October 1993 (%)
Kaluga	68	80
Mari El	70	72
Tuva	31	72
Krasnoyarsk	61	70
Moscow	37	63
Chita	33	62
Primorye	39	60
Sverdlovsk	59	53
Murmansk	19	52
Nizhnii Novgorod	27	49
Saratov	46	41
Voronezh	21	27
All Officers	39	51

The most reliable officers were stationed in Voronezh: 21% stated that they would not have followed orders to attack separatists, and 27% stated they would not have followed orders to attack Parliament in 1993. (Of all the officers who answered these questions, 39% said they would not obey orders to attack separatists, and 51% said they would not have attacked Parliament.) In contrast, officers in Krasnoyarsk were among the most unreliable: a majority indicated they would not have followed orders to attack separatists (61%) nor Parliament (70%). For many other regions, there was no consistent pattern. For instance, 39% of the officers in Primorye stated that they would not attack separatists, whereas 60% would have attacked Parliament. At this juncture, it is unclear what accounts for these differences. Voronezh, located in the poor black earth region, is typically thought to be a conservative region, yet preliminary analysis indicates that officers in Voronezh appear to be quite liberal on

a host of issues touching upon civil liberties, human rights, and democracy. Officers in Krasnoyarsk appear to be the least satisfied with service in the military, as measured by wages, job security, and opportunities for advancement. However, dissatisfaction with military service did not explain why officers in other regions responded similarly to officers in Krasnoyarsk. There is no consistent pattern to account for the regional differences. Further analysis of the regions using rigorous statistical tests will be required to determine what aspects of the regional context shape the political orientation of officers stationed in the regions. That there are differences, however, is indisputable.

Branch of Service Effects

The branch of service also has an impact on the attitudes of the officers corps. On the issues of whether the officers would quell separatist unrest and whether they would have attacked Parliament in October 1993, almost half of the officers in the ground forces would not have followed orders to do either; 47% would have disobeyed orders to put down a separatist rebellion, and 46% would not have attacked Parliament. Given that the ground forces would spearhead any attacks of the kind described here, this is a crucial finding. The officers in the other services differentiated between an attack to quell separatism and one against Parliament. Officers in the air force, strategic missile forces, navy, and air defense forces were more reluctant to attack Parliament than they were to quell separatism.

Political Implications

The results of the survey of Russian field-grade officers indicate that Moscow cannot count on the military to help resolve domestic political disputes. Evidence of this phenomenon was already apparent in Chechnia, where a number of officers refused to obey orders to bring Chechnia back under Moscow's control. Eventually, the central government managed to cobble together enough units to overwhelm the Chechians, but what occurred in Chechnia should give pause to the Russian leadership. Many officers who disobeyed orders were not court martialled; reassignments took place, but there were relatively few criminal proceedings in response to flagrant violations of military law. Thus, in the future, there will be even less incentive for officers to follow orders because few suffered serious consequences as a result of disobeying military orders in Chechnia.

A key finding is that in four of the nine regions containing nuclear weapons (Kaluga, Mari El Krasnoyarsk, and Sverdlovsk), the majority of officers openly stated they would disobey orders to put down a separatist rebellion. This lack of reliability may not necessarily be a characteristic of the officers who have actual custody of nuclear weapons. But, if a region where nuclear weapons are stationed did declare independence, it is conceivable that the nuclear weapons could be at risk. Even if the military did not openly side with regional authorities but chose to remain "neutral" on the sidelines, Moscow could lose control because regional authorities need only the passivity of the military to win such a showdown.

In conclusion, the Russian officer corps conceives its main mission as defending the nation against external attack. Moscow must prepare and rely on its internal troops should it decide to use force against the regions. The Russian military already lacks cohesiveness as evidenced by the various political platforms espoused by officers running for political office. If the central government continues to insist that the military become embroiled in internal domestic disputes, then the Russian military may go the way of the Soviet Union—complete disintegration.

4

Russia's Nuclear Legacy

*Boris Segerstahl**

Environmental problems and potential health threats are much greater and more serious when nuclear contamination is the result of a nuclear weapons program as opposed to nuclear energy production. The contamination can be caused by accidents and disasters at nuclear facilities, nuclear weapon testing, so-called peaceful nuclear explosions, imperfect technologies for the reprocessing of irradiated fuel, and poor or insufficient waste management—especially in the early days of military nuclear activities. This article reviews the legacy of problems inherited by Russia from the Soviet nuclear weapons program.

Although serious contamination resulted from the nuclear weapons programs of both the United States and the former Soviet Union, there is a difference in the size and urgency of the problems in Russia. Newly available data[1] reveal extensive and often uncontrolled radioactive contamination of soils as well as surface and ground waters; this article is a survey of some of the most urgent contamination problems and issues in Russia. To begin, it is necessary to understand the vast amount of radioactive waste (RW) in Russia (Table 1). Amounts of Sr-90, Cs-137, and Pu isotopes stored in eight major locations in the former Soviet Union are given in Table 2.

The data in Tables 1 and 2 clearly show that the main part of the waste volume is managed by Minatom and the most important (measured in MCi) storage location is Mayak. Many questions remain unanswered, however. For example, one source states that at Tomsk-7 more

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[1]Much of the available data are incomplete and/or inconsistent. The facts and figures used in this essay are drawn from several sources and represent, in the author's view, the best information available at present.

than 1000 MCi of radionuclides have been pumped down to a depth of around 300 meters. It is unclear how and if this waste, as well as materials from other locations (e.g., cascades along the River Techa), are accounted for.

Table 1. Radioactive waste in Russia.[a]

Organization	Accumulated RW		Solidified RW	
	Quantity (m^3)	Activity (Ci)	Quantity (m^3)	Activity (Ci)
Minatom	6.3×10^8	1.5×10^9	2.6×10^4	2.0×10^8
Ministry of Defense	2.7×10^4	9.8×10^2	2.0×10^2	0.2×10^2
Ministry of Transport	1.9×10^3	2.0×10^4	—	—
State Committee of Defense Industry	4.0×10^3	6.0×10^2	—	—
Ministry of Construction Industry	2.0×10^5	2.0×10^6	6.0×10^3	1.2×10^2
Total	$\mathbf{6.4 \times 10^8}$	$\mathbf{1.5 \times 10^9}$	$\mathbf{3.2 \times 10^4}$	$\mathbf{2.0 \times 10^8}$

[a]Data in this table were presented by representatives of Minatom at an International Atomic Energy Agency meeting in May 1995.

Table 2. Amounts of Sr-90, Cs-137, and Pu isotopes stored in eight major locations.

Site	Sr-90 (MCi)	Cs-137 (MCi)	Plutonium isotopes (kg)
Kyshtym (Mayak)	1260	760	30,000
Krasnoyarsk	860	530	16,000
Kursk	310	200	10,700
Chernobyl	270	170	10,000
Tomsk	260	160	115?
St. Petersburg	255	160	8,900
Ignalina	250	150	5,200
Smolensk	165	105	5,200

Three Nuclear Weapon Production Sites

Major nuclear contamination problems have been caused by three nuclear weapon production facilities, Chelyabinsk-65, Tomsk-7, and Krasnoyarsk-26, all of which are located east of the Ural Mountains.

Chelyabinsk-65 (Mayak)

Mayak is the location of the Soviet Union's first plutonium production facilities. The complex began operation in 1948 and produced plutonium for the first weapons test conducted on August 29, 1949.

Today the total amount of radionuclides stored at Mayak is probably 1000 MCi, of which 570 MCi is liquid high-level waste stored in steel tanks. More than 200 MCi of vitrified high-level nuclear waste is stored in a facility near the vitrification plant. The rest of the waste is stored at other facilities. More than 200 sites in an area of about 30 hectares are used for storage of solid waste. In addition, Mayak is one of the locations where plutonium, perhaps 30 metric tons, is stored.

Between 1949 and 1952, almost 3 MCi of liquid nuclear waste was dumped into the River Techa. Symptoms of radiation sickness in the population along the river led to the evacuation of several villages; 7500 of the 124,000 people exposed to radiation were evacuated. A cascade of reservoirs was constructed between 1952 and 1964, to prevent or slow the spread of radioactivity along the Techa River. These reservoirs are a major potential threat to the population and ecosystem along the river. In 1994, the volume of contaminated water in the reservoirs was 396 Mm^3 and the amount of radionuclides was 327 kCi.

In September 1951, the disposal site for radioactive waste was moved to a local lake, Karachay, into which approximately 120 MCi of nuclear waste has been dumped. This is more than twice the total release from the Chernobyl accident. One of the major problems resulting from the waste in Lake Karachay is the contamination of groundwater. The velocity of the underground flow between Karachay and a nearby river, River Mishelyak, is 0.39–1.77 m/day (average 0.84 m/day). The velocities differ for various contaminants. Empirical data for the velocity of equal concentration lines are: 0.23 m/day for nitrate-ion; 0.23 m/day for strontium-90; 0.14 m/day for cobalt-60. This contamination is a threat to the fresh water supply system of towns in the region.

Since the 1950s, Mayak has used concrete storage facilities for liquid nuclear waste. Each is steel-clad and designed for 20 storage tanks. The waste-filled stainless steel tanks are immersed in water for external cooling. A failure in the cooling system of one of the storage tanks in 1957 caused a chemical explosion with a power equivalent of 70 tons of TNT; 20 MCi of radioactivity were released into the air. Ninety percent of this release was deposited on the ground close to the site of the explosion, but a plume of finer particulates was carried up to a height of 1 km. This radioactive cloud was transported by the wind to the northeast and radioactivity was dispersed widely (Table 3).

Table 3. Areas contaminated by the 1957 Mayak explosion.

Contamination (Ci/km^2)	Area (km^2)
1000–4000	17
100–1000	100
20–100	280
2–20	600
0.1–2	15,000–23,000

The area within the 4 Ci/km^2 of Sr-90 isoline was 700 km^2. The population was evacuated from this region (Table 4). A sanitary zone defined by this isoline was established to prevent increased dietary intake of Sr-90. More than 10,000 inhabitants of 23 neighboring villages were evacuated. The region of contamination is known as the East-Ural Radioactive Trace.

Table 4. Population evacuated after the 1957 explosion.

Number of persons	Sr-90 contamination (Ci/km^2)	Time after accident (day)	Average exposure (mSv)	
			External	Effective equivalent dose
1054	500	7–10	170	520
280	65	250	140	440
2000	18	250	39	120
4200	8.9	330	19	56
3100	3.3	670	7	23

During a long drought in 1967, radioactive sediments in Lake Karachay were exposed. A tornado dispersed 600 Ci of radioactive dust over 2700 km^2 (defined by 0.1 Ci/km^2); the area contained 63 villages and a population of 41,500. The dose of external radiation was 7–13 mSv.

One of the major problems today, in addition to the existing contamination of the River Techa and the potential risk caused by Lake Karachay, is the cascade of reservoirs in River Techa, which contain 327 MCi of liquid nuclear waste having a total volume of 396 Mm^3. These reservoirs, together with Lake Karachay, cause the continuous seepage of radionuclides into the groundwater system in the region and into the river. The problem is exacerbated by the risk of the dams breaking, and then flooding the river valley of Techa, which would cause a major catastrophe in the region.

Krasnoyarsk-26

Plutonium production started at Krasnoyarsk-26 in the early 1950s. The whole production system, including the reactors and radiochemical plant, is located underground at a depth of 250–300 m. The volume of the complex is 7 million m^3, and inside the mountain are 3500 rooms and halls. One of the three reactors is still in operation.

In the Severnyy repository 20 km south of the plant, 4.5 Mm^3 of liquid radioactive waste has been discharged to a depth of 190–475 m over the last 30 years. Total activity is 700 MCi. The nearby Yenisei River shows heightened levels of radioactivity both in the river water and in the sediment along the river for hundreds of kilometers downstream from Krasnoyarsk. Observed levels of gamma radiation in the Yenisei River are more than a hundred times above normal. Concentrations of Pu-239 as high as 28 Bq/kg have been measured along the river banks.

A plant, RT-2, was authorized in 1977 for reprocessing spent fuel from civilian reactors. This project has run into financial difficulties and strong local opposition. A major reason for this opposition is environmental concerns.

Tomsk-7

Tomsk-7 started producing plutonium and electricity in 1958. It has a total of five reactors, two of which are still in operation. For several decades waste has been dumped into nearby reservoirs.

At Tomsk, solid and liquid wastes are stored at 50 different locations. Total activity is 125 MCi. There are two open reservoirs with an area of 75,000 m^2. Total volume of waste discharged between the mid-1960s and 1982 is about 280,000 m^3. Activity today in the reservoirs is estimated to be 126 MCi of long-lived isotopes. An underground repository for liquid waste is located 10–20 km away from the river. This facility has been in use since 1982. Wastes are pumped down to a depth of 240–340 m. Total volume disposed of is approximately 40 Mm^3. Total activity is said to be 1100 MCi of long-lived isotopes.

Local inhabitants have in some cases been found to have higher than permissible levels of radioactive substances in their bodies. Several minor accidents, including at least one storage tank explosion, have occurred.

Reprocessing

Reprocessing separates plutonium and unused uranium from spent nuclear fuel and from fission products and other wastes contained in irradiated fuel elements. Emissions from these reprocessing plants are

the main source of radioactive releases from normal operation of the nuclear fuel cycle. Approximately 330 kCi of ^{85}Kr has been released annually from Tomsk-7. Corresponding amounts at Chelyabinsk-65 are 810 kCi (one source says 2300 kCi), and at Krasnoyarsk-26 the release has been 170 kCi. In addition to radionuclides, the liquid wastes contain large quantities of cyanide, organic solvents, and acids, which add to the environmental risk and problems around the plants.

Chernobyl

The largest nuclear contamination zone in the world was caused by the Chernobyl accident. The area contaminated by Cs-137 at a level of more than 5 Ci/km^2 covers about 30,000 km^2. This area is today divided between three independent states, Russia, Ukraine, and Belarus, in the proportions 29, 12, and 59%, respectively. The total population of the area is more than 800,000 with a proportional distribution of 24, 30, and 46% between these countries. This means that the problem of finding and implementing measures to mitigate the consequences of the Chernobyl disaster is truly international. It demonstrates that a country like Belarus, which has no nuclear power plants and no nuclear industry, has to cope with the radiation legacy of a disaster that occurred in another state. This raises questions as to which country is responsible for the adverse environmental effects. The scale of the economic burden of Chernobyl can be better understood when one considers that a 12% "Chernobyl tax" has been added to goods and services in Ukraine, and that enterprises in Belarus pay an 18% tax.

Dumping Nuclear Waste

Past nuclear waste disposal in oceans and in the Arctic areas has generated concern both in Russia and in the international community. A recent report by a Russian governmental commission stated that a total of perhaps 2.3 MCi of radioactivity, including 16 nuclear reactors from submarines and an icebreaker, were dumped east of Novaya Zemlya into the shallow waters of the Kara Sea. Six of the reactors still contained nuclear fuel. Most of these reactors lie in shallow inlets at a depth of only 20–50 m. Today it is unclear what the long-term radiological effects will be as the corrosion by the sea water releases fission products into the environment.

The problem of nuclear waste disposal and contamination also exists in the seas of the Far East. A nuclear submarine accident in the Chazhma Bay (the Sea of Japan) on August 10, 1985, resulted in the release of

5 MCi of radioactive substances. A radionuclide power source of 350-kCi activity was lost during transport near Sakhalin. The radiation situation in the Arctic and Far East resulting from radioactive waste disposal has not been examined in detail.

Submarines

The Russian navy operates 84 nuclear submarines with 161 nuclear reactors. These submarines and other nuclear ships generate approximately 20,000 m^3 of liquid and 6000 tons of solid radioactive waste per year. Half of the liquid and about 80% of the solid waste are generated by the Northern Fleet on the Kola Peninsula and at Severodvinsk.

The necessity to decommission a large number of Russian nuclear submarines that are close to the end of their service life creates a further problem. Russia has a backlog of more than 100 nuclear submarines awaiting final disposal. Many of these old submarines still have nuclear fuel in their reactors because of damage, accidents, or a lack of facilities to remove and store the highly radioactive fuel. One of the fuel-crammed floating barges in the Murmansk region, called the "Lepse," appears to be leaking. Four sites in the Kola Peninsula region have been noted as storage areas for nuclear waste from the Russian North Fleet. They are at Murmansk (home port for naval vessels having a total of 220 reactors), Severodvinsk (home of the Russian North Fleet), Litsa (a submarine base located about 45 km from Norway), and Kildin (an island in the Barents Sea about 120 km from the Norwegian border).

The severity of the problems with respect to dismantling nuclear submarines was recently confirmed by the Commander of the White Sea Naval Fleet. He stated that all existing storage facilities were already full, and most of them were in bad condition.

Nuclear Explosions

A complex environmental problem is caused when nuclear devices are detonated outside military test sites for nonmilitary purposes. About 122 nuclear devices have been detonated in the Soviet Union for so-called peaceful purposes, such as mining, geophysical investigations, and the creation of underground pressure in oil and gas fields. These explosions covered the map of the former USSR—from the densely populated areas of the Donbass coal-mining region in the Ukraine to the sparsely populated areas in the Siberian permafrost, and from the Kola Peninsula in the North to the southern republics of Turkmenistan and Uzbekistan. Very little is known about the environmental impacts of

these explosions. The first devices were detonated in 1965, and activity continued until 1988. The number of yearly detonations from 1965 to 1988 is given in Table 5.

Table 5. Number of "peaceful" nuclear explosions in the former Soviet Union.

Year	Number of devices	Year	Number of devices
1965	5	1977	6
1966	2	1978	7
1967	0	1979	9
1068	10	1980	5
1969	1	1981	5
1970	3	1982	9
1971	9	1983	9
1972	7	1984	12
1973	5	1985	1
1974	5	1987	6
1975	2	1988	2
1976	2	**Total**	**122**

The USSR had two nuclear test sites: Semipalatinsk and Novaya Zemlya. Semipalatinsk now lies in Kazakhstan. This is the site where the first Soviet explosion took place in 1949. Since that time, 465 nuclear explosions, including 132 atmospheric tests, have been carried out. Contamination data for this area are only now being established. There are some indications that in Semipalatinsk the contaminated area comprises about 10,000 km^2. A special problem was caused by the fallout from the first explosion on August 29, 1949, when substantial areas in the Altai region in Siberia were contaminated.

The second site for nuclear weapons testing is the archipelago Novaya Zemlya. Tests at this site represent about 80% of the cumulative power released from all Soviet nuclear tests. Seven explosions in the atmosphere performed from 1957 to 1963 are in total power equal to all other atmospheric tests in the rest of the world. One of these is the largest nuclear explosion in history (58 megatons), which took place on October 31, 1961. As a consequence of this explosion, in some regions (e.g., Anderma), the daily radioactive precipitation was ten thousand times higher than in 1988, the last year of underground testing. In addition to atmospheric tests, 42 underground tests and 3 underwater tests were carried out at Novaya Zemlya.

Uranium Mining and Milling Sites

After the end of the Cold War, many regions faced another dimension of the nuclear legacy—huge quantities of hazardous, low-level radioactive materials from the production of uranium for energy and nuclear weapons. Approximately 30 uranium mining and milling facilities were constructed in the former USSR. These obsolete sites may pose a significant radiation health hazard to the public if mine waste and mill tailings are misused or dispersed by natural forces. The total contaminated area is estimated as 600 km^2. The ecological impact of uranium tailings is of primary concern in densely populated regions and in regions with social instabilities and military and civil conflicts (e.g., Tajikistan).

Nuclear Power Plant Sites

Commercial nuclear power plants produce the major part of the radioactivity accumulated in spent fuel. Table 6 lists an estimate of buildup of plutonium isotopes, Sr-90 and Cs-137, in major commercial nuclear power plants of the former Soviet Union. It should be noted that this is not a complete list of commercial reactors. The majority of the reactors are of type VVER-440, VVER-1000, or RBMK.

The spent fuel of RBMK reactors is "temporarily" stored on-site in special cooling ponds. Yet there is no plan for disposing of this fuel in the future. A total of 5325 metric tons of spent fuel from RBMK reactors has accumulated at nuclear power plant sites. By the year 2030, the amount of spent RBMK fuel will be 90,000 metric tons.

Part of the spent fuel from VVER-1000 plants is stored at the power plants and part at Krasnoyarsk-26. Information about the development of storage facilities at power plants is scarce. Fuel has been stored at Krasnoyarsk since 1985, waiting for the reprocessing plant, RT-2, to start reprocessing. The capacity of the storage facility at Krasnoyarsk-26 is 6000 metric tons. It has been estimated that the total amount of spent fuel from VVER-1000 reactors will be 6000 metric tons by the year 2030 with 70% coming from presently operating reactors. The storage facility at Krasnoyarsk-26 would in theory be sufficient until the year 2030 if it were used only for spent VVER-1000 fuel. Some sources say that the RT-2 plant will reprocess spent fuel from VVER-1000 reactors and from "other types." It is unclear how the capacity of the storage facilities is allocated to different types of spent fuel.

Table 6. Estimated buildup of radioactive isotopes (Pu, Sr, Cs) in major nuclear power plants in the former Soviet Union.

Location	Units	Type	Capacity [MW(e)]	Activity		Plutonium (kg)
				Sr-90	Cs-137	
Armenia	2	VVER	880	5.1	3.3	2903
Balakovo	3	VVER	3000	13.5	3.1	4351
Beloyarsk	1	BN-600	600	4.8	3.1	1602
Chernobyl	3	RBMK	3000	27.2	16.9	9999
Ignalina	2	RBMK	3000	24.6	15.3	5240
Khmelnitski	1	VVER	1000	4.5	2.7	1304
Kola	4	VVER	1760	15.9	10.2	5743
Kursk	4	RBMK	4000	30.9	19.5	10711
Novovoronezh	4	VVER	2200	17.4	10.9	8184
Rovno	3	VVER	1800	11.4	6.9	3692
Shevchenko	1	BNK-350	150	1.8	1.2	654
Smolensk	3	RBMK	3000	16.5	10.5	5188
South-Ukrainian	3	VVER	3000	17.1	10.8	5297
St. Petersburg	4	RBMK	2800	25.5	15.6	8914
Tver (Kalinin)	2	VVER	2000	10.8	6.9	3536
Zaporozhye	5	VVER	5000	25.2	15.9	7972
Total	**44**			**255.5**	**156.5**	**85290**

The spent nuclear fuel from VVER-440 and RBMK reactors is transported for reprocessing to the RT-1 plant in Mayak. Transport of RBMK fuel is a special problem because the fuel elements are very long (11 m). Presently, the Mayak reprocessing plant reprocesses 200 metric tons per year (design capacity is 400 t/year). It will take more than 12 years to reprocess all the spent nuclear fuel thus far produced by the VVER-440 reactors, given the existing throughput capacity of the plant.

Although accidents in nuclear power plants could constitute major factors responsible for future contamination, a nuclear power plant site remains a source of potential radiation risk even after the nuclear reactor is shut down. This is because nuclear power plant sites are designed for pond cooling and at least interim storage of spent fuel elements.

In addition to spent fuel, nuclear power plants are a source of low- and intermediate-level wastes produced by power operations. Currently, nuclear power plant sites are used as a storage for at least the following:

- 80,000 m^3 of liquid waste with total activity of 35,000 Ci.
- 12,000 m^3 of solidified waste with total activity of 2000 Ci.
- 50,000 m^3 of solid waste.

The International Dimension

Debates regarding the transport of spent fuel from other countries to Russia demonstrate the complexity of short-term development in the country. On one hand, Russia proclaimed itself the legal successor of the former Soviet Union, while, on the other, in December 1991, the Russian Parliament adopted a law forbidding the import of radioactive waste. This means that the Russian government inherited obligations from the Soviet Union that are in conflict with the laws of the country, namely to process spent fuel and bury waste from Soviet-made nuclear power plants in other former Soviet republics, particularly Ukraine and Kazakhstan.

Another example illustrates why transboundary aspects are important. Recently, Ukraine has considered the idea of building its own facilities for reprocessing irradiated nuclear fuel and for nuclear waste storage. Previously, irradiated fuel was transported from Ukraine to Russia, where such facilities have been available for a long time. However, transporting radioactive waste produced in Ukraine through Russia over a distance of more than 2000 km, and then storing it in Russia, places a heavy burden on the people living in that area. Apparently, many in Russia consider it an unfair risk without due compensation. In January 1992, the Krasnoyarsk nuclear complex stopped the transport of irradiated fuel from Ukraine, and the chairman of the Krasnoyarsk regional council stated that, if the region accepted nuclear waste for storage, it should also receive appropriate compensation.

Social Dimensions

The social dimensions of the nuclear legacy are of crucial importance for the proper management of the problem. They reflect the now common understanding that safety is, in part, a social judgment and not purely a technical one and that, ultimately, it is the public that must decide.

The public had great confidence in the ability of the military complex to run their installations safely. The developing nuclear industry initially enjoyed the same confidence level. This confidence favored the rapid growth of nuclear power, but later turned into an increasingly negative attitude and outspoken hostility following the nuclear accidents. According to polls, 65 to 95% of the population in different regions of the European part of Russia are against nuclear power. The number of active supporters varies from 1 to 21%. The economic situation in Russia is

aggravating the problems and controversies. The credibility of the societal institutions seems to be emerging as the greatest problem in the present environment of uncertainty and change. The following example illustrates the importance of this factor on short-term trends in the development of Russia's nuclear policy. In a city-wide referendum, 86% of the voters of Chelyabinsk, a city of more than one million inhabitants, opposed the reprocessing of spent foreign nuclear fuel at the Mayak complex; foreign fuel constitutes 47% of the total amount of spent fuel processed there. The situation is similar for waste disposal sites.

Social movements against using former sites in Russia for waste disposal may induce local authorities to close storage facilities, thus forcing the government to move wastes to other places, possibly to sparsely populated areas in the north. The idea of using, for this purpose, the Novaya Zemlya area, in which nuclear tests had formerly been carried out, has already been suggested. This may give rise to justified concern about transboundary risk in northern European countries.