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Pathogen Proliferation: Threats from the Former Soviet Bioweapons Complex

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Abstract. **This article outlines the proliferation threats of pathogen collections from the former Soviet biological weapons (BW) program and the inherent difficulties in safeguarding sensitive biological materials. It describes new U.S. government efforts to improve security conditions of these collections through the Nunn-Lugar Cooperative Threat Reduction Program. Finally, the article analyzes these U.S. programs and offers additional policy recommendations to reduce the proliferation threat from these dangerous pathogens.**

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SINCE THE BEGINNING of the U.S.-Russian Nunn-Lugar Cooperative Threat Reduction (CTR) Program in 1992, activities and funding priorities have emphasized the dismantlement of nuclear weapons and safeguarding of fissile materials in the former Soviet Union (FSU). Through the Departments of Defense and Energy, almost $500 million has been spent thus far to safeguard nuclear materials (U.S. General Accounting Office, 2000a:14). Until recently, concerns over the security of other weapons of mass destruction have been relegated largely to the background, with little attention paid to the proliferation risks associated with the exotic collections of dangerous pathogens and expertise residing across the extensive bioweapons complex in the FSU.[1]

Since pathogens can be cultured from nature or purchased, some would posit that the proliferation risks of these collections are low. Given such availability, skeptics argue that it is not crucial for terrorists or states to obtain seed pathogen stocks from former Soviet laboratories to produce biological weapons (BW). A salient counterargument is that it is no trivial task to acquire, culture, and purify *virulent* strains of biological agents—a key factor for BW with mass casualty potential.[2] This is illustrated by examining the botched bioterrorism activities of the religious cult Aum Shinrikyo. To its dismay, Aum failed to kill anyone from its repeated releases of *Bacillus anthracis,* the causative agent of anthrax, onto the streets of Tokyo. A critical aspect in the cult's failure was its acquisition and use of a vaccine strain of the bacteria that was by definition avirulent (Leitenberg, 1999).[3]

In contrast to Aum, former Soviet bioweapons facilities possess significant collections of the most virulent strains of dangerous pathogens, some of which have been genetically engineered to be environmentally hardy and resistant to medical treatment.[4] As such, the collections of pathogens from the FSU BW complex are unique in the world and would be a highly valuable commodity to those terrorist

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Table 1. Select FSU Facilities With Potential Pathogen Collections

Institute	Location	BW Agent Collections
Ministry of Defense		
Scientific Research Institute of Microbiology	Kirov	*C. burnetii, F. tularensis, Brucellae spp., B. mallei, B. Anthracis, B. pseudomallei, Y. Pestis*; Antibiotic resistant bacterial strains
Center for Virology	Sergiev Posad	monkeypox virus, Bolivian & Argentinean Hemorrhagic Fever virus, marburg virus, ebola virus, lassa & rift valley fever virus; Encephalitis: Venezuelan equine, Japanese, eastern equine, tick-borne, western equine, murray valley, Saint-Louis; *F. tularensis, B. pseudomallei, B. mallei, Y. pestis*
Center of Military-Technical Problems of Biological Defense	Yekaterinburg (Sverdlovsk)	B. anthracis, F. tularensis, B. pseudomallei, B. mallei, C. botulinum toxin, Antibiotic resistant bacterial strains
Scientific Research Institute of Military Medicine	St. Petersburg	*F. tularensis*
Scientific Research Institute of Microbiology	Strizhi	?
Ministry of Medical and Microbiological Industries (Biopreparat)		
State Research Center for Applied Microbiology "Vector"	Koltsovo	smallpox virus, monkeypox virus, marburg virus, ebola virus, lassa fever virus, Crimean-Congo & Bolivian hemorrhagic fever virus; Encephalitis: Russian spring-summer virus, eastern virus, Venezuelan; machupo virus, junin virus
State Research Center for Applied Microbiology	Obolensk	*B. anthracis, F. tularensis, B. pseudomallei, B. mallei*, drug-resistant and vaccine-resistant BW agents
Production Plant	Berdsk	*Y. pestis, F. tularensis, B. mallei, Brucellae spp.*
Combine "Syntez"	Kurgan	*B. anthracis*
Scientific and Production Base	Omutninsk	*Y. pestis, F. tularensis, B. mallei*
Combine "Biosyntez"	Penza	*B. anthracis*
Ministry of Agriculture		
Scientific Institute of Phytopathology	Golitsino	Anti-crop biological agents
Pokrov Factory of Bioprep. & Institute of Veterinary Virology and Microbiology	Vol'ginskii	smallpox virus, Venezuelan equine encephalitis virus, foot-and-mouth disease virus, Newcastle virus, fowl pox, avian influenza, rinderpest virus
All Russian Research Institute for Animal Protection	Vladimir	African swine fever virus, foot-and-mouth disease virus, rinderpest virus
Scientific Agricultural Research Institute	Otar, KZ	rinderpest virus, newcastle virus, African swine fever virus, sheep pox virus, goat pox virus, fowl pox virus, blue-tongue virus, cereal rust fungi, equine encephalitis virus, rabbit hemorrhagic fever virus
Ministry of Health		
Antiplague Institute	Almaty, KZ	*B. anthracis, Y. pestis, F. tularensis, Brucellae spp.*
Antiplague Institute	St. Petersburg	*B. anthracis, Y. pestis, F. tularensis, Brucellae spp.*
Antiplague Institute	Saratov	*B. anthracis, Y. pestis, F. tularensis, Brucellae spp.*
Antiplague Institute	Irkutsk	*B. anthracis, Y. pestis, F. tularensis, Brucellae spp.*
Antiplague Institute	Samara	*B. anthracis, Y. pestis, F. tularensis, Brucellae spp.*
Antiplague Institute	Rostov-on-Don	*B. anthracis, Y. pestis, F. tularensis, Brucellae spp.*
Antiplague Institute	Volgograd	*B. anthracis, Y. pestis, F. tularensis, Brucellae spp., P. mallei, P. pseudomallei*
Antiplague Institute	Stavropol	*B. anthracis, Y. pestis, F. tularensis, Brucellae spp.*
Antiplague Institute	Tbilisi, Georgia	West Nile fever virus, tick borne encephalitis virus
Antiplague Institute	Minsk, Belarus	*B. anthracis, Y. pestis, F. tularensis, Brucellae spp.*
Antiplague Stations (40)	Various	Various

Sources: U.S. government official, telephone interview by author, July 14, 1999 and July 16, 1999; Alibek (1999); Rimmington (1999); Bozheyeva et al. (1999); National Academy of Sciences (1997); Rimmington (1996); Papyrin (1996); Sims (1990); Geissler and Brunius (1990:80-104).

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groups or state parties interested in acquiring a potent BW capability. Furthermore, trying to prevent or detect diversion of small quantities of dangerous pathogens by insiders is a serious problem facing not only FSU laboratories, but all high-containment biological facilities. The threat of pathogen diversion from former Soviet BW laboratories has raised awareness in the international community of the inherent vulnerabilities and challenges in safeguarding dangerous biological materials.

In the following pages I will describe the existing collections of pathogens in the former Soviet BW complex and their proliferation potential under current economic and security conditions. I will also provide some description of the difficulties in safeguarding biological materials, and give an account of new U.S. efforts to address some of these proliferation concerns. Finally, I will provide an analysis and a set of recommendations for U.S. policymakers to address the remaining long-term U.S. national security threats emanating from the bioweapons complex in the FSU.[5]

The BW Mosaic

The former Soviet BW program consisted of a number of military and nominally civilian research, development, production, and weaponization sites spread across what is now Russia, Belarus, Georgia, Kazakhstan, Ukraine, and Uzbekistan.[6] The purely military sector of the BW program was managed under the 15th Directorate of the Ministry of Defense (MOD). Under the MOD, there were four main R&D laboratories in Russia: (1) Scientific Research Institute of Microbiology, Kirov; (2) Center for Virology, Sergiev Posad; (3) Center of Military-Technical Problems of Biological Defense, Yekaterinburg (formerly Sverdlovsk); and (4) Scientific Research Institute of Military Medicine, St. Petersburg. Prior to the collapse of the USSR, a fifth laboratory, the Scientific Research Institute of Microbiology, Strizhi, was built in the late 1980s and is currently operational (Alibek, 1999:298). Based on open source information and official declarations, we know that these MOD labs conducted research on a number of pathogenic organisms and toxins (See Table 1).[7] The military collection alone possesses more than 100 different strains of *B. anthracis* (Litovkin, 1999). In addition to these collections, former Soviet BW defector, Dr. Ken Alibek, has stated that the MOD facilities in Kirov, Sergiyev Posad, and Yekaterinburg had once stockpiled plague, smallpox, and anthrax biological weapons, respectively (Tucker, 1999a:5; Alibek, 1999:297-98).[8] Although the MOD facilities are not official repositories for the smallpox virus, there have been reports that strains may exist at one or more of these facilities.[9] To date, all MOD facilities remain closed to international visits.[10]

Moreover, the "civilian" component of the former Soviet BW program undoubtedly eclipsed the military sector. In 1973, following accession to the Biological Weapons Convention (BWC), the former Soviet Union established a clandestine BW program under the Main Administration of the Microbiological Industry, composed of a collection of biotech facilities known as Biopreparat. The number of Biopreparat facilities involved in BW work remains controversial, with estimates ranging from 20 to 50 facilities.[11] Within this number are included many "mobilization" facilities that were maintained in full readiness in case of war.

Two main Biopreparat research centers in Russia are the State Research Center for Virology and Biotechnology, otherwise known as "Vector," in Koltsovo, and the State Research Center for Applied Microbiology, in Obolensk.[12] Vector's research and storage collections consist of viral pathogens, whereas the Obolensk facility maintains bacterial pathogens. These institutes have pioneered research on a variety of biological agents, to include development of novel genetically engineered pathogens that have antibiotic and vaccine resistance. The main pathogen repository at Vector houses over 10,000 viral specimens, to include 109 different samples of the smallpox virus.[13] In addition to Vector and Obolensk, Biopreparat production and mobilization facilities at Berdsk, Kurgan, Omutninsk, and Penza have worked with a number of different pathogenic organisms, although it is currently unknown whether they still retain stocks of these agents.[14]

Complementing the MOD and Biopreparat programs, other BW research centers operated under the Soviet Ministries of Health and Agriculture, as well as the KGB (Table 1) (Alibek, 1999:301-2). The Ministry of Health maintained oversight for networks of medical facilities, six anti-plague research institutes, and a collection of anti-plague field stations located across the former Soviet Republics.[15] During the Soviet period these anti-plague facilities were drawn into the BW program to identify new virulent strains of endemic pathogens and to conduct research for defensive purposes. These stations continue to serve as regional collection sites for disease surveillance and are capable of conducting laboratory analyses on collected samples. Currently, there remain as many as 40 anti-plague field stations that possess small working collections of pathogens isolated from regional flora and fauna, as well as from disease outbreaks.[16] Once the stations have conducted preliminary analyses, samples are sent to the larger anti-plague institutes for further analysis, storage, and research. As an example, the Volgograd Anti-Plague Institute possesses a unique collection of strains, including *Y. pestis*, *B. mallei*, and *B. pseudomallei* (Papyrin, 1996).

The former Soviet Ministry of Agriculture also conducted extensive BW research on a variety of anti-crop and anti-livestock pathogens (Table 1). Surprisingly, perhaps as much as one-third of the manpower affiliated with the entire Biopreparat complex worked on biological agents targeted at agriculture.[17] Two of the most important facilities in this regard are the Scientific Institute of Phytopathology in Golitsino, Russia and the Scientific Agricultural Research Institute in Otar, Kazakhstan. Dr. Sadigappar Mamadaliyev, director of the Kazakhstani Institute, has recently stated that

The main pathogen repository at Vector houses over 10,000 viral specimens, to include 109 different samples of the smallpox virus

his facility possesses more than 200 strains of dangerous animal pathogens (Miller, 1999b). While such pathogens typically would not be lethal to humans,[18] a release of such agents onto agriculture or livestock could cause devastating economic losses.

These extensive collections of pathogenic organisms in civilian facilities throughout the FSU have only recently been documented, as open source information has become available and as U.S. government officials have been granted access to the repositories. Given the diffuse and enigmatic nature that still characterizes the MOD and portions of the Biopreparat complex, it would not be surprising if other pathogenic collections at new sites emerge in the future. As an example, the restructuring of the Biopreparat complex in the 1990s has spawned a number of start-up biotech companies. Some of these companies have retained or acquired their own stocks of pathogenic organisms for commercial sale. Dr. Alibek has testified that scientists from a former BW facility have launched their own biotech company, advertising sales of recombinant *Francisella tularensis* with altered virulence genes (Alibek, 1998). Although legitimate academic and commercial acquisition of such strains can be argued for development of improved public health prophylaxis and treatment, unregulated sale of these materials raises proliferation concerns. Since Russia and other New Independent States currently lack rigorous enforcement and control mechanisms for international and domestic trade involving toxins and infectious agents, it is difficult to ensure that dangerous pathogens may not be sold (whether intentionally or unintentionally) to questionable buyers.[19]

A Worrisome State of Affairs

The concern over BW proliferation has intensified since the restructuring of the BW complex in the early 1990s. With President Yeltsin's concession in 1992 that there had been a "lag in implementing the Biological and Toxins Weapons Convention," came a subsequent edict to halt all such offensive research activities.[20] This resulted in a Russian agreement with the U.S. and Britain to cut funding for its military biological weapons programs by 30%, and to reduce by half the number of personnel engaged in these activities ("Joint Statement," 1992; Dahlburg, 1992). Since 1992, the budgets of former BW institutes have typically been cut by at least half, if not more.[21] This has left many BW facilities floundering to pay research staff, security personnel, and even electric bills.[22] For example, Vector's scientific personnel receive approximately $100-150 per month.[23] International assistance programs have begun providing some supplemental funding for salaries of BW personnel at select facilities to conduct peaceful research, but at least 15 other institutes in Russia and the New Independent States are not so fortunate.[24]

The immediate downsizing and restructuring, coupled to the dire economic conditions in the FSU, has created an unstable and unregulated environment for many of these facilities and their weapons scientists. Such conditions lower the threshold for sale of BW materials, due either to desperate circumstances or personal profiteering. In terms of corruption, it has already been noted that some spin-off biotech companies, involving former BW personnel and their wares, have no qualms about profiting from sale of dangerous pathogens (Alibek, 1998). This situation is particularly worrisome with respect to the MOD BW facilities and personnel that remain off-limits to international scrutiny.

Security Concerns

The threshold for proliferation is lowered when corruption, financial instability, poor security, and weak regulatory controls exist. Like the vast nuclear complex, Biopreparat facilities across the FSU have limited security measures protecting their precious collections.[25] Guns, guards, and gates are the principal means of security, if they exist at all. Armed security guard forces at Vector and Obolensk are supplied by the Ministry of the Interior (MVD), which provides security for all strategic civilian facilities in Russia. MVD conscripts frequently rotate through in short-term assignments at a variety of civilian defense research facilities. MVD forces at BW facilities, however, are also augmented by locally hired and trained security forces.

MVD guards at Russia's civilian nuclear centers (Minatom) were hard hit by the August 1998 Russian economic meltdown. The severe economic situation and sense of desperation caused a series of violent altercations across Russian military installations involving MVD guards (Gertz, 1998). In addition to the constant problem of delayed pay, many of Minatom's MVD guards have suffered from lack of food, warm clothing, and other basic necessities while on the job (Perry, 1999). Fortunately, at this time, MVD guards at Vector and Obolensk do not appear to suffer from some of the dire conditions experienced at Minatom facilities.[26] One U.S. government official reports that "the MVD guard forces at Vector and Obolensk are well clothed, alert, and motivated."[27] However, in the fall of 1997, a visit by another U.S. government official found Vector protected by only a handful of guards, who had not been paid in months (Henderson, 1998).

To complicate matters, physical security measures at civilian bio-facilities are in poor condition. Perimeters are visibly deteriorated.[28] Although some electric sensors are present at some sites, many facilities have no means of detecting intruders. At present, there exist limited badging systems to control access to the buildings, and rigorous and consistent inspection of personnel and belongings entering and exiting the facilities is lacking.[29] U.S. government security experts have stated that physical security at these bioweapons facilities is notably worse than that encountered at Russian civilian nuclear facilities.[30] Not surprisingly, breeches of security have already occurred. Recently, a Canadian Broadcasting Service group obtained unauthorized access to one facility due to a lack of perimeter security.[31] On a positive note, however, Russian regulations require that a two-person rule is required for access to the pathogen collections.[32]

Current security measures at Biopreparat facilities are also precariously subject to available power supplies. In 1995 it was reported that approximately once a month, telephone communication and power are shut off for two days in all of Obolensk due to power shortages (Nikonorov, 1995). In addition, due to drastic budget cuts, bio-facilities are having difficulty paying their bills and providing for routine operating costs. As a result, local power companies frequently threaten to shut off electricity. At one bioweapons research facility, the local security force had to be used to prevent electric company officials from coming in and turning off the electricity in the winter of 1999 due to nonpayment.[33] Another concern is that electricity shortages are destructive to the refrigeration systems that house the pathogens, as well as biosafety containment operations. Although most bioweapons facilities have diesel-powered back-up generators, many of these have not been adequately maintained or have the necessary spare parts.[34]

Adding to the physical security problems, bioweapons facilities are not prepared to deal with the larger and more difficult threat of insider diversion. Although this is an inherent problem for all sensitive facilities, biological materials are particularly vulnerable. Unlike chemical or nuclear materials, biological materials give off no detectable security signatures. Even enhanced security stations would be unable to detect smuggling of these materials, because current systems are designed to detect metals, chemicals in conventional explosives, or neutron and gamma radiation from nuclear materials. It should be emphasized, however, that such security challenges are also problematic for dangerous pathogens stored within U.S. and British high-containment biological facilities.

Collections of biological agents, sometimes called "museums," are typically stored in a freeze-dried or frozen form within small ampules (no larger than a lipstick).[35] Freeze-dried biological agents, however, have long shelf lives even at room temperature, making them easy to transport and retain viability.[36] Although each ampule typically contains less than a gram of biological agent, laboratory culture amplifies this amount significantly. For example, a small vial of freeze-dried material, cultured, and expanded in a fermenter with nutrient media kept at constant temperature can result in kilograms of agent in as little as 96 hours.[37] In a laboratory setting, the right co-conspirators or individual could divert several ampules of biological agent. For instance, seed cultures could be transferred to smaller vials in the lab and carried out.

It is extremely difficult to track the seed cultures once they leave the "museum" and go into the working stock of the research laboratory

In general, a constant problem encountered in safeguarding biological materials is that it is extremely difficult to track the seed cultures once they leave the "museum" and go into the working stock of the research laboratory.[38] Although pathogens classified with the highest risk category must be handled under the most rigorous biocontainment conditions (i.e., restricted access, glove box, self-contained, air supplied suits), some dangerous pathogens classified under lower biosafety conditions require fewer handling restrictions, which also serve as built-in security measures.[39] Thus, pathogens under reduced biosafety classification may be more vulnerable to diversion.

Furthermore, accountancy of biological materials is questionable. In theory, Russian biosafety regulations require laboratories to keep an inventory of all ampules on authorized forms and special logs. These logs must be numbered, sewn, and secured with a seal.[40] In practice, however, such regulations are not always enforced, and there are varying degrees of independent oversight. In addition, many of these biological facilities still conduct peaceful research on infected animal models to study disease progression. Such animals are "living repositories" of pathogenic material that also need to be accounted and safeguarded against diversion. Again, the degree of animal control and accounting varies from facility to facility.

One might argue that the risk of infection would serve as a sufficient deterrent to prevent theft of pathogens. This may hold true for some outsider threats, but less so for an insider job, especially if the perpetrators (scientists, security, or support staff) have been vaccinated against particular agents.[41] Although some biological agents, such as the ebola virus, *F. tularensis*, and variola virus, are considered extremely infectious, most biological agents, if appropriately contained and sealed, can be transported with a remote risk of infection.[42] The main hazard from many biological agents comes from inhalation via their aerosolized form. While some aerosolization occurs under normal research activities, the production of large concentrations of infectious-sized particles requires specialized milling procedures like those used during the weaponization process.[43]

In spite of existing security measures, unauthorized diversion of BW material from a Russian facility by an "insider" has been reported. In 1984, a military scientist from the Sverdlovsk (now Yekaterinberg) MOD facility stole an ampule of antibiotic-resistant *F. tularensis* when he was transferred to the Institute for Applied Microbiology at Obolensk (Domaradskiy, 1996). His motivation was to continue his research on the tularemia strain at the new facility and advance his career. The theft of such a novel and infectious strain from one of the highest security BW facilities during the former Soviet times highlights the challenges involving insider diversion of biological materials.[44]

The Buyers Club?

The poor security, dire financial conditions, and ease of BW diversion at bio-facilities in the FSU have not gone unnoticed by those parties interested in acquiring a BW capability. There have been several reports of states or non-state actors seeking out former Soviet BW facilities for materials and expertise. There are no confirmed cases, however, of pathogen diversion by terrorists either through attacks or in collusion with former Soviet BW scientists.[45] In spite of this, the concern over "bio-terrorism" in Russia has grown. As a result, Vector and Obolensk have remained on heightened alert.

Probably more worrisome is the acquisition of virulent bacterial and viral strains by proliferant states who have the necessary infrastructure and resources to turns such materials into potent weapons. A leaked 1994 U.S. intelligence report stated that some strains of the smallpox virus from Russia had been sent to Iraq and North Korea.[46] Russian military sources have suggested that this exchange had been going on since at least 1992 (Rimmington, 1999:98). These allegations are based on statements made by Ken Alibek, as well as the emergence of smallpox vaccinations among military personnel in North Korea and Iraq. However, without access to intelligence information, it is difficult to determine whether these countries might have merely retained their indigenous smallpox virus stocks for weapons purposes. In any case, the possibility that there may be undeclared stocks of smallpox virus around the world influenced President Clinton's decision to retain American stocks of the virus at one of the official international repositories located at the Centers for Disease Control in Atlanta, Georgia. Furthermore, of particular proliferation concern may be some of the smaller or less visible Biopreparat facilities that possess collections of dangerous anti-human, anti-crop, and anti-livestock agents. It has been noted that some countries, such as Iran, have turned their attention to these lesser known facilities for BW expertise and materials.[47]

Nunn-Lugar Initiatives

Given the worrisome combination of valuable commodities, poor security, dire financial conditions, and state interest in these dangerous pathogens, U.S. government officials initiated discussions with officials from Biopreparat, including representatives from Obolensk and Vector, in late 1997 to provide security upgrades for strain collections.[48] This assistance, granted under the Nunn-Lugar Cooperative Threat Reduction (CTR) program, would focus on the protection, control, and accounting of biological materials (BMPC&A) at Vector and Obolensk. These two research facilities were initially chosen because: (1) they possess some of the largest and most sophisticated strain collections of biological warfare agents in Russia,[49] and (2) constructive working relationships had been developed with officials from these facilities under prior research collaborations involving the International Science and Technology Center (ISTC) and the U.S. National Academy of Sciences.

Subsequent to the initial U.S. government offer, officials from Vector visited the Snezhinsk nuclear facility and witnessed the ongoing security enhancements conducted in collaboration with the U.S. Department of Energy. The good working relationship and progress exhibited at the Snezhinsk site reassured Vector representatives to consider undertaking a similar CTR effort. Shortly thereafter, Vector officials returned to the discussion table expressing specific interest in starting a BMPC&A project. Subsequent negotiations with officials at Biopreparat "blessed" the proposed CTR collaboration and also approved the enlistment of Obolensk in a similar project. Following a preliminary 1998 agreement, the U.S. Department of Defense sent assessment teams to Vector and Obolensk to conduct full-scale site security evaluations and develop a Statement of Work plan. In a "cooperative" fashion, security personnel from Vector and Obolensk have visited the Cooperative Monitoring Center, Centers for Disease Control, U.S. Army Medical Research Institute of Infectious Diseases, and private U.S. security firms to discuss principles governing American security systems.[50] These exchanges are being used to explore a variety of security technologies and methodologies that can be designed and adapted for BW facilities in the FSU.

Recently, the Russian government has given final approval to the proposed BMPC&A project. CTR assistance will consist of two phases. Phase I will consist of physical security enhancements for Vector and Obolensk involving fence, sensor, and electronic surveillance upgrades, as well as incorporation of personal reliability programs for security personnel. Russian BMPC&A specialists from the Snezhinsk nuclear facility will be involved with the physical security upgrades at Vector. Security personnel at Obolensk have been in contact with privatized Russian security firms to procure indigenous security materials, equipment, and security training. Finally, a secondary component of the Phase I project will be devoted to upgrading biosafety conditions. Assessment of consolidation and enhancement of biocontainment systems involved with pathogen research and storage have been conducted. This will ensure that future defensive research with dangerous pathogens will be conducted in a safe and reliable manner. The cost for Phase I enhancements will range from $1-1.5 million per facility.

Ivanovsky's National Virus Collection includes 2,700 strains of 600 species of pathogenic viruses from 18 genera, including hantavirus, yellow fever virus, dengue hemorrhagic fever virus, and Venezuelan equine encephalitis virus

Phase II will involve the development of a material control and accounting program for biological agents. Of particular concern, it is difficult to account for the quantities of biological agents once the cultures have been grown in the laboratory. A key component of the Phase II program will pair Russian security specialists with U.S. security experts from high containment biological facilities to determine an appropriate tracking protocol for biological agents in the lab. Finally, vulnerability testing has also been incorporated at the end of the project to flag any remaining weaknesses in the security system. The cost for Phase II is estimated at under $3 million per facility.

Since the process of security enhancements will be conducted in parallel at both facilities, completion of these BMPC&A projects is estimated within two to three years. Initially, during Phase I of the project, the ISTC will serve as the funding mechanism for the BMPC&A projects, since the current CTR implementing agreement in Russia does not cover work with biological facilities. ISTC contracts also provide the added benefit of tax-exemption of funds. Discussions are currently underway to establish a CTR implementing agreement with the Ministry of Health in Russia, under which a variety of Biopreparat facilities are managed, to support CTR funding for Phase II.[51] Furthermore, BMPC&A projects have been successfully started at two research facilities in Kazakhstan: the Kazakh Plague Control Research Institute in Almaty, and the Scientific Research Agricultural Institute in Otar.[52] Negotiations are being finalized with officials concerning security upgrades at additional biological research institutes.[53]

In addition to site security enhancements, the ISTC has engaged the Ivanovsky Institute of Virology in Moscow on a conservation project involving its National Virus Collection (International Science and Technology Centers, 2000). The collection includes 2,700 strains of 600 species of pathogenic viruses from 18 genera, including hantavirus, yellow fever virus, dengue hemorrhagic fever virus, and Venezuelan equine encephalitis virus. In another Nunn-Lugar initiative, the U.S. Department of Agriculture has purchased special collections of plant pathogens involved in the former Soviet anti-crop BW program from the Scientific Institute of Phytopathology in Tashkent, Uzbekistan (Miller and Broad, 1998b). Samples of these plant pathogens are now housed at a high containment greenhouse at Ft. Detrick and will be used to conduct a series of joint scientific projects on peaceful research involving U.S. and Uzbek scientists.

The Road Ahead

Clearly, further challenges lie ahead as the magnitude of the former Soviet BW complex continues to unfold. A sober analysis of the proliferation threats from these pathogen collections justifies U.S. investment in bio-security initiatives for specific institutes in the FSU. Current CTR efforts at the Vector and Obolensk research centers will undoubtedly decrease the risk of diversion of BW agents from these facilities. Providing increased security to these prized pathogen collections will make it more costly, time-consuming, and difficult for would-be proliferators to obtain a potent BW capability.

Encouragingly, the current CTR bio-security programs are being designed by building on the lessons learned from prior U.S.-Russian collaborations. In terms of U.S. benefits, collaborations involving former Soviet biological programs have provided increased transparency into these establishments for a modest investment. In the biological sector, building on prior research collaborations, the BMPC&A work will provide virtually unfettered access by U.S. officials to the formerly closed Biopreparat establishments of Vector and Obolensk, something that eluded previous trilateral inspections.[54] In addition, the U.S.-Russian BMPC&A collaboration can provide important information in evaluating bio-security of dangerous pathogens at U.S. high containment research facilities, a topic that is currently under government investigation (U.S. Congress, 1999).

One aspect of the CTR BMPC&A efforts that should be closely monitored in the future is the financial condition of the Vector and Obolensk facilities. It is important to determine whether these facilities are able to financially support the proper maintenance and operation of the upgraded security measures. Furthermore, it is crucial to include programs in both Phase I and Phase II of the project that are designed to instill a "safeguards mentality" among the security and research personnel, something that has proven to be a challenge in the nuclear sector (Bunn, 2000; Potter and Wehling, 2000). Since MVD guards will rotate frequently through the facility, efforts should be made to provide consistency and efficient transfer of knowledge over time. Fancy sensors and video cameras are useless if power is shut off due to nonpayment, or if guards are not properly trained or monitored for job performance.

Furthermore, continued Congressional and CTR support should be directed at engaging additional BW research and production facilities to identify other significant pathogen collections. Once new collections of pathogenic strains have been identified, agreements should be reached with the participating institutes and ministries to either destroy or transfer (consolidate), or to enhance security in place for

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them. All three options should be weighed when evaluating an appropriate BMPC&A strategy for particular facilities, as well in the context of having an integrated CTR program.

Since Russia, Belarus, and Georgia have officially agreed to get out of the biological weapons business by signing and ratifying the Biological and Toxin Weapons Convention (BTWC),[55] destruction or relinquishment of extraneous pathogen collections (and their associated high containment laboratories) is an attractive option in a purely cost/benefit analysis.[56] The CTR upgraded high-security repositories at Vector and Obolensk would provide optimal locations for the transfer, consolidation, and safe storage of additional collections. Moving pathogens from several sites across the FSU to a few select locations will minimize the expense of securing several separate facilities (and upgrading and maintaining their expensive biocontainment laboratories), as well as ensure that defensive research on dangerous pathogens is conducted only in controlled facilities that are subject to international oversight. In addition, some thought should be given within Vector and Obolensk for intra-site consolidation in order to minimize the long-term expense of maintaining several high containment laboratories within one building.[57] Ideally, the fewer collections and research programs devoted to active research with dangerous pathogens, the less the threat of theft or offensive break-out potential.

However, the extent and characteristics of the collections, as well as political sensitivities, will determine which is the most judicious course to undertake. For example, proposals involving consolidation and destruction may be contentious. Since the former Soviet BW complex was spread over a number of different ministry jurisdictions and new independent countries, it may prove difficult to convince the various institute and government officials that it is in their best interest to give up their pathogen collections.[58] In addition, bioweapons researchers may be reluctant to give up their strains if there is no opportunity for redirection to peaceful endeavors.

To address these challenges, multilateral and bilateral funding and programs could be expanded to provide alternative research opportunities involving non-BW organisms for scientists at these facilities.[59] Such projects would promote redirection of former bioweaponeers to benign scientific endeavors—a key U.S. nonproliferation policy objective. In addition, peaceful research projects would also promote and strengthen the ideals encompassing Article X of the BTWC, which encourages scientific exchanges among states parties for utilitarian purposes (United Nations, 1972).

The development of spin-off companies from former Biopreparat institutes possesses an additional nonproliferation challenge. As has been noted, some of these institutes are believed to possess collections of deadly pathogens that are currently, or could become, marketable as sources of income. Continuing CTR engagement of the Biopreparat complex can aid in identifying these companies as they emerge. In order to restrict sales of dangerous

Addressing the complete proliferation threat is likely to be a longer-term problem given the current economic hardships facing Russia and the former Soviet republics

pathogens, Nunn-Lugar support could be provided to assist former Soviet government and industry officials in strengthening their existing export and domestic trade control policies and measures. This assistance should target regulatory measures from the federal down to the local site level. At the federal level, there needs to be more rigorous control and stronger enforcement of domestic and international transfers and sales involving dangerous pathogens. At the local level, Nunn-Lugar support could assist the FSU in establishing indigenous internal compliance programs at defense enterprises, in accordance with a mandate recently passed by the Russian Duma.[60] These internal compliance programs would function to educate company administrators and workers on federal export control policies. Such Nunn-Lugar assistance has already been started under the Departments of State and Commerce with Russian nuclear and missile defense industries; similar work could be initiated at former BW production facilities and their spin-off biotech companies to control transfer of dangerous pathogens both domestically and internationally.[61]

Some of the greatest proliferation risks, however, stem from the number of unknown collections assumed to exist at the five MOD facilities, which remained closed. Russia is long overdue in providing transparency into these facilities. Related to this matter, it is important for Russia to move forward and either restart the stalled U.S./UK/Russian trilateral agreement or unilaterally open up its MOD facilities. Only in this way will it be possible to evaluate that no offensive activities are continuing and to provide international oversight to the collections of pathogenic organisms housed in MOD labs. In 1998, the U.S. DOD initiated dialogue with the Russian MOD to consider a series of reciprocal visits to military biological facilities. Unfortunately, U.S. actions in Kosovo and criticism of Russian conduct in the Chechnyen conflict have chilled U.S.-Russian military-to-military contacts. Relations between the DOD and MOD remain shaky. Recently, however, the DOD reiterated its invitation for MOD officials to visit U.S. biological facilities—the ball is now in the Russian court to respond.

Looking at the big picture, the threat of biological terrorism and warfare from the FSU will not be reduced merely by securing dangerous pathogens. In development of an effective BW capability, materials and know-how are intimately linked. Maintaining the potency of pathogens through production, storage, delivery, and dissemination are other key components for attaining a mass casualty potential. This type of knowledge is also highly specialized and not easily acquired. As a result, it remains equally important to prevent "brain drain" of specialized expertise from former Soviet bioweapons complexes. Addressing the complete proliferation threat is likely to be a longer-term problem given the current economic hardships facing Russia and the former Soviet republics. Although prudent investment in biosecurity for Russia's bioweapons complex is likely to be covered by a few million dollars, a much more significant amount of funding is needed to deal with the larger and multi-year challenge to redirect thousands of bioweapons scientists to sustainable and peaceable careers. Since military grade biological weapons in the hands of proliferant states and terrorists is a serious U.S. national security concern, it is crucial for Congress—as well as present and future administrations—to support and sustain Nunn-Lugar programs and initiatives in the BW area in the years to come.

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Notes

1. Historically, this is illustrated by the marginal amount of funding in the CTR budget allocated directly to BW proliferation. As of January 1999, the CTR-BW Proliferation Prevention Program had notified $5 million for activities in Russia. Recently, however, a new Biotechnology Initiative has been launched to beef up U.S. engagement of BW institutes. The fiscal year 2000 budget allocates $14 million for BW proliferation prevention activities under CTR. See Russian-American Nuclear Security Advisory Council (2000:20).
2. A study of international bioterrorism incidents reveals that nearly all of the pathogens were acquired from culture collections. This is in spite of the fact that many of the perpetrators possessed the skills to culture organisms from nature. See W. Seth Carus (1999:227). A recent GAO study also emphasized the difficulty of acquiring virulent strains of BW agents by terrorists. See U.S. General Accounting Office, 1999:11, 13-14.
3. The virulence of a particular organism is determined by its invasiveness and toxigenicity. These two properties involve five main factors: (1) infection of the host mucosal surfaces, (2) entry to the host tissues through the mucosal surfaces, (3) multiplication of the organism in the host environment, (4) interference with the host defense mechanisms, and (5) specific damage to host tissues. These factors are determined by several molecular, genetic, and biochemical properties of the organism. For example, the virulence of *B. anthracis* is primarily dependent on the presence of three bacterial components: a unique capsule that can withstand host defenses and two specific toxin components that cause lethal damage to host tissues. Most strains of *B. anthracis* consist of one to three types, with an S type (capsule forming) being virulent and an R type (non-capsule forming), which is usually avirulent. The highly virulent 836 strain of *B. anthracis* developed by the Soviets was composed of a thick protective capsule and an ability to produce large amounts of lethal toxin. For more information on virulence determinants of anthrax and other pathogens see Tucker (1999a:2); Brock et al. (1994:416-417); Tucker (1999b); Roth (1988); Thorne (1960).
4. The Russian government maintains that its stockpiles of weaponized biological agents were destroyed during the Soviet period, but that it retains collections of dangerous pathogens for therapeutic and biodefense purposes. See Litovkin (1999).
5. Nomenclature for frequently described pathogens and corresponding diseases in this article will be as follows: *Bacillus anthracis*, anthrax; *Brucellae ssp*, brucellosis; *Yersinia pestis*, plague; *Francisella tularensis*, tularemia; *Burkholderia mallei*, glanders (although still frequently referred to as *Pseudomonas mallei*); *Burkholderia pseudomallei*, melioidosis; *Coxiella burnetii*, Q-fever; *Vibrio cholerae*, cholera; ebola virus, ebola; marburg virus, marburg; variola (major) virus, smallpox.
6. For more details on the hierarchy and organization within the former Soviet BW complex see Rimmington (2000); Alibek (1999); Leitenberg (1998).
7. See Alibek (1999:297-298); Litovkin (1999); Geissler and Brunius (1990:93-94).
8. Implicit corroboration of some of Alibek's claims can be supported by the presence of several pits of buried anthrax bacteria on Vozrozhdeniye Island in the Aral Sea region. See Miller (1999a).
9. Under international agreement, only two official repositories for the smallpox virus exist. One is located at the Centers for Disease Control in Atlanta, Georgia, and the other is at the State Research Center for Virology and Biotechnology, "Vector," in Koltsovo, Russia. See Broad and Miller (1999); Brown (1999).
10. During early confidence building measures and the trilateral agreement, the U.S. and UK visited Russian biological facilities (nonmilitary), with Russian teams visiting U.S. sites. After this initial round of visits, Russia backed away from the agreement, arguing that the U.S. was continuing to maintain an offensive BW program. Proof is lacking for these Russian allegations, and they are not considered credible. Since Russia's departure from the trilateral agreement, the Russian MOD facilities have never been subject to visitation. For more information on the trilateral agreement, see "Joint Statement" (1992); Mangold and Goldberg (1999:114-116, 170-176).
11. From information gained via former Soviet Biopreparat defector, Vladimir Paschesnik, U.S. and British Intelligence estimated that approximately 20 facilities were involved in the former Soviet Biopreparat program. Since Yeltsin's renouncement of an offensive BW program, Biopreparat has been transformed into a joint stock company (RAO Biopreparat). This has created a number of new spin-off companies based on former BW institutes. In addition, due to organizational changes, Yeltsin also added other new institutes under the Biopreparat rubric. See Alibek (1999:298-300); Rimmington (1999); Leitenberg (1994).
12. There were five main Biopreparat facilities. Four were located in Russia at Obolensk, Koltsovo, Lyubychany, and Leningrad (now St. Petersburg); the other in Stepnogorsk, Kazakhstan. For the purposes of this article, I will focus most of my discussion on the Obolensk and Kolstovo facilities.
13. The smallpox virus stock consists of strains, isolates, and patient samples. See Sandakhchiev (1998:152).
14. Although the majority of strain collections in Russia are located in Biopreparat research institutes, there is not enough information currently available to rule out existing stocks of biological agents in production facilities. For example, the large Biopreparat BW production facility, Stepnogorsk Scientific Experimental and Production Base (SNOPB), in Kazakhstan, also possessed a large collection of pathogens before destroying them. In fact, the Stepnogorsk facility was capable of producing the Soviet Union's most virulent *B. anthracis* strain that was resistant to several antibiotics (although this strain was never stockpiled). As another example, the Berdsk BW production facility contained a research and development lab that had worked with strains of the hazardous *Brucellae spp.* See Bozheyeva et al. (1999); Alibek (1999:59-60, 88-89, 96-97). Also, U.S. government official, telephone interview by author, July 14, 1999.
15. One network of research institutes under the Ministry of Health that investigated lethal and incapacitating BW agents was given the codename "Program Flute." In Kazakhstan alone, there

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currently exist seven anti-plague field stations and one anti-plague institute. See Alibek (1999:302); Rimmington (1998); also, U.S. government official, personal correspondence, December 14, 1999.

16. See Rimmington (1999:89); Sharov (1996); Bozheyeva et al. (1999:16-17); Rimmington (1998:170).
17. Ken Alibek has stated that more than 10,000 former Soviet scientists were working on anti-plant and anti-animal BW. However, this large number most likely also includes basic support personnel, such as custodians and maintenance personnel. Dr. Sadigappar Mamadaliyev, director of the Kazakh Scientific Research Agricultural Institute, states that his scientific team has been reduced by half, to 75 from a high of 150 during the Soviet period. See Tucker (1999a:5); Miller (1999b).
18. A notable exception to this would be the *Brucella* bacterium, which, although lethal to animals, is classified as an incapacitating agent to humans. The strain *Brucella suis* (brucella pathogenic to swine) was a key biological agent weaponized by the U.S. military in the 1950s (Franz et al., 1999). For more information on the bioterrorism threat on agricultural systems, see Frazier and Richardson (1999).
19. Regulation of trade in biological agents has only recently received attention in the U.S. and international community. During the 1980s, the American Type Culture Collection, a private U.S. company, sold Iraq seed stocks of *Bacillus anthracis* and *Clostridium botulinum* (and other pathogenic agents), which Iraq used to develop its nascent biological weapons program. Since then the company and the U.S. government have clamped down on domestic and international sale of pathogens. See Barletta and Ellington (1998); Ferguson (1999). For a good description of the current challenges in Russia's export control policies, see Orlov (1999); Katsva and Averre (1999).
20. Statement on Disarmament by Russian Federation President Boris Nikolayevich Yeltsin on January 29, 1992, Moscow Teleradiakompaniya Ostankino Television, First Program Network, 29 Jan. 1992, Text; see also Leitenberg (1994:77-105); Smith (1992).
21. U.S. government official, telephone interview by author, July 14, 1999; see also Smithson (1999:14-17).
22. U.S. government official, telephone interview by author, July 14, 1999. Also, see Tucker (1999b); Miller and Broad (1998a,b); "Russian Biomedical Research" (1996); Nikonorov (1995). However, due to limited case studies of individual BW facilities, it is difficult to accurately assess the reasons behind the financial problems faced by these BW facilities. For example, due to the preservation of Soviet organization and mentalities, particular institutes may be unwilling to downsize or to efficiently distribute their budget to former weapons personnel. More information is needed on particular BW facilities to determine the macro and microeconomic factors influencing the financial state of these enterprises. For an interesting study of the financial challenges in former Soviet weapons facilities, see Ben Ouagrham (2000).
23. Interview with U.S. government official, November 22, 1999; personal communication from biological institute manager. This figure represents an average; a technician may receive half this amount, whereas a laboratory manager may receive slightly more.
24. For example, the multilateral International Science and Technology Center (ISTC) has provided funds to support bioweapons scientists at Vector and Obolensk since 1994. However, at Obolensk, only approximately 50% of the specialized scientific personnel have received funds thus far. In addition, programs like the ISTC typically provide no more than 10% for overhead costs. A lack of funds for overhead costs threatens such items as electricity for security and refrigeration systems. Hence, financial difficulties remain. U.S. government official, telephone interview by author, November 22, 1999; also, see U.S. General Accounting Office (2000b:9); Sharov (1996); Papyrin (1996); Prokhorov (1996).
25. The security and accounting measures at FSU BW facilities outlined in this article are general descriptions; each facility has unique features that may or may not reflect the picture presented here.
26. U.S. government official, telephone interview with the author, July 14, 1999.
27. U.S. government official, telephone interview with the author, July 14, 1999.
28. U.S. Government official, telephone interview with the author, July 14, 1999; U.S. government official, interview by author, Livermore, CA, December 15, 1999.
29. At one facility, the badges given to visitors upon entering the research complex were removed upon crossing the security checkpoint within one of the laboratory buildings; at another, no badges were issued (U.S. Government official, interview by author, Washington, DC, March 15, 2000). However, Russian biosafety regulations state that visitors to high containment laboratories must be, "under escort by an associate of the structural subunit and recorded in the log." In addition, the grounds and buildings of the institution must be under 24-hour security (State System for Sanitation-Epidemiological Standardization, 1994: Section 3.1.8, 3.1.22).
30. One U.S. official observed that the outer perimeter at one biofacility was so badly deteriorated that you could probably hop over it, and a small group of terrorists could overcome the one guard stationed at the main building door. Once inside the building, terrorists would have access to collections, since there were limited interior security access controls. With a questionable response force on active duty, terrorists could enter and exit the compound before help arrived. At another facility, a U.S. official commented that there existed a collection of 2000 refrigerated isolates of *Y. pestis*, *B. anthracis*, and *F. tularensis* that was only protected by a thick wooden door, a skeleton key, and no armed guards (U.S. government official, interview by author, Livermore, CA, December 15, 1999; U.S. government official, interview by author, Monterey, CA, December 14, 1999). For other descriptions of security measures at Russian bio-facilities, see Smithson, 1999:78-79.
31. U.S. government official, telephone interview by author, July 14, 1999.
32. U.S. government official, telephone interview by author, July 14, 1999; Russian regulations. In Kazakhstan, however, the two-person rule for repository access was not historically present. Recently, the U.S. Department of Defense has instigated this protocol in its assistance to these facilities. Personal communication with U.S. government official.
33. U.S. government official, telephone interview by author, July 14, 1999.
34. Due to concerns over the Y2K problem, CTR provided Vector and Obolensk with portable, back-up generators for emergency use (U.S. government official, interview by author, Washington, DC, March 16, 2000).
35. Of the smallpox cultures (variola virus) at Vector, 90 strains are preserved as frozen material, while 24 strains are lyophilized (freeze-dried); the most valuable strains (17 samples) are kept as primary material obtained from smallpox patients (scabs). To keep the collections at Obolensk in the active state, lyophilization, cryo-preservation, and contact-free dehydration are used. See Committee on the Assessment (1999:40); Organization for Economic Cooperation and Development (1997a); Sandakhchiev et al. (1999).
36. Freeze-drying (lyophilization) avoids the need to maintain microorganisms in inconvenient and dangerous liquid suspensions during storage and transport, as well as prolonging virulence. Ideally, the lifetime and viability of freeze-dried agents is better if they are kept in cold storage, at either -70 or –196°C (liquid nitrogen). However, several scientific studies have documented that freeze-dried bacteria and viruses can remain viable stored at room temperature for years. For example, viable variola virus was derived in rather high titers from aged (1950s-1960s) lyophilized strains in tests conducted at Vector. See Sandakhchiev et al. (1999); Rhoades (1970); Steel and Ross (1963); Harris (1954); Fry (1954); Proom and Hemmons (1949).
37. Readers are cautioned, however, to realize that growth of such weaponizable material does require a certain level of expertise and training in microbiology (testimony by Barry J. Erlick, Biological Weapons Analyst, Department of the Army, 1990).
38. U.S. government official, telephone interview by author, July 14, 1999. However, Russian biosafety regulations do provide for some additional security considerations. All research work involving dangerous pathogens must be conducted in paired team

operations, with no fewer than two persons. Work in the evening and night, as well as on days off and holidays, is possible only with the written permission of the institution director, and two persons are present. Also, transfer of pathogen cultures in containers from one section to another is only by persons cleared to work with dangerous pathogens, and with an escort (State System for Sanitation-Epidemiological Standardization, 1994: Section 3.1.17, 3.1.28).

39. Four biosafety levels are used to describe a combination of laboratory practices, equipment, and facilities appropriate for work with infectious agents. In the U.S., the biosafety levels are categorized from BL-1 through BL-4, with BL-4 requiring the highest level of protection to personnel and the environment. Under Russian biosafety regulations, potential BW agents such as *Y. pestis*, ebola and marburg virus, and smallpox virus are classified as group I pathogens (U.S. BL-4 equivalent). In contrast, *B. anthracis*, *F. tularensis*, *B. mallei*, *B. psuedomallei*, and several encephalitis viruses are classified as Group II pathogens (U.S. BL-3 equivalent). However, even under U.S. biosafety regulations, *Y. pestis*, *B. anthracis*, equine encephalitis virus, and some other dangerous pathogens can be studied under BL-2 or BL-3 conditions. Work at lower biosafety levels is approved only if it does not involve large quantities, infectious aerosols, and/or personnel can undergo vaccination. See U.S. Department of Health and Human Services et al. (1999); State System for Sanitation-Epidemiological Standardization (1994: Attachment 5.1).
40. See State System for Sanitation-Epidemiological Standardization (1994: Section 3.1.45). In Kazakhstani facilities, however, green ledger books with inventory written in pencil are used for accounting. Personal communication with U.S. government official.
41. Russian biosafety regulations require "associates who by reason of their work come into contact with group I and II biological material (except cholera) are vaccinated." Group I and II biological materials are equivalent to U.S. BL-3 and BL-4 standards, respectively. State System for Sanitation-Epidemiological Standardization (1994: Section 3.1.10).
42. Even a highly infectious agent, such as Lassa virus, has been shipped internationally in such a careless fashion that agent was found seeping from the package. Miraculously, no infection resulted to individuals in contact (see Simpson and Zuckerman, 1975). Only the foolhardy, however, would repeat this means of transport; such an incident should be considered an unusual exception. Handling of Lassa virus is strongly recommended under the highest biosafety (BL-4) standards. See U.S. Department of Health and Human Services (1999).
43. Aerosolized particles ranging within the 1-25 micron range can typically penetrate the respiratory system's natural filtering and mucosal barriers (usually without being subsequently exhaled), seed the respiratory system, and amplify, thus facilitating infection.
44. The security challenges involving insider diversion of biological agents is not only limited to Russian BW facilities. In the late 1980s, the U.S. Army Institute for Research on Infectious Diseases reported the disappearance of 2500 milliliters of Chikungunya virus from their high-security repository. It is still unknown what happened to these stocks (Levitt, 1988). Furthermore, an analysis of international bioterrorism activities found that in nearly 17% of the cases, the perpetrators acquired their biological agents by stealing them from research or medical laboratories. Almost all of the thefts involved people who had legitimate access to the facilities where the biological agents were kept (Carus, 1999:223-224, 227). In a notable example, strains of *Shigella dysentariae* type 2 were stolen from a Texas medical center by a resident laboratory technician for the purpose of infecting her fellow laboratory technicians. From this incident, the medical center has implemented security measures to reduce the threat of diversion of its agents by both insider and outsider threats. The laboratory freezer is now secured and must be unlocked by a supervisor to gain entry. Stock culture labels no longer identify microorganisms by name and have been replaced by a numerical identification system. See Kolavic et al. (1999); Becka (1998).
45. Some reports have emerged linking associates of international terrorist Osama bin Laden with acquisition of biological weapons from former Soviet bloc countries. These articles have stemmed from an Egyptian trial involving members of al-Jihad, which is an affiliate of bin Laden's group. One of the defendants, Ahmad Salama Mabrouk, has stated that over the past two years, the group has acquired chemical and biological agents from eastern Europe and from east Asian countries that were a part of the former Soviet Union. Defendants have testified that they have received offers for supplies of *B. anthracis* and other agents from some of these labs for a sum of $3,695 plus freight charges. Before being captured by CIA agents in Azerbaijan, al-Jihad had planned to use these agents against U.S. and Israeli targets and public figures. It is reported that bin Laden has already set up crude bio laboratories in Afghanistan. Since these press reports rely on intelligence confirmation, it is difficult from the open source to accurately assess Bin Laden's interest and success in acquiring BW materials from the FSU. There have also been recent press reports that terrorist attacks from Chechnyan rebels may be directed towards Russian BW facilities. Readers are cautioned, however, not to take these unsubstantiated claims at full face value. See Odnokolenko (1999); McWethy (1999).
46. See U.S. Department of Defense (1994); Broad and Miller (1999).
47. See Miller and Broad (1998a); also, personal correspondence with U.S. government official.
48. The following information regarding current CTR efforts was gathered from a U.S. government official, telephone interviews by author: January 4, 1999, February 8, 1999, March 26, 1999, July 14, 1999, November 22, 1999.
49. Significant strain collections invariably exist at MOD biological facilities since these institutes "were the only holders of the State Collection of microorganisms, which were potential BW agents." However, since the breakdown of the U.S./UK/Russian trilateral agreement, Russia has denied international access to these facilities. Little is known about these collections in the open sources, outside of what Russia has submitted under declarations as part of the confidence building measures of the Biological and Toxins Weapons Convention. See Litovkin (1999).
50. A workshop sponsored by the U.S. Defense Threat Reduction Agency will be held at the Cooperative Monitoring Center, Sandia National Laboratories, in October 2000 to discuss methodologies and technologies for safeguarding dangerous biological materials. Reynolds Salerno, Cooperative Monitoring Center, telephone interview with author, June 14, 2000.
51. In Russia, for those facilities not under Ministry of Health (MOH) jurisdiction, it is envisioned that the MOH can designate certain facilities in other ministries as executive agents that can then receive CTR assistance (U.S. government official, interview by author, March 15, 2000).
52. The U.S. government has signed a CTR implementing agreement with Kazakhstan, so a direct contracting agreement can now be signed for security upgrades at bio-facilities in this country. U.S. government official, interview by author, March 15, 2000.
53. Currently this involves the following institutes: All Russia Research Institute for Animal Health, Vladimir; All Russian Research Institute of Phytopathology, Golitsino; Saratov Antiplague Institute; Stavropol Antiplague Institute; Irkutsk Antiplague Institute; Pokrov Biopreparation Plant; Institute of Bacteriophages, Microbiology, and Virology, Georgia; Center for Prophylaxis of Quarantine, Especially Hazardous Infections, Uzbekistan; Lviv State Research Institute of Epidemiology and Hygiene, Ukraine.
54. Although Vector was one of the facilities visited under U.S. and Russian confidence-building measures, tensions between the host and inspectors constrained access to the facility. For good descriptions of the tense environment surrounding the trilateral visits see Alibek (1999:194-204); Davis (1998); Mangold and Goldberg (1999:41-213).
55. At the time of this writing, Kazakhstan is a non-signatory to the BWC.
56. The costs associated with upgrading and maintaining BL-4 containment laboratories are quite high. The strict biosafety specifications for air-tight, negative pressure laboratories involve specialized gasket doors, redundant back-up support equipment and systems, specialized personnel protection gear, and stringent treatment of waste streams, to name a few. In addition, frequent replacement of materials (such as HEPA filters for air

purification systems) is also tedious and costly. For example, maintenance, repair, and use of the BL-3 maximum containment research laboratory at Dugway Proving Grounds in the U.S. was estimated to cost in excess of $US 1 million/year in 1990. Although prices in FSU dollars will be lower, significant lifetime costs will remain. See Dynamic Corporation (1990).

57. For example, at Vector there is 1,400 m^2 of BL-4 working floor space in Building No. 6 (Organization for Economic Cooperation and Development, 1997b).
58. However, consolidation and transfer of BW agents to a few centralized locations in the FSU is not an impossible feat. After the collapse of the Soviet Union, the Stepnogorsk BW facility unilaterally destroyed its pathogen collections. Moreover, as a crude analogy, BW agents can be likened to fissile material. Currently, the U.S. Department of Energy and Russia's Ministry of Atomic Energy are working to consolidate Russia's stocks of fissile material to a smaller number of sites. In a more controversial measure, Kazakhstan, Ukraine, and Belarus agreed to give up former Soviet strategic and tactical nuclear weapons located on their territories. The denuclearization involved weapons transfer to the Russian Federation with Ukraine, Kazakhstan, and Belarus agreeing to join the Nuclear Proliferation Treaty as nonnuclear weapons states. CTR assistance was granted to aid in the withdrawal and dismantlement process. For more information on the negotiations and politics involving some of these denuclearization activities see Potter (1997); Reiss (1995).
59. For some suggestions on alternative peaceful research endeavors, see Leitenberg (1998:127-131).
60. For example, the Russian Federation enacted legislation, "On Export Controls," which calls for establishment of internal compliance programs at Russian defense enterprises, as well as a number of other export control practices. For more information on recent Russian legislation on export controls, see Orlov (1999); Katsva and Averre (1999).
61. Nunn-Lugar assistance involving internal compliance programs has already been established at FSU nuclear, missile, and aerospace institutes, yet none of these have been directed towards Biopreparat facilities. The programs focus on educating officials and employees on the importance of internal compliance programs and corporate nonproliferation culture. See Office of the Coordinator of US Assistance to the NIS (1999).

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