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Cost of Disarmament:

An Overview of the Economic Costs of the Dismantlement of Weapons and the Disposal of Military Surplus

march 96

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About the Author

Michael Renner is a Senior Researcher at the Worldwatch Institute. He holds degrees in international relations and political science from the University of Amsterdam, Netherlands, and the University of Konstanz, Germany

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Cost of Disarmament:

An Overview of the Economic Costs of the Dismantlement of Weapons and the Disposal of Military Surplus

by
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Zusammen-fassung

German Summary

Die Kosten der Abrüstung

Nicht alle Einsparungen militärischer Ausgaben setzen Mittel frei, die für zivile Zwecke eingesetzt werden können. Die Verschrottung und Vernichtung von überschüssigen Waffen ist kostenintensiv und verlangt ebensoviel Know How wie ihre Entwicklung und Produktion. Neben der Notwendigkeit, ehemaliges militärisches Personal oder beim Militär beschäftigtes ziviles Personal für zivile Berufe umzuschulen und zu reintegrieren, Labors und Produktionsstätten an die neuen Aufgaben anzupassen oder umzustrukturieren sowie die Kontaminierung auf ehemaligen militärischen Liegenschaften zu beseitigen, gibt es vier Kategorien von Entsorgungsaufgaben hinsichtlich überschüssiger Waffen. Verschrottung oder anderweitige Entsorgung

- von *Waffen* - wie Pistolen, Gewehre, Granaten, Mörser usw. - sowie *Waffensysteme* - wie Panzer, Kampfflugzeuge, Artilleriegeschütze, Interkontinentalraketen usw. - die als Trägersystem für nukleare, chemische oder konventionelle Sprengköpfe, Bomben Projektile und Munition fungieren,

- von *militärischem Gerät* - wie LKW, Satelliten oder Computer - das häufig für eine zivile Nutzung konvertiert werden kann,

- von *Materialien* - wie spaltbares Material in atomaren Waffen oder chemische Kampfstoffe - die in den verschiedenen Waffensystemen enthalten sind,

- unterschiedlicher *Treib- und Kraftstoffe*, von denen eine große Anzahl für rein militärische Zwecke entwickelt wurde, und die sich daher stark von zivilen Kraftstoffen unterscheiden

Verschiedene Methoden des Umgangs mit überschüssigen Waffen wurden entwickelt; sie reichen von der Verschrottung oder dem Einmotten bis zum Export oder der weiteren militärischen Nutzung. Leitfaden für die Art der Verschrottung überschüssiger Waffen sollte sein,

- daß der Verbleib der Waffen und deren Bestandteile leicht nachzuprüfen ist, eine erneute militärische Nutzung erschwert oder unmöglich wird,

- Diebstahl oder das Verschwinden militärisch nutzbarer Materialien, die aufgrund des Verschrottungsprozesses frei werden, ausgeschlossen ist,

- Vereinbarungen in Rüstungskontroll- oder Abrüstungsverträgen - wie Fristen und Höchstgrenzen - überprüfbar sind und eingehalten werden,

- kommunale, nationale oder internationale Sicherheits- und Umweltschutzrichtlinien erfüllt werden.

Die meisten der bislang abgeschlossenen Rüstungskontroll- oder Abrüstungsvereinbarungen enthalten generell kaum Vorschriften über die endgültige Entsorgung von überschüssigen Waffen. Seit jeher hat sich die Rüstungskontolle mit der Dislozierung und dem möglichen Einsatz von Waffen aus sicherheitspolitischer Sicht befaßt, während der Verbleib der Waffen oder darin enthaltener Materialien unzureichend oder überhaupt nicht geregelt war.

In vielen Ländern stehen nur geringe finanzielle Mittel zur Bewältigung der Abrüstungsaufgaben zur Verfügung. Schätzungen über die Kosten der Abrüstung und der Verschrottung überschüssiger Waffen sind ungenau, da sie von einer Anzahl von Faktoren abhängen, wie die Entwicklung und Anwendung neuer Technologien, das Ausmaß zukünftiger Abrüstung, die Präzision des Verschrottungs- und Entsorgungsprozesses sowie die Beachtung und Einhaltung von Regeln zum Schutz der Umwelt.

Auf der Grundlage der derzeitig verfügbaren Daten wird geschätzt, daß die Kosten für das Verschrotten und die Entsorgung überschüssiger nuklearer, chemischer und konventioneller Waffen aufgrund von Abrüstungsvereinbarungen oder der einseitigen Reduzierung vorhandener Kapazitäten zwischen 90 bis 185 Milliarden US $ innerhalb der nächsten 10 bis 20 Jahre betragen. Obwohl die Entsorgung und das Verschrotten überschüssiger Waffen schon heute eine riesige finanzielle Bürde ist, die in den nächsten Jahren wahrscheinlich noch schwerer wird, sind die weltweiten Ausgaben für Abrüstung immer noch unbedeutend im Vergleich mit den Ausgaben für militärische Forschung und Entwicklung sowie den Kauf und die Wartung von Waffen und anderem militärischen Gerät. Den ungefähr 800 Milliarden US $ Militärausgaben des Jahres 1994 stehen 3,4 Milliarden US $ für die Abrüstung nuklearer, chemischer und konventioneller Waffen im gleichen Jahr gegenüber. Diese Summe stieg allerdings von 1989 kontinuierlich an und es kann erwartet werden, daß in Zukunft noch mehr Mittel erforderlich sind, um das Erbe des Wettrüstens, das während der Zeit des Kalten Krieges entstand, zu bewältigen.

Introduction

The arms control and disarmament treaties that were made possible by the thawing of the Cold War generated a volume of surplus weapons and other military equipment unmatched since the end of World War II. In addition, unilateral decisions to scrap unneeded equipment further boost the volume of surplus. There has, of course, been routine scrapping of obsolete stocks during the last half century. In the past, governments jettisoned chemical warfare agents, nuclear weapons waste, and conventional ammunition through ocean dumping, land burial, detonation, or open-air burning (Renner, 1994a). However, not only are these methods now unacceptable today, but also the volumes were much smaller than they are today. Finding safe and effective ways to get rid of the arsenals attracted little attention until recently. Steven Malevich, an executive of Alliant Techsystems in Minnesota, explained that "There were a lot of items that were never designed to be taken apart" (New York Times, 15 October 1993, p. D1).

This paper attempts to give a first overview of the cost of disarmament and dismantling of surplus weapons. Since data is available only to a limited extent, it is almost impossible to provide a comprehensive account. The data is derived from a variety of sources with differing degrees of reliability and precision. It is are a composite of actual expenditures, amounts budgeted, annual averages of multi-year figures, and, in some cases, rough order-of-magnitude estimates. In some cases, figures from different sources are inconsistent; in other cases, none are available. In many areas, only examples of an anecdotal nature can be given. These shortcomings notwithstanding, the data presented here do allow an overall judgement of the cost of coping with the Cold War arsenals in the coming decades.

The dismantling and disposal challenge can be broken into a number of categories. First, we must consider the weapons platform (such as a tank, warplane, or intercontinental missile). It is the carrier system for an array of nuclear, chemical or conventional warheads, bombs, projectiles, and munitions. These, in turn, contain key materials (such as fissile materials in nuclear arms). Finally, there is an assortment of fuels and propellants, many of which have been specifically developed for military purposes and therefore are quite distinct from civilian-grade fuels.

A number of considerations determine which methods are suitable for the dismantling and disposal of military equipment. Whichever technology is chosen, the expectation is that it should be verifiable, make renewed military use difficult or impossible, prevent the theft or diversion of militarily usable materials released in the dismantling process, meet the deadlines for completing weapons disposal and other stipulations of arms treaties, and comply with (local, national, or international) safety and environmental standards. All of these criteria have an impact on the cost of dismantlement and disposal, but environmental concern is a particularly potent factor. Rising environmental awareness, more stringent national and international laws, and growing public participation or protest render the careless practices of years past less and less acceptable.

Existing arms agreements typically provide little guidance regarding the final disposition of surplus items. Arms control has traditionally focused on deployment (permitted numbers and types of weapons systems), but has given insufficient attention to the fate of weapons withdrawn from military service or of critical materials contained in them. In some cases, such as the Conventional Forces in Europe (CFE) Treaty or the Chemical Weapons Convention (CWC), permitted *destruction* techniques are specified or certain (traditionally-employed) methods outlawed. But generally, and particularly regarding the final *disposal* of weapons or weapons materials, much is left to the discretion of the governments that are party to the different treaties.

Reluctant or, in the case of the states of the former Warsaw Treaty Organization (WTO), simply unable to devote any significant resources to dismantlement and disposal, governments are eager to contain the associated costs. They are tempted, therefore, to mothball surplus items rather than dismantle them, to let them become unusable over time, or to export them.

Another option is to convert armaments to peaceful uses rather than demolish them. In an age of (partial) disarmament, it is questionable whether military surplus becomes waste material to be discarded or an asset that can at least pay for part of the costs of disarmament. Military hardware could be reconfigured for civilian tasks, materials could be reprocessed to make them usable for non-military purposes, and scrap from dismantled weapons and equipment could be salvaged. Confronted with both a massive disarmament task and a difficult economic transformation, Russia and other Soviet successor states are particularly eager to derive some financial benefit from dismantling their vast weapons stocks. However, in many cases civilian reuse is likely to be technically difficult or economically marginal; most military hardware has little intrinsic civilian value. Another issue is that if the release of large amounts of military surplus items floods commercial markets and harms civilian companies, disarmament exerts an additional cost (Renner, 1994a).

Nuclear Weapons

Fulfillment of the obligations of the START I and II treaties will require decommissioning large numbers of ballistic missiles and missile silos, strategic bombers, and submarines. Although the agreements do not mandate the disassembly of the nuclear warheads mounted on these carrier systems, both the United States and Russia are moving ahead with the dismantlement of thousands of warheads. This in turn implies that hundreds of tons of plutonium and highly enriched uranium (HEU) will need to be stored, processed, and ultimately disposed of. As much latitude is given to the two governments, the precise quantities involved are not known, and costs can only be estimated in orders of magnitude. The Russian situation in particular is marked by great uncertainty.

An additional expense will be incurred once the ongoing negotiations for a comprehensive nuclear test ban treaty (CTBT) are concluded successfully. Although many of the details of a CTBT, including monitoring and verification measures, are yet to be agreed, rough cost projections have been made. Start-up costs of an international CTBT implementing authority are thought to be about US $100 million, and operating costs US $60-80 million per year. Challenge inspections might each cost as much as US $12 million (Arnett, 1995).

In addition, there will be costs for national implementation and compliance measures. While the CTBT will not require the closure of nuclear test sites, Kazakhstan has decided to permanently shut down the formerly Soviet Semipalatinsk site. In October 1995, the United States agreed to provide a total of US $171 million to cover the costs of sealing, and rendering incapable of future use, the site's 186 tunnels. This process is scheduled to be completed in 1999 (*Nuclear Proliferation News*, 12 October 1995).

Disabling weapons delivery systems

Between 1989 and 1995, the US Navy spent about US $780 million to dismantle ballistic missile submarines (see Table 1). It is planning to complete all START-related eliminations no later than January 2000 (Leeder, 1994). The US Air Force is decommissioning 148 of its B-52 bombers and destroying another 217; it has also mothballed 200 F-111 aircraft. Minuteman II ballistic missiles withdrawn from deployment are being placed in storage. A small portion of the more than 1,000 missiles that are expected to be taken out of service by the end of the 1990s are being sold for the purpose of launching commercial satellites—this will not only avoid the expense of destroying missiles that cost more than US $10 million each to produce, but also yield some revenue. All in all, the Air Force will spend about US $60 million on mothballing and dismantling surplus arms between 1993 and 2000 (Scott-Johnson, 1994; *New York Times*, 15 April 1994). In 1993, the US Air Force started destroying the first of 500 excess missile silos; 300 of these are to be destroyed at a cost of US $35 million, while the fate of the remaining 200 is yet to be determined (IDDS, 1993; Scott-Johnson, 1994).

Under START II, Russia is specifically required to eliminate its SS-18 missiles; it could retain, but not deploy, all other surplus missiles. Even in the absence of START, however Russia would have had to decommission a large portion not only of its intercontinental ballistic missiles, but also of its strategic bombers and ballistic missile submarine fleet—due to physical obsolescence. Reportedly, a total of 208 aircraft (Tu-95s, Tu-16s, Tu-22s) are to be destroyed at the Engels Airbase before the year 2000. Seventy of these have to be eliminated in accordance with the CFE and START Treaties. The remainder are aircraft that completed their service life and were brought to the base from all corners of Russia and other former Soviet republics. In terms of current prices the disassembly of one Tu-95 will cost about 7 million rubles. Additionally, it costs 300,000 rubles to remelt one ton of pure metal—approxiamtely 37-40 tons are obtained per aircraft (Kostrov, 1995, p. 14).

Unclassified assessments by the Russian military estimate that implementing START might cost Russia 90 to 95 billion rubles. Expressed in 1992 prices, this would be equivalent to about US $6 billion, though the ravages of Russian inflation render any dollar estimate somewhat arbitrary (Arbatov, 1993).

Disposal of missile propellants

Most Soviet-made missiles are liquid-fueled, whereas US missiles are primarily solid-fueled. The manner in which the fuels are discarded is critical—not only do they contain highly hazardous materials, but also the older or less well-maintained a missile, the more dangerous and costly the dismantling job (Molas-Gallert, 1994). Although Soviet-made missiles use unsymmetrical dimethyl hydrazine (UDMH) as a propellant and nitrogen tetroxide (NTO) as an oxidizer, the Soviet Union never developed any means of disposing or reprocessing these materials, as they were always recycled into new missiles. At present, several tens of thousands of metric tons of these hazardous substances are stored in tanks, awaiting disposal or recycling. As the military business shrinks, propellant manufacturers are becoming more and more interested in fuel demilitarization programs.

In November 1993, for instance, a US-Russian team initiated a demonstration project for the demilitarization of Russia's liquid- and solid-fueled ballistic missiles and the conversion of recovered materials to chemicals and other products. The ICBMs' nitrogen tetroxide oxidizer could be processed into nitric acid and used to produce fertilizer and other products, but possible civilian applications are limited compared with the size of the existing stockpile. UDMH fuel from liquid-propellant ICBMs could be processed into ammonia and demethylamine, both viable commercial products with significant industrial consumer demand. Demethylamine, for example, has a market price in the United States of about US $1,000 per ton and can be used as a surfactant (Lenorovitz, 1993, pp. 89-90).

Burning these fuels would be the cheapest, yet environmentally most objectionable, disposal option (Darst, 1993). The United States has conducted routine open air burning of obsolete missile fuel for many years, involving several hundreds of tons per year. Growing protests against this practice, however, led the US government to initiate a research program to develop alternative disposal technologies (*New York Times*, 17 September 1991; Esher, 1993).

Decommissioning of nuclear submarines

Some 300 nuclear-fueled submarines worldwide—including strategic (ballistic missile-bearing) and non-strategic (attack) submarines—will need to be taken out of service by the turn of the century because they are reaching the end of their life-cycles (Davis and Van Dyke, 1990).

The US Navy is planning to decommission about 60 nuclear submarines between 1992 and 2000, at a projected cost of US $2.7 billion. (A total of 165 submarines were built since 1954.) Prior to 1992, 42 submarines had already been inactivated, most of them since 1986. During 1988-1990, the average cost of completing an inactivation and reactor compartment removal and disposal was US $23.6 million; during 1990-1992, costs ranged between US $12.8-21.4 million, depending on the shipyard at which the work was performed (this analysis, by the General Accounting Office, excluded some cost categories to make costs among different yards comparable). From 1992 on, deactivations were undertaken exclusively at Puget Sound in Washington State, the yard with the lowest costs (GAO, 1992).

Initially, the US Navy had planned to dispose of the hulls at sea. The decommissioning strategy had to be changed in 1989, however, due to the discovery of toxic PCB material in submarine hulls. The hulls are now recycled and sold for scrap. The recycling cost per unit is estimated at US $3.5-4.5 million, after taking into consideration the roughly US $1.5 million value of the scrap materials. Recycling the hulls is still cheaper than storing them (GAO, 1992).

With adequate funding, production facilities and infrastructure, the United States was able to initiate an integrated program for the disposal of nuclear-powered submarines in the early 1990s. To date, the United States has decommissioned 69 of these submarines, of which 32 are completely dismantled and 37 are inactivated, awaiting final disposal. The estimated cost of inactivating and scrapping one nuclear submarine is about US $38 million (Loring Morrison, 1995).

Table 1: Cost to the US Navy for Dismantling Ballistic Missile Submarines to Satisfy START Requirements

In Millions of US dollars

1989	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
17	39	59	141	255	198	75

Source: *Leeder, 1994.*

Between 1989 and 1993, more than 80 Soviet/Russian submarines were retired from service, and due to arms control treaties a similar number is likely to be removed by the year 2000. In the past, the Soviet government had gotten rid of at least some obsolete submarines by sinking them (Handler, 1993b).

The naval nuclear support infrastructure in the former Soviet Union was already in poor condition prior to the massive write-off of submarines. It is now stressed to its limit, with decommissioned submarines with their fuel still on board accumulating at bases and shipyards in the North and Far East. Although Russia has developed a concept and adopted a program of complete disposal of nuclear-powered submarines, a key problem has been the lack of financing and actual implementation of the program. For example, a detailed plan has been drawn up at Severodsvinsk for a submarine scrapping infrastructure, including the construction of more dry docks, a fuel assembly removal plant, and storage and transport facilities. The plan involves a total projected cost of almost 23 billion rubles (Nilsen and Bohmer, 1994, pp 50-51).

According to Vice Admiral Viktor Topilin, chief of the Navy's Main Technical Directorate, breaking up a single nuclear vessel costs more than 5 billion rubles. To date, funds for the work are being provided by cutting expenditure on maintaining the combat readiness of the Navy's ships. The Navy's budget has already been cut to the bones however, and the available funds for decommissioning will be insufficient (Maryukha, 1994, p. 32).

Enterprises involved in the scrapping business were told by the government that the costs would be recovered through the sale of scrap metal. Nevertheless the experience of the "Zvezdochka" enterprise in Severodvinsk—where nine Alfa-class nuclear submarines are currently awaiting final disposal—has not borne out these predictions. After cutting up the first submarine in 1993, the enterprise suffered a loss of 311 million rubles. The work turned out to be more expensive than the value of the scrap metal. By December 1994 the cost of salvaging one submarine had jumped to 23 billion rubles and the plant's losses ran into the billions (Filippov, 1995, p. 80).

Russia especially lacks adequate facilities to properly dispose of submarine reactors and their spent fuel. By early 1993, only one-third of the submarines slated for decommissioning had their spent fuel removed. Reactor vessels removed from Pacific fleet submarines are left floating at the Pavlovsk naval base, as storage facilities on land are unlikely to be available before the year 2000. It may take as much as 30 to 40 years to dispose of all the Russian submarines that will be pulled out of service during the 1990s (Leskov, 1993; Handler, 1993a; Nilsen, 1993).

The 1995 budget of the Russian government provides for expenditures to handle nuclear waste to the tune of 450 billion rubles. If the fleet receives at least half of this money, there is hope that the problem with salvaging nuclear submarines will slowly start to be resolved (Litovkin, 1995, p. 32).

Dismantling nuclear warheads

The US Department of Energy (DOE) has been dismantling between 1,000 and 1,600 nuclear warheads annually in recent years. The Congressional Office of Technology Assessment (OTA) estimated annual costs for dismantlement and fissile materials disposal to be US $500 million to US $1 billion over the next decade (OTA, 1993). A more recent estimate places the annual costs closer to the high end of this range (Schwartz, 1995). Russia is probably dismantling less than 2,500 warheads per year, according to Western non-governmental analysts (Norris and Arkin, 1994). MINATOM head Viktor Mikhaylov stated in 1994 that Russia is spending up to 1 trillion rubles on dismantling warheads; he estimated the cost of dismantling a single warhead at US $100,000. Hence, Russia may be spending the equivalent of some US $200-250 million per year (IDDS, 1994).

The other former Soviet republics with nuclear arms on their territories have agreed to ship them to Russia for dismantlement. In 1993, Ukrainian officials estimated the dismantling and withdrawal cost at US$ 1.5-5 billion (IDDS, 1993).

Converting highly enriched Uranium (HEU)

After addressing the problem of warhead disassembly, the fundamental question is how to dispose of the dangerous fissile materials contained in them. The options are more straightforward for HEU than for plutonium. The generally accepted path is to blend HEU with depleted or natural uranium, in effect diluting it from weapons-grade enrichments of 90-95 percent to below 5 percent, thus making it usable as commercial nuclear reactor fuel.

Under a 1992 agreement, the United States pledged to purchase 500 tons of HEU derived from Russian warheads over the next 20 years (Russia is believed to have 1,200 tons of HEU). Diluted to some 15,000 tons of low-enriched uranium, this would be enough to run US nuclear reactors for roughly a decade. The entire deal is reckoned to be worth about US $11.9 billion (IDDS, 1994). In each of the initial five years, the United States plans to purchase 10 tons of HEU, bringing Russia a revenue of US $240 million annually; the amount will then rise to 30 tons per year, with an implied value of about US $725 million annually (author's calculations). The first shipment was received in June 1995, but implementation of the agreement has been clouded by pricing and trade disputes (*New York Times*, 12 June 1995 and 9 July 1995). Moreover, in the near future other problems could result from the planned privatization of the US Enrichment Corporation (USEC) the government-owned company that handles the deal exclusively. Critics argue that it will then have little commercial interest in handling the Russian product, which comes at a higher cost than its own and so will cut into profits (*New York Times*, 25 July 1995, p. C4).

In November 1994 another purchase of weapons-grade material was completed. Details of "Operation Sapphire," the code name for the secret transfer of more than 1,320 pounds of weapons-grade uranium from Kazakhstan to the United States, were disclosed only after completion of the transfer. According to US Defense Department officials, President Nazarbayev of Kazakhstan had learned early in 1994 of the existence of the large stockpile of HEU at a metallurgical plant in Ust-Kamenogrosk. Although Kazakhstan was guarding the material—which had been intended for use in military naval reactors—the effort was a drain on its meager resources and the uranium posed a temptation for any terrorist group or renegade nation in the market for nuclear arms components. After extensive negotiations, according to which the United States agreed to provide cash and non-cash support to Kazakhstan, different sources reported the value of assistance at anywhere between US $30-100 million. The cost of the transfer itself was US $7 million (Thompson, 1994, p. 38; Schwartz, 1995, pp. 20-21; IDDS, 1994).

The US government has begun to convert some of its own military HEU into civilian nuclear reactor fuel. The volume involved—13.2 tons—is equal to only a little more than 1 percent of its stockpile of 994 tons. An additional 50 tons, with a market value of US $500 million and reprocessing costs of US $100 million, are currently scheduled for dilution. Additional amounts of HEU may be released in the future (*New York Times*, 12 June 1995).

Plutonium problems

Plutonium poses a much greater disposal challenge than HEU. Although a variety of options are being discussed, none will actually be available for many years to come. Arjun Makhijani, president of the Institute for Energy and Environmental Research in Maryland, explained that DOE "is extending its definition of interim [storage] to longer and longer periods. Before, 'interim' . . . was six to 10 years. Now, they're talking about building 50-year storage facilities" (*New York Times*, 16 July 1995, p. D1). Thus, the surplus plutonium will need to be placed in guarded storage for an extended period—at an estimated cost of US $2-3 billion over a decade (Rohde, 1994).

One of the most discussed proposals suggests the blending of plutonium with uranium into so-called mixed-oxide (MOX) fuel to be used in adapted or newly-built light-water reactors; another option favours burning plutonium in breeder reactors. Another solution is to encase it in glass (vitrification) for burial in so-called geological repositories. Though none of these paths is entirely satisfactory, vitrification appears to be far preferable from the perspective of disarmament, economics, public safety, and environment (Bloomster et al., 1990; Makhijani, 1992; Berkhout et al., 1992). The costs are rather speculative at this juncture—they are likely to range from several hundred million to a few billion dollars. A November 1993 RAND study suggested that vitrification might be the least costly option (Bloomster et al., 1990; Nuclear Safety Campaign, 1994).

Russia is determined to derive some economic benefits from dismantling its nuclear arsenal; with Japanese and German aid, it is exploring the

MOX and breeder reactor options. Also, in 1993 Russia and the US company General Atomics signed an agreement to build a US $1.5 billion fission reactor (*New York Times*, 21 June 1993). The country is so cash-strapped, however, that its plans may remain just that. The United States has not yet officially decided what to do with its plutonium. Whereas Moscow regards its plutonium as a treasure, Washington is inclined to see it as a dangerous waste that needs to be discarded (*New York Times*, 6 April 1993 and 16 July 1995; IDDS, 1994). White House science advisor John Gibbons has stated: "Plutonium has essentially a negative economic value" (*New York Times*, 19 August 1994).

Planned US facilities to vitrify military high-level nuclear wastes are sizable enough to accommodate all US weapons plutonium, should such a decision be reached. However, plans to construct and operate two vitrification facilities have experienced repeated delays, technical difficulties, and cost overruns (*New York Times*, 21 June 1993; IDDS, 1993). At one of the two facilities, in Savannah River, Georgia, costs have escalated from US $1.53 billion to nearly US $4 billion (Schwartz, 1995).

Regardless of what is done with the plutonium, eventually it will have to be placed in some kind of repository. Identifying proper and acceptable permanent burial sites remains an unresolved and highly controversial endeavor. Projected opening dates for US repositories in Nevada and New Mexico, for example, continue to slip further into the future. Cost estimates are of course speculative, and are likely to grow significantly. Already, some US $4 billion has been spent at the Nevada site (Schwartz, 1995). One thing, however, is certain: final disposal of the excess plutonium "will be pursued with none of the sense of national mission that attended its manufacture" (*New York Times*, 19 August 1994).

The other declared nuclear powers—China, France, and the United Kingdom—are not part of any nuclear arms control agreements. Hence, decisions to dismantle any carrier systems or warheads would be primarily dictated by reasons of obsolescence rather than disarmament. In its 1994 budget, the French government revealed for the first time the budget allocated for disassembling warheads. At 65 million francs (US $11 million), the expense was equivalent to less than 2 percent of the French nuclear weapons program during the same year (IDDS, 1994).

Chemical Weapons

The Chemical Weapons Convention (CWC) was completed in late 1992 and is expected to come into force during 1996. It mandates the destruction of all stockpiles and of production facilities. To date, only the United States, Russia, and Iraq have formally declared the possession of chemical arsenals. Iraq, despite being forced to destroy its chemical stocks under UN supervision as a condition of the 1991 Persian Gulf ceasefire, did not sign the CWC. However, the destruction of Iraq's 125,000 chemical munitions and 600 tons of bulk chemical agents is virtually completed (Morrison, 1994, p. 1134). Prior to the CWC signing, the United States and Russia had already concluded bilateral agreements to rid themselves of their chemical weapon stockpiles. And in the United States, the Army is required by a Congressional decision to destroy all of its old stocks.

Chemical weapons disposal in the United States

Destroying chemical weapons is reckoned to cost up to 10 times as much as producing them (Robinson, Stock, and Sutherland, 1993). The United States has considerable experience in chemical weapons destruction, but the amounts disposed of to date pale in comparison with the volumes now awaiting destruction—some 31,400 tons. The US Army has adopted high-temperature incineration as the sole destruction method. It has operated two test facilities at Tooele, Utah and at Johnston Atoll in the Pacific Ocean, and is in the process of constructing incinerators at the eight locations at which chemical warfare agents are stored (thus avoiding the need to transport any weapons) (IDDS, 1992; OTA 1992).

Nonetheless the prototype facilities have experienced persistent mishaps, the target date for completing the destruction of stocks has slipped from September 1994 to December 2004, and total cost estimates have soared from an original US $1.7 billion in 1985 to US $11.9 billion currently (IDDS, 1992; Stock and De Geer, 1994; Morales, 1995). Annual funding for the US Army's Chemical Material Destruction Agency has risen from about US $200 million in the late 1980s to about US $600 million, as shown in Table 2 (Tischbin, 1994; Morales, 1995). In addition to the weapons stockpile, there are large amounts of old, buried chemical ammunitions. The cost of disposing of them properly is estimated at another US $17.7 billion over the next 40 years (US Army, 1993b).

Costs of chemical weapons in Russia

Russian President Boris Yeltsin said in 1993 that destroying his country's stocks (officially assessed at some 40,000 tons, though some have charged that the stocks are much higher) could cost more than all of Russia's other disarmament programs combined. While the United States has begun to destroy small amounts of chemical weapons, Russia's program has been delayed by technical difficulties, lack of money, and popular opposition that is at least as strong as that in the United States. During 1994, the plan was to have three facilities begin operations in 1997; however, these plants would be able to eliminate only 43 percent of existing stocks by 2004, the likely deadline imposed by the CWC (IDDS, 1993; Stock and De Geer, 1994).

In October 1995, the Russian government approved a federal program for chemical weapons elimination for the period from 1996 to 2009. According to this program, Russia will start eliminating 7,500 tons of blister agents in newly built facilities in the city of Kambarka (Udmurtia) and the village of Gorny

Table 2: Annual Budget of the US Army Chemical Material Destruction Agency, 1988-1995

In US $ millions

1988	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
197	178	253	291	374	534	499	600[1]

[1] *Amount authorized by Congress.*

Sources: *Tischbin, 1994; IDDS, 1994; Morales, 1995.*

(Saratov region). The annual capacity will amount to 1,850 tons (*FBIS Daily Report*, FBIS-Sov-95-208, 26 October 1995).

In a second stage, chemical artillery shells and aviation bombs with phosporite-organic agents will be dismantled. Stocks are estimated at 32,500 tons. New facilities for this purpose will be built in the Kurgan region and near Kizner (Udmurtia). Elimination of weapons should be completed by 2005. Work to decontaminate and close down facilities for dismantling is expected to be finished by 2009 (*FBIS Daily Report*, FBIS-Sov-95-208, 26 October 1995).

It is, however, next to impossible to come up with any reliable cost projections for Russia. The US experience does not offer much of a benchmark for comparative purposes. Although Russia may end up relying on US technology, its cost structure is rather different. Russia has a larger stockpile than the United States, but unit-per-unit it should be less costly to destroy because unlike its US counterpart, the Russian arsenal does not contain explosive charges (GAO, 1994).

Official Russian cost estimates have varied widely; in 1994, a Russian expert estimated the cost to be in the range of US $1.3-2.8 billion. This does not include the cost of demolishing production facilities (Kisselev, 1994). Even aside from the difficulties of expressing costs adequately in US dollars or other Western currencies, ruble estimates differ considerably: in March 1994, during State Duma hearings, an estimate of 2.5 trillion was mentioned (Stock and de Geer, 1995). The plan approved in October 1995, by contrast, is thought to involve expenditures of 16.6 trillion (*FBIS Daily Report*, FBIS-Sov-95-208, 26 October 1995).

The 1994 Russian government budget allocated 116 billion rubles (about US $46 million) for chemical weapons elimination (IDDS, 1994). While struggling to finance the destruction of its chemical warfare arsenal, Moscow is placing its hopes on two factors: foreign assistance and the sale of chemical byproducts salvaged from the weapon stocks. The expectation is that these two revenue sources will cover at least 30-40 percent of the cost. Moscow has asked for as much as US $1 billion in foreign assistance, but aid pledged or forthcoming has so far fallen short of this target (GAO, 1994; IDDS, 1993).

As part of the chemical weapons dismantling program, Russia hopes to reuse some of the chemical agents for civilian uses. One of a series of proposals intended to derive valuable materials from chemical disarmament is to extract arsenic from lewisite weapon stocks and to transform it into gallium arsenide, which is used in the manufacture of semiconductors. Up to 2,000 tons of arsenic, with a potential market value of US $9 billion, could be extracted. However, numerous uncertainties plague schemes such as this one, including practicality, net financial benefit, and environmental and safety implications (Brin, 1993; *Wall Street Journal*, 2 September 1993).

Costs for international verification

In carrying out the stipulations of the Chemical Weapons Convention (CWC), the United States, Russia, and all other signatories will have to bear an additional cost. A whole new body, the Organization for the Prohibition of Chemical Weapons (OPCW), is currently being set up to oversee the implementation of the treaty.

The 1994 and 1995 OPCW budgets were US $29.7 million and US $32.5 million, respectively, but once the CWC enters into force and the organization is fully operational, annual costs may come to US $75-100 million (Batsanov, 1994; Stock, Geissler, and Trevan, 1995; *Pacific Research*, February 1994). Still, these expenses are considerably lower than anticipated. Initial plans foresaw a staff of up to 1,000 (compared with the current plan of 365) and an annual budget of US $150-180 million. Western governments successfully insisted on cost curtailment, although this possibly compromised the OPCW's ability to detect, and hence deter, treaty violations (*Finacial Times*, 26 August 1992; Wadhwa, 1993).

Conventional Weapons

Conventional arms control has by and large been limited to the European continent, much of it enshrined in the Conventional Forces in Europe (CFE) Treaty. Beyond Europe, considerable amounts of mostly small arms have become surplus with the end of long-standing conflicts in places like Nicaragua, El Salvador, Haiti, Namibia, Ethiopia/Eritrea, and Mozambique. In many cases the ultimate destination of this hardware is far from clear, however. There is a substantial danger that much of what is still usable may find its way to new zones of conflict rather than being dismantled and destroyed. United Nations peacekeeping missions have played important roles in terminating almost all these conflicts, yet overseeing disarmament frequently remains an unfulfilled mandate. In El Salvador, for instance, a great part of some 300,000 weapons distributed by the army to civilian supporters are still in circulation *(International Security Digest*, April 1995). There have been several disarmament and demobilization efforts and a few weapons buy-back programs, such as in Haiti, but their success is limited and their contribution to long-term peace and security remains unclear.

The costs related to conventional surplus weapons stocks depend on the various methods of handling the surplus (Laurance and Wulf, 1995):

- Mothballing of weapons—a simple but costly method, because weapons must be safeguarded and maintained if to be reemployed or sold in the future
- Export of surplus weapons—by far the most economically attractive solution, but also the politically most risky
- Let them rust away—mainly a result of lacking appropiate storing technologies and funding
- Dismantling weapons—disabling is usually possible within a short span of time and at limited costs, while the final disposal of weapons and their components can be extremely costly and technically complex
- Conversion of weapons—actually a very limited option, used mainly by Russia
- Dumping of surplus weapons—a cheap but environmentally hazardous method

Conventional force reduction in Europe

The CFE Treaty came into force in 1992 and was to be fully implemented by November 1995. To comply with the treaty, arsenals from the Atlantic to the Urals had to be slashed by almost 15,000 tanks, more than 10,000 armored vehicles, about 5,000 artillery pieces, and a much smaller number of combat aircraft. As much as 90 percent of these cuts had to be made by members of the former Warsaw Pact (IDDS, 1991 and 1992). The treaty, however, gives considerable leeway as to how the reductions in deployed weaponry may be achieved. A substantial portion of the surplus equipment is not being destroyed, but instead was relocated outside the geographical area covered by the treaty (an option available to Russia, the United States, and Canada), was exported, was converted to civilian use, or was recategorized. Given the range of options, the share of the excess equipment actually destroyed is unclear.

Any effort to track down CFE-related expenditures is hobbled by the poor availability of relevant data, in part due to inadequate record-keeping of government agencies. Governments often employ regular armed forces personnel and also contract industrial companies to dismantle excess weapons. In most cases, the salaries of military personnel are not incorporated into disarmament cost estimates because they would have been payed, even in the absence of disarmament. Subsequent figures also do not include possible revenues from selling scrapped metal and other parts from dismantled weapons. However, generally speaking, the scrapping and dismantling of conventional weapons is comparatively cheap. The whole CFE disarmament process did not cost more than US $1-2 billion. NATO's Verification Coordinating Committee concluded in late 1994 that destruction or decommissioning is less costly than mothballing surplus equipment (Lachowski, 1995).

Among members of NATO, Germany and the United States have by far the largest expenses in carrying out the CFE provisions. The annual expenditures of the other NATO states are considerably lower—typically not surpassing US $5 million each (Renner, 1994b). Germany is disposing of about 80 percent of the equipment of the defunct East German armed forces and a projected 30 percent of that of the pre-unification Bundeswehr. All in all, close to 11,000 major weapons systems were planned to be eliminated by 1995, and as many as 25,000 during the following 15 years (Volmerig, 1993; Giessmann, 1992). As Table 3 shows, the German government spent DM 864 million—slightly more than US $500 million—in 1991-1994 on CFE destruction (Federal Republic of Germany, Bundesministerium der Verteidigung, 1991-1994; Federal Republic of Germany, Bundesministerium der Finanzen, 1994).

Table 3: German CFE Expenditures 1991-1994

In DM millions

	1991	1992	1993	1994
Destruction	97.8	192.7	185.9	387.2
Verification	0.3	0.6	0.6	5.5

Sources: *Federal Republic of Germany, Bundesministerium der Verteidigung, 1991-1994; Federal Republic of Germany, Bundesministerium der Finanzen, 1994*

Through the NATO cascading program, the United States (like Germany) transferred large numbers of treaty-limited equipment to other NATO members. Thus, during the first full year of the CFE implementation period, the United States avoided any binding obligation to eliminate equipment (though it made a voluntary decision to destroy more than 600 old tanks stored in Italy). During 1991-1994, the United States incurred US $134 million in CFE-related expenditures (including destruction, verification, diplomatic, and bureaucratic costs) (GAO, 1993).

The former Warsaw Pact states have had to undertake far larger reductions in their arsenals than have NATO members, but they also have very limited financial resources for this task. Although their expenditures may not seem particularly large by Western standards, they are substantial for countries that are economically hard-pressed. Belarus, for instance, estimates its total costs at US $33 million. During a 1994 meeting of the CFE Joint Consultative Committee, a number of Eastern states unsuccessfully called for the creation of an international fund to support weapons destruction. Russia in particular has repeatedly complained about its CFE costs. It would prefer to let its surplus tanks rust away rather than undertake the expensive process of cutting them apart (IDDS, 1994; GAO, 1993). Russia does not even have enough money to keep a Soviet era promise to scrap military equipment withdrawn from western parts of Russia and stored east of the Urals as well as in former Central Asian republics. The Soviet Union moved the weapons to avoid their inclusion under CFE limits. By November 1995, Russia had destroyed 19 percent of the 6,000 tanks, 40 percent of the 1,5000 armored vehicles,and 39 percent of the artillery systems in question—most of them obsolete. Russia estimates that it needs three more years to complete the task and evaluated the cost at about 100 billion rubles, or about US $ 21 million ("Russia unable to scrap...,"1995).

Sales of scrap from destroyed pieces of equipment are offsetting at least part of the costs incurred. The Czech Republic, for example, had spent US $2 million by early 1994, but apparently managed to input no net costs (Czech Republic, 1994; IDDS, 1994). The same is true, to differing degrees, for a variety of countries in East and West. Spain, for instance, had CFE reduction expenditures of 610 million pesetas in 1992-1994, but reutilization of materials brought in about 2 billion pesetas during the same period of time (Fisas Armengol, 1995).

Conventional surplus and arms export

Even after fullfilling the reduction liabilities under CFE guidelines most NATO and former Warsaw Pact states still have large amounts of conventional surplus. As a result of cuts in defense expenditures and reduction in armed forces, military holdings must be further downsized. (For estimates see Kopte and Wilke 1995.) During the last five years, much of this surplus has been offered on the international arms markets. In fact, since 1989 a growing number of all major arms sales have involved transfers of surplus stocks. In 1994 second-hand sales accounted for 30-40 percent of all major arms exports. The Stockholm International Peace Research Institute (SIPRI) estimates trade in used weapons at US $6.1 billion for 1994. Great Britain's gross income from surplus weapons sales between 1988 and 1993 was officially put at 320.7 million British Pounds (£) (United Kingdom, 1994,p.v).

In coming years, an increasing number of second-hand weapons and equipment will be offered for sale. Particularly in the United States and Russia, surplus stocks include a large number of highly sophisticated weapons such as combat aircraft, battle ships, submarines, and tanks. Some of these weapons are given away for free or at very low prices (ships are often leased to foreign countries). While this limits the revenue gained, it also avoids or reduces the cost of mothballing or scrapping the weapons.

Russia faces far greater difficulties in using exports as a way to get rid of surplus. One illustrative example is its navy. Russia is unable to maintain the sizable armada that the Soviet Union had built up. Much of the Russian (and Ukrainian) navy is therefor wasting away. Because Russia is unable to sell its ships on the world arms market, it has decided to sell them for scrap. A South Korean company is scheduled to buy as many as 259 ships (including 220 surface vessels and 39 submarines) and two Kiev-class aircraft carriers (which were among the most sophisticated in the Russian fleet) from Russia's Pacific fleet for this purpose. The contract prohibits military use of the vessels; they are to be disarmed before the sale and dismantled under Russian supervision. Precise financial arrangements are not known, but the carriers' scrap value is estimated at about US $100 per ton. There has been some speculation that the sale might be offset against Russia's US $1.5 billion debt to South Korea (*Agence France Presse*, 7 April 1995; *International Security Digest*, April 1995).

Small arms and the cost of demobilization

No reliable overall statistics exist on the flow and stocks of small arms—either surplus or in use—but the numbers must be immense. For instance, since World War II some 55 million AK-47 and AK-74 Kalashnikovs have been produced—primarily by Russia, but also in eight other countries, including China and Poland (*International Security Digest*, November 1994).

There are also no reliable estimates on the economic and social costs of surplus weapons in the many crisis regions in Africa, Asia and Central America. In many countries the large number of small arms in circulation poses a severe danger to economic development and internal security. In such African countries as Angola, Mozambique, Ethiopia, and Somalia, surplus stocks are estimated to include millions of small-caliber weapons. Hundreds of thousands of tons of weapons were shipped to Afghanistan between 1983 and 1987, and a large portion of this arms 'pipeline' leaked into parts of Pakistan, India, and Kashmir. In Central America, surplus weapons are an unwelcome reality in El Salvador, Nicaragua, and Haiti. For example, some 300,000 arms distributed by the Salvadoran army to civilian supporters during the civil war are still in circulation, according to official figures (*International Security Digest*, April 1994).

The surplus of these arms results from the fact that several long-standing conflicts have ended and a significant share of the opposing forces are being demobilized. Demobilization expenditures are linked closely to the cost of dealing with surplus weapons, abut they do not indicate the extent to which surplus arms are being brought under control. Table 4 summarizes demobilization (and, in some cases, reintegration) costs in selected countries. The mandates of a number of UN peacekeeping missions include the monitoring and facilitating of the demobilization process, but the disarmament of ex-soldiers has been accomplished only in part.

Table 4: Costs of Demobilization Programs in Regional Conflicts

In current US $ millions (with the exception of South Africa)

Country	*Estimated Cost*
Angola	104.5
Chad	18.9
El Salvador	238.0[1]
Mozambique	54.4-62.6 [$47 million, according to UN]
Namibia	46.6
Nicaragua	43.6[2]
South Africa	1.2 billion Rand [short-term costs for retraining and retrenchment]
Uganda	19.4[3]
Zimbabwe	23.0

Notes:
[1]Projected costs for demobilization and reintegration in Nicaragua were US $142 million for the FMLN and US $96 million for the government army. At the beginning of 1994, however, the Salvadoran government still needed to raise US $137 million to pay for reintegration programs.
[2]For 'contra' demobilization; another US $40.8 million was needed for Sandinista army demobilization, although it remains unclear just how much money was actually available.
[3]First phase of plan to demobilize half of Uganda's armed forces. Total cost is expected to come to about US $45 million.

Sources: *GENERAL: World Bank, 1993,* p. 84. *ANGOLA: United Nations, Security Council, 1995. EL SALVADOR: Aguilera, 1993,* pp. 7-9. *1995; Notisur-Latin American Political Affairs,* 12 May 1995. *MOZAMBIQUE: United Nations,1994c. NICARAGUA: Aguilar Urbina, 1994. SOUTH AFRICA: Singh and Wezeman, 1995,* p. 573. *UGANDA: International Security Digest, December 1994,* p. 1.

In some cases, so-called gun buy-back programs have been used to motivate ex-combatants to turn in their weapons voluntarily. The US Army relied on this tool in Central America (Panama, Haiti). In Panama in 1989, US troops offered the following incentives for turned-in weapons (in US dollars): $25 for ammunition; $50 for RPG grenades; $100 for pistols and revolvers; $125 for shotguns; and $150 for rifles and automatic weapons. Some 8,848 weapons were collected at a cost of US $811,000 (World Bank, 1993, p. 33).

Between early December 1994 and February 1995, roughly 12,600 weapons were bought back by the US-led multinational forces in Haiti, and another 17,300 weapons and grenades were seized without payment. Prices paid ranged from US $200 for handguns and US $400-800 for semi-automatic and automatic weapons up to US $1,200 for heavy and large-caliber weapons (Council for a Livable World, 1995; United Nations, 1995e).

Effective demobilization, reintegration, and surplus weapons collection programs ('micro-disarmament') can have a major stabilizing effect in countries emerging from long years of warfare. Such programs, as Table 4 shows, are rather inexpensive compared to the costs of dealing with other types of surplus weapons. They are also quite small in contrast to the resources that were devoted to sustaining wars. Nontheless, for the countries involved—which have been weakened by protracted conflict—they are a quite substantial burden. Timely and adequate support from the international community is crucial in firming up the war-to-peace transition process.

Scrapping of Conventional Ammunition

None of the presently existing arms control or disarmament treaties concern themselves with ammunition. However, in the wake of the end of the Cold War and in parallel with CFE equipment reductions, a number of governments are reducing their holdings. The United States, Russia, Belarus, Ukraine, and Germany are among the countries with the largest surplus amounts.

By far the largest amounts of ammunition are held by governments in the former Soviet Union. Russia apparently has roughly 35 million tons, some of it dating back to the early parts of the twentieth century and entirely obsolete; Belarus has 1 million tons, and Ukraine has at least 750,000 tons. In the United States, more than 500,000 tons of ammunition are slated for demilitarization (Malevich, 1993; *Financial Times*, 20 January 1995). The US military has a stockpile of more than 5.6 million tons of conventional munitions (Siegel, 1995). In 1990, Germany had about 295,000 tons of ammunition left over from the East German army (Nassauer, 1995, p. 50).

Dumping at sea was the preferred option in the past, and this practice has still not entirely stopped. At the beginning of 1993, new international restrictions under the convention for the Protection of the Marine Environment of the North East Atlantic came into force. Most NATO members have agreed to stop dumping obsolete bombs at sea by the end of 1995, within the framework of the London Dumping Convention. Currently, open-air burning and detonation—as questionable environmentally as ocean dumping—appear to be the most common methods *(International Environment Reporter,* 23 September 1992*; JPRS Report: Environmental Issues,* 18 November 1994*).*

In the second half of the 1980s, the US Army demilitarized an average of about 24,000 tons of ammunition each year. With the end of the Cold War, the stockpile slated for demilitarization grew substantially. About 340,000 tons of ammunition were demilitarized during 1990-1995, at a cost of about US $300 million—almost US $900 per ton. The annual budget grew from US $15 million in 1990 to US $100 million in 1995 (US Army, 1993a; McCoy, 1994). As detailed in Table 5, at least another 630,000 tons are to follow over the next several years (Siegel, 1995).

Table 5: Conventional Ammunition Slated for Demilitarization, United States, Projections for 1995-2001

In thousands of tons

1995	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*Total*
125[1]	129	95	83	74	64	62	632

[1] By 15 April 1995, the total amount demilitarized had already reached 126,000 tons, surpassing the 125,000 ton figure projected for the fiscal year ending 30 June 1995.

Source: *Siegel, 1995.*

Yet, as Table 6 shows, disposal of obsolete ammunition is taking place even as modernization and new procurement continues. During 1990-1994, Congressional appropriations to procure new ammunition added up to a staggering US $6.6 billion (US Congress, 1990-1994). The Army intends to phase out open-air burning and detonation by the year 2000, and to boost the rate at which it recycles explosives into new munitions from 30-40 percent in 1993 and 1994 to 75 percent by 1996 (US Army, 1993a). While what the Army refers to as 'resource recovery and reuse demilitarization' represents a positive change from an environmental perspective, it is difficult to categorize it as disarmament.

Table 6: US Expenditures for Demilitarization and Procurement of Ammunition, 1990-1995

In US $ millions

	1990	*1991*	*1992*	*1993*	*1994*	*1995*
Demilitarization	15	31	50	35	68	100
New Procurement	2,011	1,367	1,369	1,094	735	n.a.

Sources: *McCoy, 1994 (for demilitarization expenditures); US Congress, 1990-1994 (for procurement appropriations)*

The case of the former East German (NVA) ammunition stocks offers an interesting example for the disposal of surplus ammunition. Approximately 295,400 metric tons of ammunition had been handed over to the West German Bundeswehr in 1990. Records indicated that only 14,000 tons were kept in service. Roughly 40 percent or 118,172 metric tons were exported—the bulk of that amount was simply given away or sold at extraordinarily cheap prices. By the end of 1995, 175,000 metric tons had been dismantled and destroyed in three facilities (Nassauer, 1995).

The cost of eliminating this ammunition is difficult to determine as these figures are usually included in a general weapons disposal cost category. Initial estimates of costs were on the order of DM 1.5 billion (or US $1 billion). Depending on the type of ammunition, estimates ranged from DM 1,000-15,000 per ton with the average cost somewhere around DM 5,000 per ton. Net costs to the German government may be somewhat lower (about DM 1 billion as of the end of 1995), because revenues from the export of NVA equipment sales between 1990 and 1993, which brought in roughly DM 1.1 billion, offset destruction expenditures (Sirak, 1995, p. 15).

A cost-neutral alternative to ammunition destruction is being pursued by Ukraine in a joint venture with the US company Alliant Techsystems, the largest supplier of munitions to the Pentagon. The venture involves the scrapping of 220,000 tons of surplus ammunition. Operations started in January 1995 and are scheduled to last five years. After the munitions are taken apart, the propellants and explosives are removed and put to commercial use in mining and construction or are converted into fertilizer. Scrap metal from munitions casings—copper, steel, brass, and aluminum—is to be sold by another venture participant, the British metals trading company Rapierbase. Sales are expected to generate more than US $100 million in revenue over five years, while the total cost of dismantling is estimated to be US $57 million. Alliant is investing US $17 million (*New York Times*, 28 July 1993 and 27 December 1994).

During the Cold War, the amounts of ammunition discarded in both the former Warsaw Pact nations and in the West was quite modest. The Ukrainian venture represents the first large-scale effort to demilitarize weaponry in the former Soviet Union that employs new technologies (*New York Times*, 27 December 1994). Alliant has entered a similar joint venture in Belarus. Perceiving a substantial market, it hopes to franchise the process in Russia and the United States (*Financial Times*, 20 January 1995). However, given the costs of dismantling ammunition in Germany, the cost projections by Alliant Techsystems appear to be very low and overly optimistic.

Mine Clearance

Landmines are quite different from other categories of weapons considered in this report. Although large numbers of them are found in national stockpiles—just like other arms—the immediate concern is caused by those that are 'deployed.' They differ in two important ways from other armaments. First, unlike other arms, mines are often not retrieved even after the military usefulness of their deployment has ended. Second, armed forces deploy their weaponry in carefully selected locations. The same may once have been true for landmines, but increasingly the trend has been toward dispersal in a highly indiscriminate manner. Scattered randomly, landmines have become a ubiquitous threat to the normal functioning of many societies. Not only are large population groups transformed into unsuspecting victims, but also the effort and cost of clearing unmapped mine fields has assumed astronomical proportions. Experience suggests that it takes 100 times as long to detect, remove, and disarm a mine as to plant it.

More than 250 million landmines have been produced over the past 25 years, including approximately 200 million anti-personnel mines. Production runs from 10 to 30 million each year. Estimates of the number of mines scattered in 62 countries range from 65 million to more than 100 million. The mines continue to be laid far faster than they are being removed: in an average year, clearing operations struggle to remove roughly 100,000 mines; but 2 million, perhaps even as many as 5 million, additional mines are being laid during the same period of time (Anderson, 1994; United Nations, 1994a and 1995b; Human Rights Watch/Arms Project and Physicians for Human Rights, 1993).

Mines are extremely cheap to manufacture, but difficult and expensive to remove. The production cost of US $10-$20 for an average mine compares with direct and indirect removal costs of US $300-$1,000 per mine (Grant, 1994). Accordingly, the United Nations and the International Red Cross recently issued estimates of how much it would cost to clear all mines worldwide ranging from at least US $33 billion to US $85 billion (United Nations, 1995a; Battersby, 1994). The cost of removing mines laid in just a single year would be at least US $600 million (United Nations, 1994b).

Actual demining efforts are severely underfunded. UN involvement in mine-clearance assistance has grown from operations in just one country in 1988 to 14 such operations in 1994 and 18 in 1995. Some of these efforts have taken place in the context of peacekeeping and humanitarian operations. A Voluntary Trust Fund for Assistance in Mine Clearance was established in November 1994. Altogether, the agencies in the U.N. system spent some US $67 million during 1993, and about US $70 million in 1994. In just the first four months of 1995, the United Nations asked for about US $70 million to finance mine-clearance operations, but additional funds are needed to start up a growing number of programs. In a 1994 report to the General Assembly, Secretary-General Boutros-Ghali expressed a desire to obtain an additional US $100 million in funding. At a July 1995 high-level international meeting to close the funding gap for demining, donors pledged US $87 million in new funds (United Nations, 1994d, 1995b, and 1995d).

In Latin America, the Organization of American States (OAS) has been involved in mine clearance. The OAS established a special fund in 1992 for demining assistance to Central American countries, and initiated extensive mine removal efforts in Nicaragua, Honduras, and Costa Rica. Although El Salvador received some OAS and other international assistance, it devised its own national demining program and signed a US $5 million contract with a Belgian company, International Danger and Disaster Assistance. All told, some US $8 million was spent in Central America in 1993 and 1994 (*New York Times*, 13 January 1994; Gjivoje, 1994; Human Rights Watch/Arms Project and Physicians for Human Rights, 1993). In January 1995, El Salvador's demining program was declared completed (United Nations, 1995c), but more remains to be done in the region. Honduras recently asked the United States for US $1 million to help remove some 150,000 mines planted along its border with Nicaragua (*International Security Digest*, May 1995).

Kuwait signed demining contracts worth about US $700 million after the Iraqi occupation (*New York Times*, 28 February 1994). Although Kuwait's spending represents far more than what is available in the rest of the world combined, the well-financed mine clearance efforts in that country could take 20 years (Quinn, 1994). With its petroleum-generated wealth, Kuwait is in a situation quite unlike that faced by other countries in the war-to-peace transition, who are so weakened economically that they cannot afford to devote anything near adequate resources to mine clearance (Human Rights Watch/Arms Project and Physicians for Human Rights, 1993).

A growing number of governments have declared a moratorium on the export or even the production of mines. Nevertheless a number of national armed forces, including those of the United States, oppose a ban. Instead, they argue for the production of self-destruct mines. For about US $2, a mine could be fitted with a self-destruct device; it might cost about US $700 million to fit existing mine stockpiles with such mechanisms (Battersby, 1994). Yet, more likely than not, money spent on such refitting would further detract from the already meager resources currently available for mine clearance. A recent UN press release lamented: "While land-mines have become more sophisticated over the years, clearance techniques have changed little since 1942 and astonishingly little research into mine-clearance technology has taken place" (United Nations, 1995d).

An option far more desirable than refitting of mines is their destruction. Following grassroots and parliamentary pressure, the Dutch government announced in November 1994 that it would destroy its stockpile of 423,000 anti-personnel and anti-tank landmines, originally designated for possible export. The cost of destruction has been estimated at US $5 million (*Arms Trade News*, December 1994; *Landmines Update*, December 1994).

Environmental Restoration

The full costs of meeting the surplus weapons dismantlement and disposal challenge can only be estimated. A factor of considerable uncertainty relates not to the weapons per se, but to the industrial facilities at which they were manufactured and the military bases at which military equipment is deployed, stored, and maintained. The management of wastes generated and the decontamination of land and facilities are pressing—and very expensive—tasks.

In particular, the facilities of the nuclear weapons complexes in the United States and the former Soviet Union (and presumably also in the other nuclear weapons states) are severely contaminated. In the United States, official projections of waste management and environmental restoration costs now run anywhere from US $200 billion to US $350 billion (DOE, 1995). Other estimates suggest that they may be even higher.

No matter how much money is made available, however, the unpleasant truth is that a real 'clean-up' is virtually impossible. The most that can be expected is that the contamination problem will be contained without any disastrous accidents. Hence, there is a considerable non-monetary cost in the fact that certain areas will have to be closed to human use permanently.

Environmental remediation efforts in the United States got seriously under way in the 1980s, and budgets grew rapidly to the extent that the environment-related expenditures of the Departments of Defense and Energy each are larger than the budget of the Environmental Protection Agency (see Table 7). These budgets, however, have come under attack by the newly Republican-controlled Congress,

Table 7: Environmental Management Budgets of the US Departments of Defense and Energy (DOD and DOE), Fiscal Years 1990-1995
In US $ millions

	1990	*1991*	*1992*	*1993*	*1994*	*1995*
DOE	2,701	4,132	4,752	5,914	6,368	6,138
DOD	1,391	2,564	3,687	4,980	5,389	5,668

Sources: *Gray, 1995; DoD, 1995.*

ending the growth these budgets enjoyed over the past several years.

Little information is available for Russia, but it is clear that Moscow devotes insufficient resources to cope with contamination that is at least as severe as that faced by the United States. In 1994, Alexey Yablokov, head of the Interagency Commission on Ecological Security of Russia's National Security Council, estimated the need for military cleanup spending "without chemical and radioactive polluted areas" (i.e., contamination related just to conventional military activities) at about US $2-3 billion. Actual spending appears to be only a miniscule fraction of the requirements (Yablokov, 1994). The Russian government budget contains a provision for "clean-up of nuclear accidents" of 275 billion rubles in 1993 and 838 billion rubles in 1994 (Ball et al., 1994, p. 425; George et al., 1995, p. 404).

Areas vacated by former Soviet troops face a significant clean-up challenge as well. In 1993, for example, it was estimated that cleanup costs for 2,770 square kilometers of militarily used land in the former East Germany could add up to DM 25 billion (Huck, 1994, p. 15). Latvia sent Moscow a US $147 million bill for land use and anticipated clean-up (*Financial Times*, 9 March 1994). The Polish government has approved a five-year National Remediation Program for former Soviet bases with an estimated cost of US $800 million (Heidemij, 1995).

Compared with the two main Cold War protagonists, absolute costs in other countries are more limited. In relative terms, however, they do involve substantial sums. Canada, for example, initiated a program to address clean-up challenges in Fiscal Year 1992/93 and has spent a little more than Canadian $100 million so far, plus an undisclosed amount on dealing with unexploded munitions at shooting ranges. (Prior to 1992, the country had spent about Canadian $37 million on remediation efforts.) In 1994, another Canadian $200 million were earmarked over five years to clean up military hazardous wastes, but Defense Department officials concede that a serious effort may take three times that amount (*New York Times*, 24 July 1994; Downs, 1994). The German Defense Ministry's budget for environmental clean-up and protection has also grown substantially, to about DM 1.2 billion each in 1993 and 1994 (Federal Republic of Germany, Bundesministerium der Verteidigung, 1994).

In all countries, expenditures to address the environmental aspect of weapons production and disposal are still in an early stage. The first year that the US Department of Defense spent more money on actual remedial activities than on investigations and studies was 1994, for example (Renner, 1994c, p. 27). Expenditures, in the United States and elsewhere, are likely to grow as clean-up efforts gather momentum.

Military Expenditures and Disarmament Expenditures

The availability of disarmament expenditure data in many countries is poor, but the number of disarmament commitments and the size of their respective surplus arsenals would suggest that the United States, Russia, and Germany are incurring by far the largest expenses. Germany's expenditures are in the realm of conventional arms, whereas the United States and Russia are concerned with the entire range of armaments. Of these two, data availability is incomparably better for the former. In addition the United States has substantially greater resources at its disposal to tackle the challenge of dismantlement and disposal (see Table 8).

Table 8: US Arms Control and Disarmament Expenditures, 1989-1994

In US $ millions

	1989	*1990*	*1991*	*1992*	*1993*	*1994*
INF Treaty	128	78	84	86	[40]	[40]
START Treaty	17	39	59	141	277	220
CFE Treaty	0	0	0	51	26	22
Chemical weapons	180	270	316	421	583	610
Ammunition disposal	17	15	31	50	35	68
SUBTOTAL[1]	342	402	490	749	961	960
Verification and diplomatic/bureaucratic expenditures[2]	71	63	116	131	116	141
TOTAL	413	465	606	880	1,077	1,101

[1]Not included are Department of Energy expenditures for nuclear warhead dismantling, for which no precise annual figures are available; the Office of Technology Assessment has estimated that these costs are likely to be in the range of $500 million to $1 billion per year.
[2]Expenditures by the Arms Control and Disarmament Agency (ACDA) and the On-Site Inspection Agency (OSIA).
Source: *Adapted from Renner, 1994b.*

Compared with spending for military R&D and the procurement and maintenance of weapons and equipment, worldwide expenditures for the dismantlement and disposal of surplus weapons are still very small. Identifiable and estimated expenditures for nuclear, chemical, and conventional disarmament rose from US $1.5 billion in 1989 to US $3.4 billion in 1994 (Worldwatch Institute, 1995). Clearly, these figures do not capture the entire range of spending that is taking place, but they leave no doubt about the enormous discrepancy between budgets devoted disarmament and those devoted to traditional military purposes.

Disarmament expenditures are likely to continue to grow, as the full costs of reversing the Cold War arms build-up are beginning to make themselves felt—particularly those for the final disposal of surplus equipment and materials. The escalating expense for chemical weapons destruction in the United States, for example—estimates have grown more than five-fold during the past decade—suggest strongly that the complete costs of meeting the dismantlement and disposal challenge can only be estimated. As the detailed discussion in this paper suggests, these costs will likely measure in the tens of billions of dollars and substantially higher if weapons waste and facility clean-up are included.

This report focuses on the dismantling and disposal costs of items currently considered surplus. However, whether as a result of possible future treaties or simply as a consequence of the fact that weapons systems become obsolete over time and must eventually be decommissioned, additional costs will at some point be incurred with regard to all weapons stocks. This is an issue that would need to be considered in calculating the true costs of procuring new armaments.

As many countries face similar types of technical challenges, a cooperative international program to investigate, develop, and share promising technologies to safely dismantle and dispose of military equipment and materials is vitally important. A series of pilot projects and workshops have been conducted within the framework of the North Atlantic Cooperation Council (NACC). However, they are relatively limited in scope, and they are not accessible to the large number of non-NACC countries. A more global undertaking could easily be financed out of the still tremendous R&D budgets— which absorb tens of billions of dollars each year—devoted to developing new weapons technologies.

Given the economic difficulties of many former members of the WTO and the uncertainties about whether treaty deadlines such as the one imposed by the CWC will be met and whether surplus items will be disposed of in a responsible manner, it would seem that there is a strong need for improved financial aid to the countries in question. The United States and other Western countries have pledged aid, but the amounts involved are insufficient and disbursement is often slowed by bureaucratic obstacles (Renner, 1994b). Instead of a piecemeal approach, it would be sensible to establish a well-endowed international disarmament fund. This fund might be established for a variety of disarmament and peacebuilding endeavors worldwide. As sufficient funding for weapons dismantlement and disposal provides a clear boost to international security, this fund would best be financed out of military budgets—thus helping to establish more of a balance between military and disarmament expenditures.

Overall Costs of Dismantling of Weapons and Disarmament

Country	*Selected Programs (examples)*	*Time Period*	*Estimated total costs (in US dollars)*
Nuclear			
United States	Dismantling ballistic missile submarines (Navy)	1989-1995	780 million
	Air Force mothballing and dismantling	1993-2000	60 million
	Dismantling 500 missile silos	n.a.	50 million
	Dismantling warheads and fissile materials	10 years	5-10 billion
	Buying HEU from Russia	20 years	12 billion
	Storage of HEU/plutonium	10 years	2-3 billion
	Vitrification or similar technology		3-5 billion
	Overall costs	*10 years*	*20-30 billion*
	Cleaning and safeguarding militarily used nuclear facilities and sites	n.a.	400-1000 billion
Russia	Implementing START I	10 years	6 billion
	Overall costs	*10 years*	*8-15 billion*
	Cleaning and safeguarding nuclear sites and facilities	n.a.	n.a.
Ukraine	Withdrawal and dismantling of nuclear weapons	10 year	1.5-3 billion
Chemical			
United States	Dismantling, storing, and burning materials	10-20 years	11-15 billion
	Environmental clean-up	20 years	15-20 billion
Russia	Dismantling, storing, and burning materials	20 years	5-15 billion
	Environmental clean-up	20 years	10-30 billion
All countries	OPCW-related costs	20 years	1.5-2 billion

Conventional			
All CFE countries	Dismantling, scrapping of weapons	5 years	1-2 billion
	Verification	10 years	500 million
Ammunition			
All countries	Dismantling, scrapping, storage of old ammunition	10-20 years	5-10 billion
Mine Clearance			
All countries	Mine clearance	n.a.	30-80 billion

Overall costs for a 10-20 year period estimated at: US $90-185 billion

Sources: *see text and author's estimates*

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