Introduction and Summary 1

Since the end of the Cold War, the proliferation of weapons of mass destruction has become much more prominent in U.S. national security and foreign policy planning. Revelations about Iraqi, North Korean, South African, and Israeli nuclear weapon programs, the possibility of a nuclear arms race in South Asia, and the multidimensional conflicts in the Middle East all point to the immediacy of this problem. Adding a dangerous new twist is the dissolution of the Soviet Union, a superpower armed with nuclear, chemical, and biological weapons whose successor states are wracked by economic crises and political instability.

At least three main factors underlie this renewed emphasis on proliferation. First, the reduced military threat from the former Soviet Union has increased the relative importance of lesser powers, especially if armed with weapons of mass destruction. Second, certain international political and technological trends are increasing the threat to international security from proliferation. Third, new opportunities are opening for enhancing the current international regimes designed to stem proliferation.

Since at least as far back as the 1960s, when it sponsored the Non-Proliferation Treaty (NPT), the United States has recognized that proliferation is a global problem and combating it requires high levels of international cooperation. This country has also exerted unilateral influence, successfully in several cases, to discourage proliferation; it will no doubt continue to do so. Nevertheless, placing priority on nonproliferation will require the further development and enforcement of international norms and behavior supporting that objective. International conditions today offer significant opportunities for such cooperation.

UNITED NATIONS

INTRODUCTION

Frightening as they are, weapons of mass destruction-taken here to be nuclear, chemical, and biological weapons—represent only part of the world's post-Cold War security problems. Diffusion of militarily useful advanced technology, continuing conventional arms sales, and the resurgence of hitherto suppressed regional and ethnic rivalries are spurring a broader problem: the growth of advanced military capability among states and sub-national groups that are potentially hostile toward each other. Not only are weapons of mass destruction and their delivery systems spreading, but so are advanced conventional weapons (e.g., those other than nuclear, chemical, and biological), along with equipment needed to build a command, control, communication, and intelligence infrastructure. Even "low-technology' weapons can produce massive casualties, as shown by the Allied fire bomb attacks in World War II that caused up to 100,000 deaths in Tokyo and 200,000 in Dresden. Nevertheless, proliferation of nuclear, chemical, and biological weapons is of particular concern for at least two reasons:

- The large-scale and indiscriminate nature of their effects—particularly against unprotected civilians—differentiates mass-destruction from conventional weapons. Mass-destruction weapons make it possible for a single missile or airplane to kill as many people as thousands of planeloads of conventional weaponry. These weapons can give small states or subnational groups the ability to inflict damage that is wholly disproportionate to their conventional military capabilities or to the nature of the conflict in which they are used.
- Unlike most categories of conventional weapons, which will likely be considered legitimate instruments of national self-defense for the foreseeable future, weapons of mass destruction engender widespread revulsion. Some 150 nations have renounced nuclear weapons, formalizing their commitment by joining the Nuclear Non-Proliferation Treaty as non-nuclear-weapon states. Moreover, the United States and many other nations have forsworn chemical and biological weapons completely, even in retaliation for in-kind attack, by joining the Biological Weapons Convention (with 125 parties) and the Chemical Weapons Convention (with more than 140 signatories). These three treaties codify strong, if not yet universal, international norms against weapons of mass destruction. The states seeking these weapons today are generally pursuing them covertly, attesting to the reluctance states have to admit to such developments. Thus, controlling weapons of mass destruction may well be feasible despite the dubious track record of past attempts to regulate or ban other weapons of war.

This is the first report of OTA's project on the proliferation of weapons of mass destruction. It describes the various weapons of mass destruction, reviews the status of their proliferation worldwide, and discusses possible consequences of their spread. It also surveys the range of nonproliferation policy measures, offering a menu of tools from which a coherent nonproliferation policy could be constructed.

A separate background paper examines the technical bases for nuclear, chemical, and biological weapons, along with their delivery systems, and seeks to identify opportunities to control or to monitor their production. A forthcoming report will provide a more complete specification and analysis of selected nonproliferation policy options.

Weapons Described

Nuclear, chemical, and biological weapons are commonly lumped together under the term weapons of mass destruction, ' yet their effects, relative lethalities, and military applications are very different. Nuclear weapons, which can be more than a million times more powerful than the same weight of conventional explosives, create

shock waves, high pressures, flying debris, and extreme heat—the same mechanisms by which conventional explosives injure and kill, albeit at vastly increased scale. Unlike conventional explosives, however, nuclear blasts also create neutron and gamma radiation, which can kill or harm those exposed at the instant of detonation.[1] In addition, they can generate long-term radioactivity in the form of *fallout*, which can spread over an area much greater than that affected by the bomb's immediate effects. In addition to producing acute illness or death at considerable distances from the detonation, fallout can also lead to delayed medical problems such as cancer or genetic abnormalities.[2]

Chemical agents are poisons that incapacitate, injure, or kill through their toxic effects on the skin, eyes, lungs, blood, nerves, or other organs. Some chemical warfare agents can be lethal when vaporized and inhaled in amounts as small as a few milligrams. As potent as chemical agents are, however, biological agents-disease-causing microorganisms such as bacteria, rickettsia, and viruses-can be many times deadlier, pound-for-pound. Laboratory tests on animals indicate that, if effectively disseminated and inhaled, 10 grams of anthrax spores (a form of disease-inducing bacteria) could produce as many casualties as a ton (one million grams) of nerve agent. Toxins--defined as toxic substances made by biological organisms, or their synthetically produced versions—are banned by both the Biological and the Chemical Weapons Conventions.

Delivery Systems

To do their deadly work, agents of mass destruction have to be integrated into weapons (e.g., an aerial bomb, a ballistic missile warhead, or even a suitcase) and delivered to their targets. Such weapons can be highly threatening without sophisticated delivery systems. A nuclear device planted by a terrorist or commando squad, or delivered by a disguised cargo ship, civil aircraft, or even a small pleasure boat, can kill just as many people as one delivered by intercontinental ballistic missile; a given quantity of certain lethal microorganisms would probably kill even more people if spread effectively by human agents than if by a missile. In the cases of rival states bordering each other, weapons of mass destruction mounted on even short-range means of delivery can pose a major threat. Nevertheless, states able to couple weapons of mass destruction to delivery systems with longer range or greater ability to penetrate defenses can threaten more nations with higher levels of destruction, and with greater likelihood of success. At the same time, since such delivery systems—taken here to be ballistic missiles, cruise missiles, and combat aircraft—generally pose greater technical challenges, they are more amenable to international controls than are less sophisticated delivery systems.

Of these three delivery systems, ballistic missiles have attracted the most attention, both because they are difficult to defend against and because they appear to be particularly suited for weapons of mass destruction. (They generally do not have much military value in proportion to

[1] Nuclear weapons detonated at high attitude can also generate powerful radio waves (called ''electromagnetic pulse' that can wreak havoc with electronic equipment, but do not pose a direct human health risk.

[2] In principle, nations or groups could develop *radiological* weapons whose effects are similar to those of fallout from a nuclear weapon (albeit over a far smaller area) without any of the blast effects or extreme temperatures that make nuclear weapons so devastating. Radiological weapons disseminate highly radioactive material over an area using mechanical means or conventional explosives. They resemble chemical weapons much more than nuclear weapons in their effects, since they contaminate territory and poison living organisms but do not destroy physical structures. Conventional attacks on nuclear power plants could be tantamount to radiological warfare, as the accident at Chernobyl suggests. The amount of fallout from such an attack could be massive, far greater than that from a "traditional' radiological weapon that disperses radioactive material directly.

Although there are as yet no documented cases of anyone trying to acquire radiological weapons, the Geneva-based Conference on Disarmament has an ad hoc committee charged with concluding a convention on them. Sweden has proposed that attacks on nuclear facilities be included, while the United States, France, and Germany favor dealing only with traditional radiological weapons.

their cost when armed with conventional warheads, although they can have considerable political significance.) Combat aircraft also pose a potent threat for delivery of mass-destruction weapons. They are much more widely available than missiles, and efforts to control their spread are greatly complicated by the multiple roles that aircraft play. Cruise missiles and other unmanned aerial vehicles could also be used as delivery methods, although such vehicles with the range and payload of typical combat aircraft or ballistic missiles are not yet widely available.

MAJOR FINDINGS

The Proliferation Threat

Those states most actively working to develop weapons of mass destruction, although limited in number, are for the most part located in unstable regions of the world—the Middle East, South Asia, and the Korean peninsula. For at least the next decade, few if any of these states will be able to deliver such weapons more than a thousand kilometers or so in a reliable and timely manner. Therefore, the greatest threat posed by these states is to their neighbors and to regional stability. Despite their current limitations in long-range military delivery systems, however, proliferant states-at least in principle--can threaten any country on earth using unconventional means (e.g., covert or disguised delivery systems such as a ship or truck).

Proliferation poses dangers to all nations. It poses particular problems for the United States. As a global power, the United States will almost certainly retain allies and vital interests overseas that might be threatened by states possessing weapons of mass destruction. Should the United States need to defend its interests with military force--whether acting unilaterally or under multilateral auspices such as those of the United Nations--U.S. armed forces, and possibly U.S. territory, might become targets for weapons of mass destruction.

The breakup of the Soviet Union presents immediate threats to the global nonproliferation regimes. One possibility is that Ukraine, Kazakhstan, or Belarus will renege on their commitments to return the nuclear weapons stationed within their borders to Russia and, in the case of Ukraine and Kazakhstan, to join the Non-Proliferation Treaty as non-nuclear-weapon states. (Belarus has already ratified the WT.) Such actions would seriously undermine the nonproliferation regime. Another danger is the leakage of nuclear weapon materials or actual weapons to potential proliferants elsewhere in the world if the nuclear custodial system in Russia itself were to break down. Yet another concern is the export from former Soviet republics of equipment, technology or expertise relevant to producing weapons of mass destruction.

Prerequisites to Effective Nonproliferation Policy

If nonproliferation policy is to succeed, it must receive substantial international cooperation. Cooperation is *necessary* because no nation or small group of nations by themselves can prevent proliferation or contain its consequences. Cooperation is *possible* because many countries have come to recognize that the proliferation of nuclear, chemical, and biological weapons poses a genuine threat to all nations. However, since states will not always agree on nonproliferation measures, maintaining and acting on an effective consensus will require each participating country to give up some freedom to act independently.

Some analysts argue that containing proliferation in the long run will require a far deeper level of international cooperation than has been achieved to date, one that builds international institutions for a much more cooperative global security regime. Others argue that the international political system is inevitably anarchic and that as a

result, the degree of cooperation needed to contain proliferation cannot be achieved.

Whether or not either of these views proves correct, the end of the Cold War has opened up new opportunities for cooperative nonproliferation policies. One promising sign is the revitalization of the United Nations Security Council. Progress has also been made with the signing of the Chemical Weapons Convention and the strengthening of various multilateral groups that have formed for the purpose of controlling the spread of proliferation-sensitive technology: the Nuclear Suppliers Group, to control exports of nuclear technology; the Australia Group, to control materials useful for chemical and biological weapons; and the Missile Technology Control Regime, to restrict traffic in missile systems and missile technology.

If U.S. nonproliferation policy is to succeed, the United States must give it high priority. With its leadership role in the world community, the United States has the opportunity and the ability to mobilize international nonproliferation efforts. Free of previously overriding Cold War security concerns, the United States can now attach greater priority to nonproliferation. Doing so, however, is not without costs. Nonproliferation may conflict with economic goals, as export promotion is balanced against export controls. Promoting openness, transparency, and verification of nonproliferation commitments, on the one hand, conflicts with maintaining the secrecy of national-security or proprietary information, on the other. Nonproliferation will also likely conflict with other foreign policy objectives such as maintaining relations with individual states. For example, would the United States be willing to sacrifice its relationship with Israel-and possibly risk Israeli national survival-to pressure that state to give up a nuclear arsenal it believes essential to its security? How prominently should nonproliferation figure in U.S. relations with China, a regional power whose cooperation the United States seeks in other diplomatic or economic arenas?

Strategies for inhibiting proliferation have four broad elements, all of which contribute to existing nonproliferation regimes and form the basis for future ones. For the most part, these elements are mutually supportive, although as described later in this chapter, tensions between them can arise. By emphasizing these elements in different proportion, nonproliferation policies can be tailored to particular situations. These elements include:

- obstacles to impede those working to acquire weapons of mass destruction, ranging from protection of weapon-related information, to export controls, possibly all the way to preemptive military attack against production or storage facilities;
- punitive measures to deter or punish proliferants, including economic sanctions or diplomatic isolation imposed on countries developing these weapons, and on states, firms, or individuals who assist in such developments;
- rewards to increase the attractiveness of voluntarily forgoing these weapons, such as development assistance (financial or technical) that is tied to nonproliferation; and
- global or regional security improvements to reduce the perceived needs for the weapons.

The increasing international flow of technical knowledge, high-technology goods, and trained specialists is eroding the ability of the United States and its allies to withhold technologies relevant to producing weapons of mass destruction from states of proliferation concern. Nevertheless, although technical capability is necessary to develop weapons of mass destruction, it is not sufficient, and it is certainly not causal. A host of nontechnical factors such as the diplomatic, political, organizational, and economic costs and benefits bear on a state's decision to pursue such weapons.

In the long run, the most effective nonproliferation measure is to convince states that it is

in their own best interest to forgo weapons of mass destruction. Reducing the incentives for seeking such weapons and raising the costs of doing so are both important. External obstacles and disincentives can play an important role in raising the costs of proliferation to a state considering it, possibly tipping the balance towards nonproliferation. Such coercive measures can also buy time for other diplomatic or political measures to forestall the development of weapons of mass destruction. However, they may not always be sufficient to stop states determined to acquire weapons of mass destruction.

Technical Aspects of Nonproliferation Policy

Trying to control proliferation through controlling exports or placing other obstacles in the way of potential proliferants requires technical analysis of the production pathways for making these weapons. Controls will not work if the target state can readily make controlled items indigenously, find uncontrolled sources of supply, or develop alternatives. Technical analysis also underpins measures to monitor the production of weapons of mass destruction, measures that are needed to evaluate potential threats as well as to formulate verification regimes by which states can assure each other that they are not pursuing such weapons.

ISSUES FOR CONTROLLING PROLIFERATION

- Obtaining fissionable nuclear weapon material (enriched uranium or plutonium) today remains the greatest single obstacle most countries would face in the pursuit of nuclear weapons. For this reason, theft or black market purchase of nuclear material or warheads from the former Soviet arsenal—or collaboration between potential proliferants whereby one provides nuclear materials to another-would be extremely troubling. Although nuclear material production, weapon fabrication, and testing require specialized equipment, in many cases this equipment can be fabricated indigenously by proliferants using equipment (e.g., machine tools) that also has civilian applications.
- Most of the equipment needed to produce chemical weapons has civilian applications. Moreover, most of the same chemicals, or *precursors,* used to make chemical-warfare (CW) agents are also used in commercial products. Some agents (e.g., sulfur mustard and the nerve agent tabun) could be produced with widely available chemical-industry equipment. The most potent nerve agents (e.g., sarin, soman, VX) involve a process step--the alkylation of phosphorous—that is less common, but that nevertheless is used in a handful of commercial products such as some pesticides and fire retardants.
- Virtually all the equipment underlying production of biological and toxin agents has civil applications and has become widely available as fermentation technology, and the pharmaceutical and biotechnology industries more generally, have spread worldwide. Since militarily significant quantities of biological agents could be produced in a short time in small facilities, they could be used offensively without the need for long-term stockpiles. Crude dissemination of biological agents in an aerosol cloud can be performed with commercially available equipment, such as an agricultural sprayer mounted on a truck, ship, or airplane. However, developing reliable, efficient projectile or missile warheads for precision delivery of organisms over a target requires surmounting major technical hurdles. Even so, the United States overcame these hurdles by the 1960s.

MONITORING PROLIFERATION AND VERIFYING COMPLIANCE WITH NON PROLIFERATION AGREEMENTS

- All facilities for producing weapon-grade nuclear material have unique features amenable to detection by intrusive onsite

inspection. Many have distinctive signatures that are detectable remotely, although facilities needed for some approaches to material production might not be readily detectable.

- Production of chemical-warfare agents can be detected through analysis of samples taken during an onsite inspection. However, considerable access to production facilities is required to collect appropriate samples. Moreover, highly sensitive analytical chemistry techniques that are decisive under laboratory conditions might be less so under some circumstances in the field, particularly if the proliferant has been producing related legitimate chemicals (e.g., pesticides) in the same facility and is willing to expend time, effort, and resources to mask, obscure, or otherwise explain away chemical agent production activities. Such efforts, while not likely to eliminate grounds for suspicion, could create ambiguities or otherwise complicate detection of chemical agent production during an inspection.

  Identifying where to look for evidence of covert production is probably the greatest challenge for monitoring chemical weapon proliferation, since highly reliable technologies to detect chemical agent production from outside a facility are not currently available. Information on plant design and purchase of precursor chemicals may suggest a chemical agent production capability, and may therefore lead to challenge inspections under the Chemical Weapons Convention.
- Detection of biological and toxin agent production is particularly challenging because clandestine production sites need not be large or distinctive, because the equipment involved has legitimate civilian applications, and because offensive work can be conducted under the guise of defensive preparations. Identifying where to look for evidence of biological agent production is even harder than for chemical agents. Several suggestive signatures of biological weapon production do exist, and, if integrated effectively with each other and with other sources of intelligence, they might make it possible to infer a weapon production capability. However, the evidence supporting such an inference may not be sufficient to justify claims of treaty violation before the international community, either because it cannot be publicly released or because public allegations of treaty violation typically require a substantially higher burden of proof than intelligence assessments. Sensitive techniques exist to identify biological or toxin agents if access to a suspect site is made available. However, such techniques alone do not ensure that an effective onsite inspection regime can be established to detect production of biological or toxin weapons.

WEAPON CHARACTERISTICS AND COMPARISONS

Lethality and Military Utility

One motivation for developing nuclear, chemical, or biological weapons is their ability to destroy or interfere with military targets. More generally, however, these weapons may also be sought for symbolic, deterrent, intimidating, or terrorist purposes that may not be simply related to their value from a purely military perspective.

Nuclear weapons, particularly at large yields (hundreds of kilotons or higher) are the most potent means of mass destruction.[3] In addition to killing tens or hundreds of thousands of people or more, a nuclear weapon can obliterate the entire

[3] One *kiloton is* the explosive blast generated by 1,000 tons of high explosive.

physical infrastructure of a large city and contaminate a much larger area with radioactive fallout. Given this destructive power, nuclear weapons have been developed for strategic use against a nation's military infrastructure, its economic base, and even its population. In addition, the nuclear powers have developed many tactical nuclear weapons for a variety of battlefield missions. These weapons are particularly threatening to concentrations of military force such as tightly clustered naval groups, port or depot facilities, troop concentrations, or massed forces of tanks and other armored vehicles.

Unlike nuclear weapons, chemical and biological agents-if detected-can be defended against through use of gas masks, protective clothing, shelters, and decontamination procedures. Although these weapons can contaminate territory, they do not destroy infrastructure. If protective measures are taken in time-which requires adequate warning-they can dramatically reduce casualties, and hence the military and political implications, of a chemical or biological attack. Nevertheless, such weapons can still have military value against protected troops, since forcing troops to don protective gear impairs their ability to function on the battlefield and lowers their military effectiveness. Means for penetrating protective gear would have serious implications for the military utility of chemical or biological weapons. Although such means have been examined, they have operational shortcomings; moreover, defensive equipment is being improved to mitigate that threat.

Gas masks and protective clothing can shield against chemical and biological weapons, but they impair military @activeness.

Biological weapons are so potent that under conditions favorable to the attacker, they can kill as many people as comparably sized nuclear weapons, potentially making them extremely dangerous as a strategic or terrorist weapon against dense population centers. However, their characteristics make them particularly difficult to use on the battlefield. Except for some toxins, biological agents act more slowly than chemical or nuclear weapons, taking days or weeks to achieve full effect. In addition, their effects are much harder to control or predict than those of nuclear weapons, since 1) individuals differ markedly in their sensitivity to biological agents; 2) the lethal areas created by such agents, which depend on wind and other weather conditions, are hard to predict (indeed, such agents may even be blown back upon the attacker by an unexpected shift in wind direction during a battlefield engagement); and 3) biological agents must be kept alive through the dissemination process and long enough afterward to infect the target personnel, but not so long as to impede future use of the area.

On a pound-for-pound basis, chemical weapons are much less lethal than either nuclear or biological weapons, and correspondingly greater amounts would have to be delivered to have

comparable results. Indeed, it may not even be appropriate to consider them to be weapons of ''mass destruction. ' Yet they can still induce terror, particularly among troops or civilians without protective gear.

In some battlefield scenarios, chemical weapons might be no more effective than the same weight of conventional high-explosive munitions, even when used against unprotected people. Like biological weapons, their effects depend on variable factors such as weather and terrain, limiting their predictability. Nevertheless, chemical weapons do have tactical applications. Persistent chemical agents cart create local "no-man' s-lands' in which restrictions would be imposed on military operations of either side. Attacks using nonpersistent agents could disrupt enemy defenses but still permit attacking troops to overrun the territory soon afterwards. Some chemical agents can be used as incapacitants, either in lieu of lethal force or in conjunction with it.

Ease of Acquisition

Barring a shortcut, such as the direct acquisition of nuclear materials usable in weapons, the infrastructure required to produce nuclear weapons is considerably more difficult and expensive to develop than that for either biological or chemical weapons. It is also the most amenable to limitation through control of international technology transfers. Mass production of lethal chemical agents requires a greater investment than that of biological weapons, but is not nearly as expensive or challenging as production of nuclear materials.

Table 1-1, drawn from the technical analyses in a separate OTA background paper, compares the relative difficulties involved in trying to produce nuclear, biological, or chemical weapons in several categories.[4] Note that the table differentiates between producing materials (nuclear materials, chemical warfare agents, and biological pathogens) and building the munitions and delivery systems needed to make those materials militarily functional.

Since international norms remain and are being strengthened against proliferation of these weapons, proliferants may very likely try to acquire them secretly. Concealing potential indicators of the necessary activities adds to the expense and difficulty of acquisition. With enough effort and resources, the magnitude and scope-and possibly even the existence-of a covert weapon program might well be successfully concealed; the burden will be on the suspecting parties to detect relevant indicators and to interpret their meaning accurately. The background paper exties various ''signatures' that might indicate the presence of a clandestine weapon program.

Probability of Use

Nuclear weapons have been detonated on adversaries only twice-against Hiroshima and Nagasaki in World War II. Biological weapons, despite their apparent ease of manufacture and their devastating effects, have not played a

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Kurdish victims of an Iraqi chemical attack on *the Iraqi town of Halabja during the Iran-Iraq war.*

[4] OTA background paper on technologies underlying weapons of mass destruction in press.

Table I-1—Technical Hurdles for Nuclear, Biological, and Chemical Weapon Programs

	Nuclear	Biological	Chemical
Nuclear materials or lethal agents production			
Feed materials	Uranium ore, oxide widely available; plutonium and partly enriched uranium dispersed through nuclear power programs, mostly under international safeguards.	Potential biological warfare agents are readily available locally or internationally from natural sources or commercial suppliers.	Many basic chemicals available for commercial purposes; only some nerve gas precursors available for purchase, but ability to manufacture them is spreading.
Scientific and technical personnel	Requires wide variety of expertise and skillful systems integration.	Sophisticated research and development unnecessary to produce commonly known agents. Industrial microbiological personnel widely available.	Organic chemists and chemical engineers widely available.
Design and engineering knowledge	Varies with process, but specific designs for producing either of the two bomb-grade nuclear materials can be difficult to develop: . Separation of uranium isotopes to-highly enriched uranium; . Reactor production and chemical processing to produce plutonium.	Widely published; basic techniques to produce known agents not difficult.	Widely published. Some processes tricky (Iraq had difficulty with tabun cyanation, succeeded at sarin alkylation; however, sarin quality was poor).
Equipment	Varies with different processes, but difficulties can include fabrication, power consumption, large size, and operational complexity: ● Electromagnetic separation equipment can be constructed from available, multiple-use parts; ● Equipment for other processes is more specialized and difficult to buy or build.	Widely available for commercial uses. Special containment and waste-treatment equipment may be more difficult to assemble, but are not essential to production.	Most has legitimate industrial applications. Alkylation process is somewhat difficult and is unusual in civilian applications. Special containment and waste treatment equipment may be more difficult to assemble, but are not essential to production.

prominent role in wartime.[5] Chemical weapons, on the other hand, were heavily used in World War I and have been employed several times since then in regional conflicts. Most recently, Iraq used chemical weapons during the 1980-1988 war with Iran, resulting in some 50,000 Iranian casualties, with Iran belatedly retaliating in kind.[6] Iraq also used chemical weapons against its own Kurdish population. Although the threat of Iraqi chemical weapons loomed large over coalition military forces and civilians in surrounding countries during Operation Desert Storm, they were not in fact used during that conflict. Nevertheless, if the past is any guide, chemical

[5] In World War II, Japan used biological agents including bubonic plague on an experimental basis in occupied China, reportedly killing some hundreda of Chinese civilians but also causing thousands of illnesses among its own troops (see ch. 2). Biological weapons were not used in any other theater of the war.

[6] 'R@mony of R. James Woolsey, Director of Central Intelligence, before the Senate Committee on Governmental Affairs, Feb. 25, 1993.

Table I-l-(Continued)

	Nuclear	Biological	Chemical
Plant construction and operation	Costly and challenging. Research reactors or electric power reactors might be converted to plutonium production.	With advent of biotechnology, small-scale facilities now capable of large-scale production.	Dedicated plant not difficult. Conversion of existing commercial chemical plants feasible but not trivial.
Overall cost	Cheapest overt production route for one bomb per year, with no international controls, is about $200 million; larger scale clandestine program could cost 10 to 50 times more, and even then not be assured of success or of remaining hidden. Black-market purchase of ready-to-use fissile materials or of complete weapons could be many times cheaper.	Enough for large arsenal may cost less than $10 million.	Arsenal for substantial military capability (hundreds of tons of agent) likely to cost tens of millions of dollars.
Weaponization			
Design and engineering	Heavier, less efficient, lower-yield designs easier, but all pose significant technical challenges.	Principal challenge is maintaining the agent's potency through weapon storage, delivery, and dissemination. Broad-area dissemination not difficult; design of weapons that effectively aerosolize agents for precision delivery challenging (but developed by U.S. by '60s).	Advanced weapons somewhat difficult, but workable munition designs (e.g., bursting smoke device) widely published.
Production equipment	Much (e.g., machine tools) dual-use and widely available. Some overlap with conventional munitions production equipment.	Must be tightly contained to prevent spread of infection, but the necessary equipment is not hard to build.	Relatively simple, closely related to standard munitions production equipment.

SOURCE: Office of Technology Assessment, 1993.

weapons are considerably more likely to be used in the future than either nuclear or biological weapons.

IMPLICATIONS OF PROLIFERATION

Mass killing of human beings is not new to warfare, or even to this century. Nevertheless, weapons of mass destruction compress the time and the effort needed to kill. Wars lasting only a few days could now devastate populations, cities, or entire countries in ways that previously took months or years. Particularly ominous is the fact that the states now working hardest to develop weapons of mass destruction (see following section) are for the most part located in unstable regions of the world, where bitter and unresolved rivalries have erupted into war in the recent past and hold the prospect of doing so again. Not only might future wars lead to the actual use of weapons of mass destruction, but the deployment of such weapons in these regions could increase tensions still further.

Even if these weapons are not used, they cast shadows that can affect interstate relations and

international balances of power. A few analysts, pointing to the role that nuclear weapons seem to have played in preventing war between the United States and the Soviet Union, argue that their spread will actually increase international stability. Most, however, consider such a view to be dangerously misguided. The Cold War was not without serious crises and close calls, such as the Cuban Missile Crisis. In the Middle East, South Asia, and the Korean peninsula, hostile powers share common borders, contest core values and vital national interests, and lack both the mutual learning experience and the technical safeguards that have helped the superpowers come to live with the mortal threat each poses the other.

Proliferation, therefore, poses real dangers from the point of view of international security and human welfare. Moreover, in addition to its global consequences, it poses particular problems for the United States. As a global power, the United States will almost certainly retain allies and vital interests overseas that might be threatened by states possessing weapons of mass destruction. Should the United States need to defend its interests and principles with military force—whether acting unilaterally or under multilateral auspices such as those of the United Nations—U.S. armed forces or territory might become targets for weapons of mass destruction.

The threat of nuclear attack is nothing new to the United States. Having faced a massive Soviet nuclear arsenal for decades, the United States has shown itself willing at least to contemplate the loss of many U.S. cities, and millions of American lives, to ensure its own survival and the survival of the states under its nuclear umbrella. (Granted, this posture has always posed problems for many who questioned what "national survival' means in the context of tens, let alone hundreds or thousands, of nuclear weapons detonating on U.S. territory.) At the same time, however, the existence of the Soviet nuclear arsenal strongly tempered U.S. views of which ''vital national interests' were worth risking nuclear war to defend. If additional countries acquire the means to threaten U.S. allies, U.S. forces overseas, or even U.S. territory with nuclear weapons, the United States will be forced to reevaluate the conditions under which it is willing to risk nuclear attack. Even though it might retaliate with its own nuclear arsenal, U.S. retaliation may not compensate for U.S. or allied losses.

Plausible scenarios for the current set of suspected proliferants to threaten U.S. territory with nuclear or other weapons of mass destruction are difficult to devise. None possess missiles or aircraft with sufficient range to reach the United States, nor are potentially hostile powers likely to develop such systems in the next 10 years (see next section). Nevertheless, a state that badly wanted to wreak destruction on a U.S. city could probably do so, whether it had advanced delivery systems or not—and whether the United States had effective defenses against such advanced delivery systems or not.

PROLIFERATION THREATS AND PROSPECTS

Only five countries (the United States, Russia, the United Kingdom, France, and China) acknowledge possessing nuclear weapon stockpiles.[7] Three more-Ukraine, Kazakhstan, and Belarus--have former Soviet strategic nuclear weapons located within their borders (although as yet they do not control them), and it is not yet certain that they will give them up. Only three states (United States, Russia, and Iraq) say they have chemical weapon arsenals, and all of these weapons are in the process of, or are slated for, destruction. No countries admit to active offen-

[7] South Africa has acknowledged having assembled six nuclear weapons but says it has since destroyed them.

sive biological weapon programs.[8] Few countries, therefore, are overtly deploying or preparing to deploy weapons of mass destruction. The difficulty in assessing the extent of the proliferation threat lies in determining which states are doing so secretly. Merely counting the states that today are *capable* of mounting a program to produce weapons of mass destruction inflates the proliferation threat considerably, just as counting only the states *acknowledging* such production errs in the opposite direction.

This report names countries commonly cited in the public literature as having nuclear, chemical, or biological weapons, or as having programs to acquire them. Consistent with the unclassified nature of this report, the estimates given here are not based on classified sources and should in no way be considered authoritative or indicative of official U.S. Government assessments. Therefore, the tables in this report may well disagree in some respects with the best intelligence information available to the U.S. Government, which itself can be uncertain and incomplete. If an incomplete public understanding of the current extent of proliferation poses problems for U.S. nonproliferation policy, it behooves U.S. policymakers to ensure that the open literature better reflects the actual state of affairs.

Keeping Score

Besides the five acknowledged nuclear powers and the three non-Russian former Soviet republics that still have nuclear weapons on their territory, only three "threshold states" appear to possess nuclear weapons or have the ability to deploy them on short notice: Israel, which is widely believed to have a clandestine arsenal; India, which tested a nuclear device in 1974 and probably has stockpiles of nuclear weapon material available, but has made no overt moves to develop a nuclear arsenal; and Pakistan, which is cut off from U.S. military aid because the President cannot certify that it does not possess a nuclear explosive device.[9] None of these countries is a member of the Nuclear Non-Proliferation Treaty. South Africa has admitted to mounting a nuclear weapon program that culminated in the construction of six nuclear weapons, confirming suspicions that had included it in this threshold category. However, stating that it has destroyed those weapons, it has since joined the Nuclear Non-Proliferation Treaty as a non-nuclear-weapon state and opened up its nuclear facilities to international inspection. Little information has been released so far on the results of those inspections, but to date (June 1993) they have not resolved 'serious questions' that the United States has concerning South Africa's compliance with its NPT obligations.[10]

A few other states reputed to have nuclear weapon programs are apparently not as far advanced as the above four: Iran and Libya, both NPT members; North Korea, which has given and then retracted notice of its intent to withdraw from the NPT, and possibly Algeria, which is not an NPT member. North Korea appeared to have taken steps to back away from its nuclear weapon program, permitting inspection (after years of delay) of facilities that clearly seem to have been intended for nuclear weapon production. However, after having been caught attempting to mislead international inspectors as to the extent of its nuclear program, it refused to open other suspicious facilities for inspection. Rather than comply with its commitment under the NPT to

8 Russia has admitted that the Soviet Union's offensive biological weapon program persisted after the U.S.S.R. signed the Biological Weapon Convention banning such work but insists that this program has since been halted.

9 In 1992, Pakistan's Foreign Secretary was quoted as declaring that Pakistan had all the p@ for a nuclear weapon. He subsequently retracted this statement, with the Ministry of Foreign Affairs claiming he had been misquoted.

10 "Adherence to and Compliance with Arms Control Agreements and the President's Report to Congress on Soviet Noncompliance with Arms Control Agreements," prepared by the U.S. Arms Control and Disarmament Agency, Jan. 14, 1993, p. 18.

cooperate with such inspections, it gave notice of its intent to withdraw from the NPT, becoming the first nation ever to do so. To many observers, such actions confirm that North Korea not only had been pursuing nuclear weapons all along, but seeks to preserve the capability to do so.

Iraq is a special case. Although the 1991 Gulf War and its aftermath arrested and reversed Iraq's nuclear weapon program before it could come to fruition, United Nations inspections showed the program to have been much broader and more advanced than Western intelligence agencies had suspected. Few observers doubt that the program will resume in the absence of the extraordinarily international monitoring efforts imposed upon Iraq by the United Nations Security Council.

Argentina and Brazil in the past had been thought to be pursuing nuclear programs, albeit ones that were less advanced than those of the threshold states. In recent years, however, they have agreed to open up their nuclear facilities to bilateral and international inspection to assure each other and the rest of the world that they are not developing nuclear weapons.

Public reports of the extent of chemical and biological proliferation differ with each other more than do assessments of nuclear proliferation. OTA has reviewed several compilations of states suspected of pursuing chemical or biological weapons; those states appearing in a preponderance of these lists are identified in figure 1-1, together with the states mentioned above as still suspected of pursuing nuclear weapons. (See ch. 2.)

In all, 14 countries are listed in figure 1-1 as widely believed to possess or to be pursuing nuclear, chemical, or biological weapons. Given official U.S. Government statements that ''more than 25 countries . . . may have or may be developing" weapons of mass destruction and their delivery systems, figure 1-1 may understate the number of countries pursuing such systems.[11] Part of the discrepancy may be states that are pursuing delivery systems but not nuclear, chemical, or biological weapons, which would not be included in figure 1-1; the remainder might indicate countries suspected by U.S. intelligence of pursuing such weapons but not yet identified in open sources.

Most of the states listed in figure 1-1 have bought or developed simple ballistic missiles with at least the capability of Scud missiles. All have combat aircraft with characteristics that make them candidates for delivering weapons of mass destruction. None seems to have cruise missiles adapted to this purpose, but the spread of applicable technologies makes cruise missiles a threat to be concerned about in the future.

Three features stand out in the combined perspective offered by figure 1-1. First, the estimate for the current number of states actively pursuing nuclear weapons is small, and smaller than it might have been a few years ago. Second, the set of countries trying to acquire nuclear weapons overlaps considerably with the set suspected of having chemical and biological weapon programs. Third, the most immediate and serious threats (beyond the potential threat posed by former Soviet republics) are concentrated in three regions of international rivalry: the Koreas, India-Pakistan, and the Middle East.

Longer term assessments of the extent of proliferation are harder to make, although some trends are clear. For example, for 'at least another decade," only China, Russia, and possibly Ukraine, Kazakhstan, and Belarus--all possessing weapons that have long been capable of being targeted at the United States—will pose a ballistic missile

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11 Testimony of R. James Woolsey, Director of Central Intelligence, before the Senate Committee on Governmental Affairs, Feb. 24,1993. Although he gave some information on the activities of some countries, his testimony did not identify all of the states believed by the United States to be pursuing weapons of mass destruction and their delivery systems, much less specify which ones are pursuing which weapons.

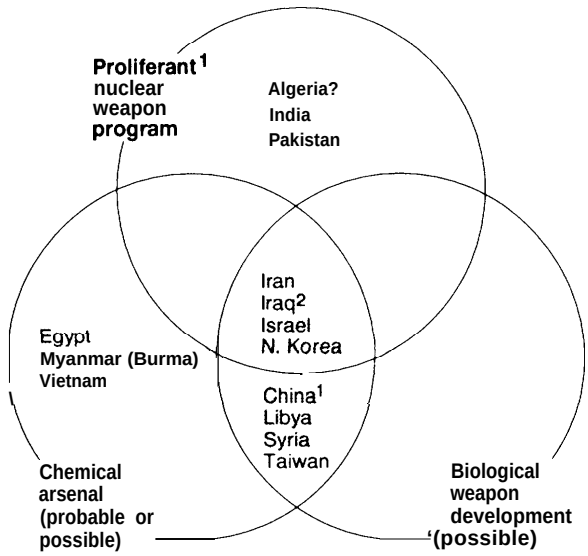
threat to the territory of the United States.[12] Projections of the future number of nuclear, chemical, or biological powers are more elusive. It is hard to determine even the present status and anticipated progress of existing programs. Even with the wealth of information that has been uncovered about the Iraqi nuclear weapon program, for example, experts disagree over how long it would have taken the Iraqis to assemble a working weapon. Moreover, extrapolating from current trends can be misleading. We have already noted several examples of apparent 'roll-back" in nuclear weapon programs. Further changes in the world situation, including those that nonproliferation policies seek to bring about, will affect the extent of future proliferation.

Trends Fostering Proliferation

RISKS FROM THE BREAKUP OF THE SOVIET UNION

The breakup of the Soviet Union-and the shakiness of governmental authority in its successor republics-could contribute to proliferation problems. The threat is potentially great, but hard to predict. One set of problems could arise from the emergence of Ukraine, Kazakhstan, or Belarus as new nuclear powers and the ramifications such actions would have on the nuclear nonproliferation regime. Another concerns the future integrity of Russia itself, or at least of the system of controls over Russian nuclear weapons and nuclear weapon materials. A third issue, perhaps the most immediate risk posed by the Soviet breakup, is the possible leakage to potential proliferants of people, critical information, equipment, materials, or even complete weapons. Such assistance could be of great value not only to nuclear but also to chemical or biological weapon programs. Finally, in the longer term, various former Soviet republics may choose to develop weapons of mass destruction indigenously, perhaps drawing on facilities that had once contributed to Soviet weapon programs.

Figure I-l-Suspected Weapon of Mass Destruction Programs



[1] The United States, Russia, United Kingdom, France, and China are nuclear-weapon states party to the Nuclear Non-Proliferation Treaty and therefore are not considered nuclear "proliferants." However, China is suspected of pursuing chemical and biological weapons and is included in this figure for that reason.
[2] Iraqi programs have been reversed under UN Security Council Resolution 687.

SOURCE: Tables 2-6, 2-7, 2-8; Office of Technology Assessment, 1993.

THE END OF THE COLD WAR

Apart from the acute crises posed by the collapse of the Soviet Union, the end of the Cold War has the potential for weakening restraints against proliferation. Countries that had formerly enjoyed Soviet or U.S. security guarantees may now feel more exposed and insecure, increasing

12 Robert M. Gates, Director of Central Intelligence, before the Senate Governmental Affairs Committee, Jan. 15, 1992. See "Weapons Proliferation in the New World Order," S. Hrg. 102-720, 102d Cong., 2d Session, Jan. 15, 1992, p. 7. Britain and France, with submarine-launched ballistic missiles capable of reaching the United States, are not considered to pose a threat.

the motivation to develop their own weapons of mass destruction. Moreover, controls that the Soviet Union had formerly exerted over its allies no longer exist, or at least have been considerably weakened given the reduced role that Russia is playing in international affairs. As the United States reshapes its own security relationships in recognition of the Cold War's end, in particular by withdrawing overseas forces, it too may lose some leverage over its allies.

PERSISTENCE OF REGIONAL CONFLICTS

Outside the sphere of the former Soviet Union, the most serious drivers for proliferation of weapons of mass destruction remain the seemingly intractable regional conflicts in South Asia and the Middle East, where most of the current proliferants are located. In South Asia, India and Pakistan are unable to resolve their ethnic and territorial dispute over Kashmir, while India also--or perhaps even primarily--feels threatened by China, the nuclear power to the northeast. In the Middle East, the current peace process does not promise early resolution of the Arab-Israeli conflict. In addition, the Iraqi invasion of Kuwait illustrates that, even independent of Israel, the Arab and other Islamic countries (e.g., Iran) would probably continue to arm against one another.[13]

Proliferation of conventional arms, fueled by these regional conflicts as well as by the glut of military industrial capacity and weapon stockpiles in the wake of the Cold War, can stimulate the quest for weapons of mass destruction as ''equalizers. ''14At the same time, continued sales of high-performance combat aircraft and the spread of missile technology bolster states' ability to deliver weapons of mass destruction.

SPREADING TECHNOLOGY AND INDUSTRIALIZATION

Economic and technological development will, in general, enhance national wealth, technical skill, and industrial capabilities useful for indigenous production of weapons of mass destruction and their delivery systems. It will also increase the number of potential foreign suppliers of skill and technology to proliferant nations. Consequently, it will be increasingly difficult for a small number of industrially advanced countries to control weapon proliferation by denying access to key technologies or materials.

Indeed, the dissemination of technologies that have at least some relevance to producing weapons of mass destruction might need to be not only tolerated but encouraged if populations in developing nations are to improve their health, environment, and standards of living. This is especially true for chemical and biological technologies. Technologies that can contribute both to military and civil objectives, often referred to as ''dual-use" technologies, are actually multi-use, providing basic capabilities that can be used in a host of applications (e.g., computing, metal-forming, and diagnostic testing). Controls on some dual-use technologies will prove to be infeasible (if the technologies involved have already disseminated too widely) or undesirable (if too many non-weapons-related activities would be constrained as well).

These difficulties notwithstanding, export controls will remain an important nonproliferation tool. For example, although Iraq's indigenous industrial base was more capable than most outsiders realized, it still had to import much of the equipment used in its weapon facilities. This level of importation was made feasible only by Iraqi oil revenues.

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13 Arab and Iranian disputes with Turkey, a NATO member, have the potential to involve the United States directly.

14 For discussion of the spread of conventional military technology, see U.S. Congress, Office of Technology Assessment, *Arms Trade*, OTA-ISC-460 (Washington, DC: U.S. Government Printing Office, June 1991).

RESISTANCE TO DISCRIMINATORY REGIMES

A few developing countries, most notably India, object to external attempts to deny them nuclear and missile-related technologies that are accepted as legitimate for certain other countries, Nevertheless, most nations of the world have been willing to live with the two-tiered, nuclear/non-nuclear structure of the NPT. This factor is not an issue with the Chemical Weapons Convention or the Biological Weapons Convention, both of which apply to all states without distinction.

WEAKENED TABOO AGAINST CHEMICAL WEAPON USE

The 1925 Geneva Protocol prohibits the use of chemical and biological agents in warfare. This ban was observed in most of the conflicts following its entry into force, including World War II (except the use by Japan, then a non-party, of chemical and biological weapons in China). However, more recent instances of chemical weapon use have weakened this international norm. In particular, Iraqi use against Iran in the 1980s may have demonstrated to some defense planners that chemical weapons can be a useful military tool.

Trends Favoring Nonproliferation Efforts

GENERALLY RISING NORM AGAINST PROLIFERATION

An international consensus seems to be growing that further proliferation of weapons of mass destruction should be stopped, and that chemical and biological weapons should be eliminated completely. Governments around the world have declared renewed commitments to nonproliferation. Strengthened nonproliferation norms might help deter potential proliferants. More importantly, they also improve the prospects of strong, coordinated world action to deter and punish violators.

The past few years have brought a significant increase in the number of signatories to the Nuclear Non-Proliferation Treaty, rising from 138 at the end of 1989 to 157 by January 1, 1993. Two of the nuclear weapon states that did not originally join the NPT (China and France) have joined in the last two years, as did a hold-out state that has admitted having produced nuclear weapons outside the NPT (South Africa). Although three non-signatories are believed to have actual or potential nuclear weapon capabilities (Israel, India, and Pakistan), no states have declared themselves to be nuclear powers since China in 1964. No non-nuclear members of the NPT have ‘‘gone nuclear,’ although a few have been trying.

The deep reductions in nuclear forces undertaken by the United States and Russia mean that both countries are finally making visible progress on their NPT obligation to ‘‘pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race, ’ even though they seem unlikely to seriously pursue the NPT goal of “general and complete disarmament. ” Progress in superpower nuclear arms reductions could undermine longstanding complaints about the discriminatory nature of the NPT that might otherwise have hurt the treaty’s chances for renewal when it comes up for extension in 1995. On the other hand, North Korea would deal the nonproliferation regime a serious blow if it proceeds to withdraw from the NPT

END OF THE COLD WAR

In part, the end of the Cold War has allowed the strengthening of this norm against proliferation. Besides fostering a new level of cooperation between the United States and Russia (as successor to the Soviet Union in the U.N. Security Council), the cessation of the U.S.-Soviet conflict has also made possible changes in national priorities and policy emphases. Although nonproliferation policies may continue to conflict with other policy goals, they need no longer be subordinated to Cold War objectives. In addition, foreign policy and intelligence resources are being redirected from Cold War efforts to deal with proliferation.

Should Russia revert to a foreign policy that is seriously threatening to Western interests, nonproliferation will be set back. Granted, even during the Cold War, the Soviet Union took a strong stance against nuclear proliferation, and an anti-Western Russia would likely do the same. But future efforts to contain the spread of all types of weapons of mass destruction will require significant Russian-United States cooperation in support of nonproliferation norms, not just parallel policies in limited areas (see ch. 3).

RECENT REVERSALS OF NATIONAL POLICIES

Reversals in the nuclear weapon programs of Argentina, Brazil, South Africa, and (albeit involuntarily) Iraq follow decisions in earlier decades by Sweden, South Korea, and Taiwan to halt programs that had seemed directed at nuclear acquisition. Such reversals, however, are themselves reversible: despite some moves by North Korea to open up to international inspection, its subsequent actions have given rise to serious doubts.

GROWING COOPERATION IN EXPORT CONTROL REGIMES

Several multilateral groups have formed to control the export of equipment or materials that might be used in the production of weapons of mass destruction or of missiles. These control regimes have been strengthened in the past few years, both by covering additional items and by expanding their membership. Particularly notable is the April 1992 decision of the 27-member Nuclear Suppliers Group to require importers of nuclear technology to accept international monitoring (through the International Atomic Energy Agency's system of safeguards) over their entire nuclear programs, not just over the particular facilities built with imported technology. This action leaves China as the only supplier of nuclear technology that does not require such 'full-scope safeguards' as a condition of sale. By requiring full-scope safeguards, exporters prevent states from acquiring expertise in safeguarded facilities and using it to build and operate other facilities that are not open to international inspection or controls.

U.N. ACTIONS IN IRAQ

Besides reversing Iraqi mass destruction weapon programs, recent U.N. Security Council resolutions make approving references to international nonproliferation and disarmament treaties, setting useful precedents in demonstrating international resolve against weapons of mass destruction. The Security Council has also taken on both short- and long-term onsite monitoring tasks to assure that its decisions mandating elimination of Iraqi weapons of mass destruction are carried out.

CHEMICAL WEAPONS DISARMAMENT AND THE CHEMICAL WEAPONS CONVENTION

The two largest chemical weapon powers, the United States and Russia, have committed themselves to the destruction of their chemical arsenals, together with their development and production facilities. The Iraqi chemical arsenal is being dismantled under U.N. supervision. Most significantly, the Chemical Weapons Convention (CWC), signed by more than 140 states in early 1993, bans for the first time the development, production, and possession of chemical weapons (in addition to their use) and reinforces the international norm against chemical weapons. Regardless of any doubts that may remain as to whether the CWC's verification regime is adequate to the task and whether it will be stringently implemented, the Convention strengthens the international consensus that chemical weapons are illegitimate. If some nation were to use chemical weapons in the future, the international community may feel committed to react more strongly than it did against Iraq's use in the 1980s.

BIOLOGICAL WEAPONS CONVENTION VERIFICATION

In the wake of the Russian admission that the Soviet Union had violated the Biological Weapons Convention, the United States, the United

Kingdom, and Russia have agreed on a program to inspect each other's biological facilities.[15] Although states that have joined the Convention disagree over the feasibility or desirability of a formal verification regime, an international Ad Hoc Group of Governmental Experts on Verification (VEREX) is considering potential verification measures.

In sum, despite some dangerous trends and many uncertainties, the world community has significant new opportunities to curtail, and perhaps roll back, the spread of weapons of mass destruction.

THE NONPROLIFERATION POLICY CONTEXT

The United States and other countries concerned about the proliferation of weapons of mass destruction have instituted measures seeking to impose obstacles to the acquisition of weapons of mass destruction; to create disincentives in order to deter states from developing such weapons or to persuade them to reverse course; to offer benefits to states that agree to forgo such attempts; and to develop **security** improvements to reduce the perceived needs for the weapons. These measures have been implemented to date through three primary mechanisms: national policies and laws governing states' actions with respect to others that are developing or assisting in the development of weapons of mass destruction; multinational agreements to restrict exports of certain technologies or to take action against those states found to be violating international nonproliferation norms; and international treaties and institutions open to all states who agree to subscribe to their principles.

Imposing Obstacles to Proliferation

Obstacles that can be put in the way of states trying to acquire weapons of mass destruction include using secrecy to restrict the flow of knowledge; adopting export controls; taking diplomatic or other action to stop exports by third parties; and acting to stop or discourage experts from providing assistance. Since the United States is not the only source of technology, knowledge, or other support that might be useful to a proliferant, such measures must be imposed multilaterally to be effective. At the same time, however, U.S. leadership is necessary to mobilize effective international cooperation.

If, despite these barriers, a proliferant nation manages to acquire facilities for a weapon program that another country or countries deem to pose an intolerable security threat, the ultimate recourse might be to impose another kind of obstacle: destroying the facilities by military attack. However, such an approach is fraught with legal, political, and operational difficulties, and must be considered at most as a last resort.

EXPORT CONTROLS

Export controls are intended to block the most straightforward paths to developing weapons of mass destruction and to raise the price and the time required for alternate approaches. They can also provide information valuable for monitoring programs to develop weapons of mass destruction. Export controls will remain an important component of nonproliferation policy for years, especially in the nuclear area. However, control regimes can be defeated if their targets can "invent around" restricted technologies or products, if controls are attempted on goods that are too widely available, or if some potential suppliers are not included. Moreover, it is very difficult to control the education of scientists and engineers in one country who may later return or migrate to another to develop weapons of mass destruction.

In the United States, export controls are established by a number of public laws and regulations

15 "Joint U.S./U.K./Russian Statement on Biological Weapons," Sept. 14, 1992, reproduced in *The Arms Control Reporter* (Cambridge, MA: Institute for Defense and Disarmament Studies, 1992), vol. 11 (1992), p. 701.D.1

(see ch. 3), and they are also formally or informally coordinated with those of other states. They now cover a range of technologies related to nuclear, chemical, and biological weapons, as well as ballistic missiles and conventional armaments.

SANCTIONS AGAINST SUPPLIERS

The United States can impede weapon programs in proliferant states by helping foreign governments block aid that their own citizens or corporations may be providing such programs. If U.S. intelligence uncovers foreign plans to provide such assistance, the United States can request the government having jurisdiction over such activities to stop them. In addition, U.S. laws can impose sanctions directly against foreign individuals or companies, including criminal penalties, debarment from U.S. Government procurement, and denial of access to the U.S. market (see ch. 3). Should a foreign government itself be aiding proliferation, the United States can take diplomatic measures against it such as denial of trade preferences, arms transfers, or financial assistance.

MILITARY ACTION

In extreme cases, the United States, another nation, or a multinational coalition might feel compelled to attack facilities, equipment, or materials believed to be connected to weapons of mass destruction. However, if not authorized by the United Nations Security Council, such an action would generally be viewed as contrary to international law unless it could be shown to be required for national self-defense, and unless other means short of attack had been exhausted. (Although they made precisely those arguments, the Israelis were unable to convince the world community that their 1981 raid against Iraq's Osirak nuclear reactor was justified.)

Military action involves very high risk. Operationally, the attacking country or group of countries must contend with questions about the quality of its intelligence, how well the attack can be executed, and how badly the attack will damage the proliferant state's weapon program. As the Israeli raid showed, military attack is not a permanent solution. Strategically, a potential attacker must consider the degree of international backing it is likely to expect and the prospect of retaliation (military, diplomatic, or terrorist). Military action that is not explicitly sanctioned by the international community risks damaging consensus on future cooperative nonproliferation policies and might even build sympathy for the victim of the attack.

Disincentives and Sanctions Against Proliferants

Mechanisms exist in U.S. law—but are not laid out in international law—to punish states found to have used weapons of mass destruction or to have engaged in activities related to their development (see ch. 3). At the international level, enforcement of international nonproliferation commitments falls to the United Nations Security Council, which has the authority to respond to ''threats to international peace and security" by imposing measures such as sanctions, severance of travel and communication links, diplomatic isolation, or even military action under Chapter VII of the United Nations charter.[16] Actions of the Security Council are binding upon all U.N. members. Security Council enforcement of existing nonproliferation commitments such as the Nuclear Non-Proliferation Treaty and the 1925 Geneva Protocol could deter further proliferation and

16 By themselves, international organizations involved with nonproliferation such as the International Atomic Energy Agency, typically can take no punitive action stronger than expelling members found to have violated their commitments to the organization. However, the IAEA can refer evidence of violations to the United Nations Security Council for further action. It did so for the first time in April 1993, when it found North Korea in violation of its safeguards agreement.

strengthen global nonproliferation norms.[17] Conversely, inaction in such cases will weaken the nonproliferation regime.

Any United Nations efforts to enforce treaty commitments will not directly affect those states that have not acceded to these commitments in the frost place. However, in January 1992, the Security Council declared the proliferation of weapons of mass destruction to be a threat to international peace and security, opening up at least the possibility of taking action even against proliferants who are not party to global nonproliferation regimes.

Within the United States, current laws and regulations to deter or punish proliferants stress economic sanctions. However, other measures could be taken, many of which serve not only to deter further proliferation but to help address the consequences of proliferation if it occurs. These measures include:

- embarrassment by disseminating intelligence or other information exposing illicit activities;
- provision of technical or military assistance to states threatened by weapons of mass destruction;
- development and deployment of active defenses (e.g., missile or air defenses) or passive measures (e.g., gas masks and protective clothing) to protect against the weapons;
- diplomatic isolation of proliferants or formation of countervailing military alliances; and
- withdrawal of U.S. security guarantees.

The effectiveness of these measures will depend, like other nonproliferation measures, on the degree of international cooperation behind them. The presence of strong international norms against acquisition and use of these weapons will be important to getting that cooperation.

UN PHOTO, E. DEBEBE

The United Nations Security Council, which has primary responsibility for the enforcement of international nonproliferation obligations,

Benefits for Forgoing Weapons of Mass Destruction

Coercive measures by themselves may not always be sufficient to stop states from acquiring weapons of mass destruction. The best hope for nonproliferation in the long term lies in building a consensus among potential proliferants that they should jointly refrain from acquiring these weapons. However, several factors make such a consensus difficult to achieve. States seeking weapons of mass destruction may want them for military purposes (including intimidation or deterrence), for political influence, for national pride, or for international status. The presence of nearby nuclear powers is a powerful incentive to develop nuclear weapons, and a cascading one. (China acquired them because of the United States and the Soviet Union; India because of China; Pakistan worries about India, etc.) To forgo weapons of mass destruction, potential proliferants must come to see that their

17 The 1925 Geneval Protocol bans use, but not development, production or stockpiling, of chemical and ‘ ‘bacteriological’’ weapons. Many states ratifying it reserved the right to retaliate in kind against chemical or biological attack, or considered it binding only with respect to other signatories. Therefore, it effectively became a ‘‘no first use” agreement. Moreover, no attempts have ever been made to enforce it against violators. Signatones who have since acceded to the Chemical and the Biological Weapons Conventions, which unconditionally ban those weapons, have rescinded their reservations to the Geneva Protocol.

political or military needs can be met in some other way.

Although it is not likely to sway a determined proliferant, financial, technical, and other development assistance can be offered to states forgoing the development of weapons of mass destruction.[18] Exemptions from export controls on dual-use items, or preferential access to international aid organizations, might also be offered. The Nuclear Non-Proliferation Treaty (NPT), for instance, promises technical assistance in the peaceful uses of atomic energy, including medical and agricultural applications. Note, however, that such assistance can be a double-edged sword, since familiarity with nuclear technology can contribute to military as well as peaceful goals. The Chemical Weapons Convention (CWC) offers more in the way of incentives than the NPT, promising not only access to chemical technology but also various assurances to parties who find themselves threatened or attacked with chemical weapons. Members of the CWC envisage that chemical weapon-related export controls will be relaxed against member-states judged to be in compliance. The Biological Weapons Convention (BWC) makes similar provisions for promoting transfers of biotechnology to member-states, although these have never been implemented.

Security Benefits To Reduce the Demand for Proliferation

Technical assistance notwithstanding, the central bargain of consensual nonproliferation agreements is that states give up their own rights to acquire weapons of mass destruction on the condition that they will not be needed to deter the weapons of others. This deal underlies regional or global arms control arrangements such as the Nuclear Non-Proliferation Treaty, the Chemical Weapons Convention, the Biological Weapons Convention, the Latin American Nuclear-Free Zone (Treaty of Tlatelolco), and the South Pacific Nuclear-Free Zone (Treaty of Rarotonga). These treaties codify the international norms against weapons of mass destruction and have value for that reason alone. Beyond that, however, most of them are also associated with verification regimes intended to permit parties to assure each other that they are in compliance (see box l-A).

Nonproliferation treaties involve a "free-rider" problem: states that remain outside the regime can sometimes enjoy the benefit of reducing the threat to themselves without having to pay the price of giving up their own weapon options.[19] Moreover, the NPT—which permits the United States, Russia, Britain, France, and China to retain their nuclear arsenals--does not eliminate the potential nuclear threat that member-states may believe these nations to pose. (It does, however, commit the nuclear weapons states to pursue nuclear disarmament and to assist non-nuclear states in their peaceful nuclear programs.)

The long-run success of nonproliferation policy is likely to depend, at least in part, on the reduction of the security threats used to just@ acquisition of weapons of mass destruction. The security problems in each region of proliferation concern are different; each will require specially tailored arrangements if parties are to trust one another enough to halt or reverse their military competitions. Such arrangements may consist of combinations of political accommodations, eco-

18 Instead of serving primarily as an incentive to adopt other nonproliferation policies, development assistance could itself be a nonproliferation measure to the extent that lack of development, economic deprivation, and competition for economic resources are a source of conflict. Similarly, policies that alleviate international tensions resulting from demographic trends, differing political systems, ideology, and resource pressures can also be considered nonproliferation measures. Analysis of such policies, however, goes outside the scope of this assessment.

19 For this reason, the Treaty of Tlatelolco contains a provision that keeps it from coming into force until all states in the region become members. Twenty-three of the Treaty's parties have waived this provision accepting the Treaty's obligations. Brazil and Chile, which had not previously waived the provision, and Argentina and Cuba, which had not entered the Treaty at all, have recently said they will join the Treaty or permit it to enter into force for them.

Box 1-A-International Nonproliferation Treaties and Their Verification Regimes

Nuclear Non-Proliferation Treaty (NPT)

The NPT prohibits all member-states except the five acknowledged nuclear powers from acquiring nuclear weapons. It also requires ail non-nuclear-weapon member-states to implement a safeguards agreement with the International Atomic Energy Agency (IAEA) covering ail nuclear materials that might be useful for weapons. IAEA safeguards are intended to detect, and therefore to deter, the diversion of materials from peaceful nuclear programs to military use, although they cannot by themselves prevent such diversion.

Under the NPT, non-nuclear-weapon member-states must declare to the IAEA all facilitiesthat handle nuclear materials, and these facilities then become subject to safeguards. But the IAEA has had little ability to monitor whether states were conducting nuclear weapon activities in undeclaredfacilities. The limitations of this approach became clearafterthe 1991 Gulf War, when Iraq was revealedto have mounted a major nuclear weapon program outside of its declared nuclear program. Although monitoring declared nuclear facilities will continue to be crucial to verifying compliance with the NPT, it addresses only half the problem. Some means must also be found to allay suspicions that nuclear weapon activities might be undertaken in covert or undeclared facilities.

The IAEA has always had the formal abilityto undertake "special inspections" of undeclared fadiities if it had reason to suspect illicit activities there. However, it did not exercise this authority until February 1993, when it attempted to inspect suspicious sites in North Korea. (in response, North Korea refused access to IAEA inspectors and announced its withdrawal from the NPT.) To carry out such inspections, the IAEA must be able to receive and act on information identifying suspect facilities, and it must have the backing of the U.N. Security Council in case the target state refuses to cooperate.

Since the NPT entered into force in 1970 for a 25-year period, a review conference will be held in 1995 at which member-states must decide whether to extend the treaty, and for how long. consequently, successful extension of the NPT, preferably for an indefinite term, is one of the most important issues facing the nuclear nonproliferation regime.

Treaties of Tlatelolco and Rarotonga

Both of these nuclear-weapon-free zone treaties create regional organizations to monitor compliance and also require that member states submit to IAEA safeguards.

Chemical Weapons Convention (CWC)

The newly signed Chemical Weapons Convention bans the development, production, possession, and use of chemical weapons and establishes the most comprehensive verification scheme yet formulated in an international treaty. When it comes into force, it will create a new international institution-the Organization for the Prohibition of Chemical Weapons (OPCW)--that will receive routine declarations from member states and conduct routine inspections of declared chemical facilities. More significantly, it will also have the ability to conduct "challenge inspections" at any site--government or private-suspected of illegal activity. Far more facilities produce, ship, or use chemicals than are involved in peaceful nuclear activities, making the routine notification and inspection activities of the OPCW much more complicatedthan those of the IAEA. Moreover, the CWC's challenge inspection provisions are much more rigorous than the IAEA's provisions for ''special inspections.'' The final treaty text--and the implementation procedures now being negotiated among treaty signatories-are based on the principal of "managed access," in which the state being searched has the right to limit the access of treaty inspectors in order to protect information not germane to the treaty. An important challenge in implementing the CWC's inspection provisions will be balancing the need to monitor treaty compliance with the need to protect proprietary and national-security information unrelated to the CWC.[1]

[1] See Office of Technology Assessment, *The Chemical Weapons Convention: Effects on the U.S. Chemical Industry*, OTA-BP-ISC-1O6 (Washington DC, U.S. Government Printing Office, August 1993).

(Continued on next page)

Box 1-A—International Nonproliferation Treaties and Their Verification Regimes—(Continued)

Biological Weapons Convention (BWC)

Signed in 1972, the Biological Weapons Convention bans development, production, and stockpiling of biological agents or toxins for purposes other than "prophylactic, defensive, and other peaceful activities."[2] Unlike the NPT or the CWC, however, it makes no explicit provisions for verification. The Treaty text requires only that member states are to "consult one another" and "cooperate in solving any problems which may arise in relation to the objective" of the treaty. States believing other states to be in breach of the treaty may lodge a complaint with the UN Security Council, and states are obligated to cooperate with any Security Council investigation.

Pursuant to the Third Review Conference of the BWC in 1991, an expert working group has been considering means by which a verification regime for the BWC might be instituted. Under the Bush administration, the United States opposed implementation of such a regime on the grounds that development and production of biological weapons—much more so than chemical or nuclear weapons—are easy to hide. Therefore, a formal verification regime would not prove to be much of a deterrent to cheating, nor would it provide sufficient confidence in other states' compliance to be worth the costs of conducting and submitting to highly intrusive inspections. Moreover, the United States argued that ineffective verification measures could instill a false sense of confidence and prove to be worse than no verification regime at all. Other states, including many U.S. allies, countered that even a modest verification regime has some prospect of catching violations and that any state contemplating cheating would have to take that risk into account. Moreover, the verification regime would mandate declarations of all activities relevant to the Biological Weapons Convention. These declarations, when combined with onsite inspections, would make it easier to detect anomalies indicative of a violation.

Under the Clinton administration, the United States is reassessing its position on the value of establishing a BWC verification regime. Balancing the degree of intrusiveness needed to detect or deter cheating with the need to protect proprietary and national-security information will be even more difficult for the Biological Weapons Convention than it is for the Chemical Weapons Convention.

SOURCE: Office of Technology Assessment, 1993.

[2] The formal name of the Biological Weapons Convention is the "Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction."

nomic measures, military confidence-building measures, and arms control. They may also involve security guarantees provided to regional states by powers outside the region (positive security assurances), or assurances from extra-regional powers that military force-or weapons of mass destruction-will not be used against regional states (negative security assurances).

Regional security measures and nonproliferation policies have to proceed in tandem. States lacking confidence in regional security arrangements may be unwilling to forgo development of weapons of mass destruction, thus posing a potential threat to their neighbors that will make it harder to resolve the regional security situation.

Some analysts go so far as to assert that a transformation of the whole basis of global security will be required to have any chance of inducing restraint among many of the states that might otherwise turn to weapons of mass destruction. Proliferation cannot be controlled, they argue, unless the international political system is fundamentally changed from one in which states assure their own security through their military forces and alliances, to a "cooperative security" regime in which states do not maintain forces

sufficient to conduct aggression in the first place. With the Cold War over, these analysts believe it is now possible to move towards such a world.

When Nonproliferation Fails

The United States cannot assume that all those states now acquiring or possessing weapons of mass destruction will soon renounce them, nor that future nonproliferation policies will be 100 percent effective. It must therefore consider measures to mitigate the consequences of proliferation for U.S. and international security.

Modifying U.S. military force structure and operational planning to cope with proliferation is unquestionably an important task for U.S. policy makers. If they prove technically feasible, actions such as improving intelligence capabilities or adopting passive and active defenses might improve U.S. military capabilities without interfering with nonproliferation objectives. Indeed, by lessening the military value of an opponent's weapons of mass destruction, such actions can simultaneously serve to deter an opponent from acquiring such weapons, and to deter or militarily counter their use if acquired anyway.

Other preparations to mitigate the conse-quences of proliferation, however, might exacerbate the process of proliferation. For example, the existing nuclear powers might wish to deter or even to prevent chemical or biological attack by holding out the prospect of using nuclear weapons. Giving nuclear weapons this mission, however, could increase their perceived utility and status, weakening nuclear nonproliferation efforts. Moreover, advertising a willingness to use even conventional force to preempt or to respond to proliferation may persuade some countries not to forgo weapons of mass destruction, but instead to seek them as a counter-deterrent.

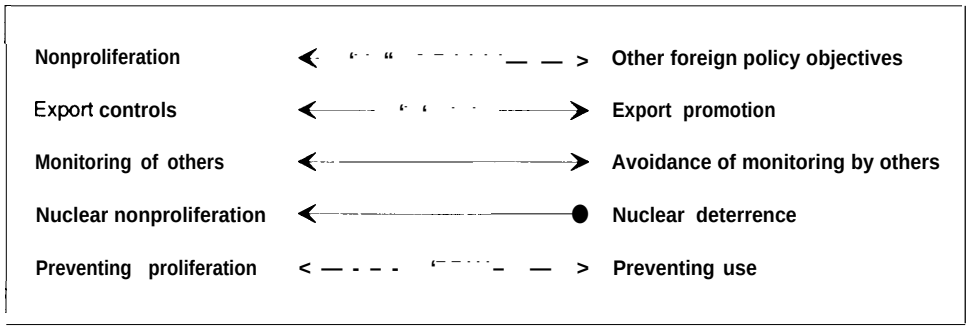
Other measures short of military force might lessen the chances that proliferation will lead to use of nuclear weapons, but these pose serious dilemmas. The established nuclear powers may conclude that if additional states are going to develop and deploy nuclear weapons anyway, it would be prudent to minimize the risk that those weapons might actually be used. Therefore, they might wish to help the emerging nuclear powers develop stabilizing doctrines of deployment and deterrence, and implement appropriate technical safeguards against accidental or unauthorized use. However, this would be tantamount to admitting these states into the nuclear club, showing that proliferation can lead not to international condemnation but to legitimacy and even enhanced status.

CONFLICTING OBJECTIVES

Many of the choices to be made in designing and implementing nonproliferation policies are between potentially *conflicting objectives;* that is, the extent to which nonproliferation should take precedence over other objectives of U.S. policy when they cannot both be pursued simultaneously. Certainly the end of the Cold War has removed one such conflict, eliminating what had been an overriding concern and permitting nonproliferation to take much greater priority. Yet tensions between nonproliferation and other policy objectives continue to force tradeoffs.

Many conflicts between competing goals are mirrored in the organizational structure of the U.S. Government, with particular agencies pursuing missions that at times conflict with each other. With the possible exception of the Arms Control and Disarmament Agency, whose complete agenda in the post-Cold War organization of the U.S. Government is still evolving, no single agency has nonproliferation as its primary mission. The other agencies that have the greatest roles in nonproliferation policy-the Departments of State, Defense, Energy, and Commerce—are all charged with pursuing other goals that can compete with nonproliferation, some of which are described below.

Figure 1-2—Potentially Conflicting Objectives



SOURCE: Office of Technology Assessment, 1993.

The pairings depicted in figure 1-2 and summarized below are not discrete alternatives, but rather opposite poles of a continuum. Intermediate positions are certainly possible, but seeking one goal will generally imply lessening emphasis on the other. These choices must be made on a case-by-case basis, since the appropriate balance between conflicting objectives varies depending on the individual situation.

Nonproliferation v. Other Foreign Policy Objectives

U.S. relationships with other states involve a host of objectives, both generic and country-specific. For example, the U.S. Government may wish to maintain favorable relations with other states, encourage them to support U.S. positions in international fora, restrain their conventional arms buildups, promote exports, support human rights, and work towards common environmental goals. Expending limited U.S. influence to stress nonproliferation goals may mean losing a target state's cooperation on other matters, or even provoking its hostility.

Consider the cases of Israel and China. Israel has a very strong, longstanding relationship with the United States, one in which nonproliferation has never figured prominently. Ensuring the security of a democratic ally threatened by hostile neighbors has outweighed whatever concern the United States has had over Israel's apparent nuclear and ballistic missile arsenal. Even if Israeli weapons of mass destruction are not themselves deemed to threaten the United States or U.S. interests, however, their implicit acceptance complicates nonproliferation policy. Other states condemn U.S. policy as reflecting one standard for friends and another for all other countries, hampering attempts to build international consensus behind nonproliferation policies.

U.S. policy towards China also illustrates tensions among conflicting objectives. U.S. policymakers have sought to stop Chinese sales of nuclear and missile technology. At the same time, they must also take note of China's overall strategic importance in the Pacific region, its growing economic clout, the need to gain China's agreement (or at least its acquiescence) in U.N. Security Council actions, and the desire to promote human rights and democratization within China. Threatening to revoke China's "most-favored-nation" (MFN) status potentially provides the United States considerable leverage over China, just as threatening to withhold the U.S. commitment to Israeli security provides leverage over Israel. In both cases, however, other factors that outweighed nonproliferation have so far kept these threats from being executed.

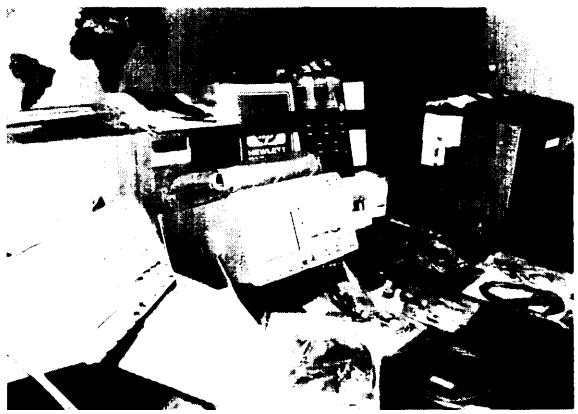
Export Controls v. Export Promotion

The push to improve U.S. economic performance, increase jobs, and rectify the trade imbal-

ance makes it a major national priority to increase exports. Tightening the export-control system for nonproliferation purposes may sometimes conflict with this goal. No respectable exporter deliberately seeks the business of those developing weapons of mass destruction, although too many disreputable ones apparently do. However, some exporters may unwittingly assist proliferants if they do not know by whom and for what purpose their products will be used, or if their goods are diverted after sale.

Tightening export controls and applying sanctions against foreign violators have economic and political costs that must be weighed against their return in international security. These costs may be deemed worth paying, but they should be acknowledged. First, controls can somewhat restrict international trade. Although the number of export denials is a small fraction of all international transactions, many transactions must be screened in order to detect those that ultimately are denied. Consequently, a wide range of businesses must keep informed about and comply with complex regulations and licensing procedures. Individual companies may find themselves losing legitimate sales and the other business opportunities that might have followed those sales. More seriously in terms of U.S. jobs and exports, U.S. firms may also find that foreign competitors under less stringent controls are moving in to take over their markets. Although U.S. policymakers may be willing to hold U.S. firms to a higher standard, such a policy would interfere with U.S. export performance without generating any nonproliferation benefits if other countries do not follow suit.

In addition to their costs to exporters, controls also impose costs on legitimate foreign users of advanced technology. During the Cold War, damage to the Soviet civil sector resulting from Western export controls was seen as a "fringe benefit" of a policy already justified on security



Dual-use *electronic equipment seized by the U.S. Commerce Department's Office of Export Enforcement while in the process of being exported illegally to Iran. The equipment was intended for Iran's Ministry of Defense and its Atomic Energy Organization.*

grounds. In a nonproliferation context, however, exporting states may seek to restrict the spread of weapon-related technology without placing unnecessary obstacles in the way of an importing state's legitimate economic and technological development—a much tougher assignment.[20] By the same token, however, the greater the dependence of a developing country's civil economy on imported technology, the more leverage would be provided by making access to that technology contingent upon acceptable nonproliferation behavior.

Policies governing export controls must address two sets of issues. The frost involves the internal structure, implementation, and enforcement of U.S. export controls. U.S. export-control procedures have been the source of bureaucratic and political controversy for decades, a situation that is likely to be aggravated as nonproliferation replaces the Cold War as the primary driver of export control policy. The second set of issues involves the coordination of export control policies among different nations, and the role that

20 M. Granger Morgan and Mitchel B. Wallerstein, "controlling *the* High Technology Militarization of the Developing World," James Goodby, cd., ***Bipolarity Revisited: Problems in North-South Security Relations After the Cold War,*** (Oxford University Press, in press).

unilateral initiatives play in shaping multilateral consenses. Multilateral control regimes aimed at different weapons of mass destruction and delivery systems have evolved separately; they have differing memberships, procedures, and objectives. Participating governments may wish to examine the existing structure of these multilateral regimes to see if tighter coordination, or consolidation, is desirable or feasible.

Monitoring Others v. Avoiding the Costs of Being Monitoring

Nonproliferation regimes are strengthened by empowering international nonproliferation organizations to make intrusive onsite inspections of suspect activities (see box l-A). Yet states will not easily accept such inspections unless other states do likewise.[21] If the United States expects other states to provide access to outside inspectors, it may have to open itself up to inspection as well. Such inspections have costs that must be weighed against their nonproliferation benefits. In addition to the disruption of normal activities, U.S. Government or industrial facilities exposed to foreign inspections must incur costs to protect classified or proprietary information unrelated to the purpose of the inspection. Even greater costs might be incurred by failing to protect such information, or by inadvertently disclosing secrets that might actually aid a proliferant's own weapon programs.

Nuclear Nonproliferation v. Nuclear Deterrence

One way to reduce the appeal of nuclear weapons is to reemphasize the role they play in international relations. But to do so would mean that the nuclear powers must rely on them less, weakening the credibility and utility of U.S. nuclear deterrent threats--especially those intended to deter military actions short of nuclear attack. Conversely, to the extent that nuclear weapons are given a prominent role in ensuring the security of the United States and its allies--particularly against threats from non-nuclear powers-it becomes harder to make the case that other countries should not be able to address their security concerns in similar ways. Granted, retention by the United States of its nuclear arsenal is very unlikely to be the sole factor inducing another state to pursue nuclear weapons. However, U.S. decisions involving continued nuclear weapon development and testing, continued production of nuclear weapon materials, or reliance on nuclear threats against nonnuclear attack, will certainly influence nuclear nonproliferation norms.

Some argue that in the long run, there is no way to sustain a stable world order in which some states possess nuclear weapons but all others are forbidden to acquire them. In such a view, stopping nuclear proliferation is impossible without a universal prohibition against national nuclear arsenals, with all nuclear weapons either placed in the hands of a supranational organization or banned entirely. However, such a world still seems remote.

Preventing Proliferation. Preventing Use

As discussed above, some measures to reduce the risk that nuclear weapons might be used—measures that would require the acknowledgement of new nuclear powers—would actually conflict with controlling proliferation by other states in the longer term.

This conflict arises only in the case of nuclear weapons, since the Nuclear Non-Proliferation Treaty prohibits not their existence but their spread beyond the five acknowledged nuclear powers. Although it would be extremely controversial, one could imagine a change to the nuclear nonproliferation regime that legitimized nuclear arsenals in additional states. The challenge would be to assure that such a change would not lead to further proliferation, and further admissions to the

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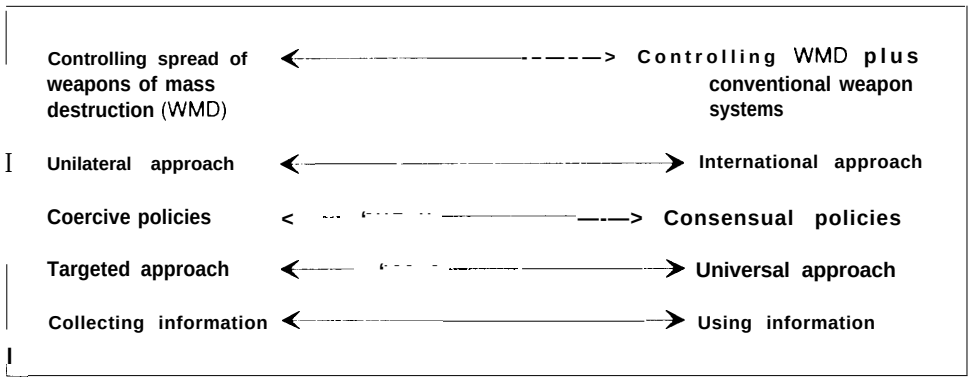
21 The United Nations inspections of Iraq, which have the right to go anywhere at any time, are part of a regime imposed upon a defeated power and cannot be considered a precedent for inspection provisions that states would accept voluntarily.

Figure 1-3—Potentially Conflicting Approaches



SOURCE: Office of Technology Assessment, 1993.

nuclear club, in future years. In the case of the Chemical and Biological Weapons Conventions, which impose global bans, exceptions that legitimized the chemical or biological arsenals of one or more countries would be totally incompatible with the treaties themselves.

CONFLICTING APPROACHES

In addition to choices between nonproliferation and other policy objectives, balances must also be struck between conflicting approaches to nonproliferation policy. Like the preceding set, these approaches--summarized in figure 1-3--do not represent diametrically opposed positions, but rather indicate opposing tensions that must be balanced against each other.

Scope of Control Efforts

As noted in the beginning of this chapter, the proliferation of weapons of mass destruction takes place within the context of the proliferation of military capability more generally. Low-technology weapons, advanced conventional weapons, and the command, control, communications, and intelligence infrastructure needed to use these weapons most effectively are all spreading around the world. From the point of view of a military planner, all such weapons in the hands of potential adversaries-mass destruction or conventional-make it more difficult to deter war or to prevail should war erupt. Elements within the Pentagon now define proliferation as "the destabilizing spread, especially to countries of concern in key regions, of a wide array of dangerous military capabilities, supporting capabilities, allied technologies, or know-how," placing weapons of mass destruction at one end of a considerably broader spectrum of concerns.[22] Such a view argues for an integrated strategy in response.

Other linkages between weapons of mass destruction and conventional weapons also exist. A given delivery system might be adapted to carry either class of weapon, linking a state's conventional military power with its capability to deliver weapons of mass destruction. Similarly, one state's conventional forces can motivate an opponent to seek nuclear, chemical, or biological weapons in response, linking a state's conventional military forces with its *opponent's* mass-destruction weapons. As stated earlier, some analysts go so far as to argue that weapons of mass destruction cannot be controlled in the long run without effective limitations on other aspects of military power as well.

22 Under Secretary of Defense for Policy-Transition Working Papers, "Special Transition Proposal—Counterproliferation Strategy," Counterproliferation Initiative, Feb. 2, 1993.

A contrasting view notes that weapons of mass destruction differ markedly from other military systems in terms of international legitimacy. Whereas the pursuit of nuclear, chemical, and biological weapons can be deemed violations of international norms, conventional arms have long been accepted as legitimate and necessary to a state's self-defense. No objective standards exist to differentiate acceptable levels of conventional military capability from levels that pose threats to "international peace and security. " Therefore, those extending nonproliferation policy to include conventional armed forces cannot avoid basing their decisions at least in part on their individual national interests-interests that may not be shared by other nations. Mobilizing effective international nonproliferation efforts will therefore become that much harder. Moreover, those who see the proliferation of weapons of mass destruction as far more dangerous than the spread of conventional, or even advanced conventional, weapons, would not wish to divert effort away from the more serious threat.

The linkages between conventional arms and weapons of mass destruction can give rise to paradoxes. In the past, one policy measure employed by the United States to reduce a state's (e.g., Pakistan's) motivation to acquire nuclear weapons had been to provide it with conventional arms (e.g., F-16 aircraft) in order to address its security needs. However, such planes can serve multiple roles, conceivably including the delivery of Pakistan's purported nuclear weapons. Thus, conventional arms transfers intended to reduce a state's demand for weapons of mass destruction may actually have the effect of increasing its capability to deliver them.

Balancing Unilateral and International Approaches

International cooperation is necessary for nonproliferation to be successful. However, other nations will not always agree with the United States on either the problem or the solution. In such cases, the United States will have to decide whether to preserve consensus, at the risk of not taking what it sees to be appropriate action, or to proceed unilaterally, at the risk of disrupting international consensus.

Those analysts emphasizing consensus typically stress that proliferation should be treated as a violation of international norms of behavior. They argue that nonproliferation policies with widespread international legitimacy will be much more effective than ones viewed primarily as furthering the objectives of the United States or any other single power. This approach emphasizes the role of international institutions, as opposed to individual states, because such institutions provide a greater degree of international support. However, a drawback of this approach is that unless each nation places high priority on nonproliferation, each will have reason to downplay it at times (see above discussion on conflicting objectives). Therefore, the cases in which consensus for international action can be reached might be considerably fewer than many states individually might wish. At the same time-and largely for the same reason-nations have traditionally been reluctant to cede authority to international bodies that might later act in opposition to their own interests. Thus, even when an international institution is able to identify a consensus position, it may not be able to do much.

Proponents of an ''internationalist' approach envision a world in which civilized nations agree on strong norms against the development, acquisition, production, threat, or use of weapons of mass destruction, possibly excepting some residual nuclear capability in the nuclear weapon states. States unwilling to subscribe to these norms, or found to be violating them, would be considered by the others as pariahs. Such norms can come about if-and only if-a very large number of individual nations see them as compatible with their own national interests. In that case, states may be willing to use international institutions for real enforcement, based on information

submitted by individual states or acquired directly.

Proponents of a more unilateral approach see proliferation as a threat to U.S. national interests against which the United States must take its own steps, whatever other nations may think or do. Although they would agree that nonproliferation policies are more effective if implemented multilaterally, they argue that the United States should not restrict its actions to cases where consensus can be reached. In this view, international regimes strong enough to implement a consistent multilateral approach are unlikely to emerge; at any rate, the United States should not put itself in the position of having to rely on them. Through the use of ad hoc coalitions, such as that assembled for the Gulf War, the United States could gain the benefit of a group response while still preserving some freedom of independent action. The drawback of U.S. action in the absence of international backing, however, is that it may antagonize other states whose cooperation will be needed to implement a more effective multilateral policy. Moreover, if a proliferant state can portray itself not as an international pariah but instead as a victim of superpower bullying, it can encourage other countries to withhold support from--or even to undermine--U.S. nonproliferation policy.

Balancing Coercive and Consensual Policies

Nonproliferation policies include both *coercive* measures, imposed to frustrate efforts by **states to** develop weapons of mass destruction, and *consensual* ones that invite states to voluntarily forgo such developments. Coercive measures tend **to be** directed against particular states. Consensual ones, on the other hand, typically involve actions—such as joining **treaty regimes—that any state** is free to take, and they therefore avoid the need to single out targets. In the near term, coercive measures can impede progress towards developing weapons of mass destruction; in the long run, they can help raise the costs of such programs and so discourage states from pursuing them. In the near term, consensual policies may not be accepted by those states most likely to develop or deploy weapons of mass destruction. In the long run, however, the most effective nonproliferation measures are those in which states decide that it is in their own best interest to forgo weapons of mass destruction.

Like the case of unilateral and multilateral approaches, coercive and consensual measures can be mutually supportive. Yet states may respond to coercion with defiance, refusing to join nonproliferation regimes. Conflicts between coercive and consensual measures may become particularly relevant in cases where potential proliferants are in a position to export proliferation-sensitive technology. Punitive measures aimed at discouraging the development of weapons of mass destruction in such states may make it difficult to elicit their cooperation in forgoing proliferation-sensitive exports.

Balancing Targeted and Universal Approaches

The targets of coercive U.S. nonproliferation policies such as export controls and sanctions can be chosen in one of two ways. In a *targeted* approach, the United States applies these measures to specific countries determined to be of particular proliferation concern. In a *universal* approach, the target countries are not specified by name, but rather consist of all states that meet given criteria such as violation of, or refusal to join, international nonproliferation treaty regimes.

Given that the motivations for and the consequences of developing weapons of mass destruction vary greatly from country to country, the targeted approach provides greater flexibility and discretion for tailoring nonproliferation policy. In particular, it permits the United States to treat states not considered security threats differently from states judged to be particularly dangerous to their neighbors or hostile towards U.S. interests.

For exactly this reason, however, targeted policies are harder than universal ones to justify and implement multilaterally. Identifying some states and not others as causes for concern unavoidably leads to charges of discrimination and double standards.[23] Moreover, the states implementing multilateral nonproliferation policies will probably not agree on who the problem countries are.

Balancing Collection and Use of Intelligence

Much of the information available to the U.S. Government pertaining to proliferation is classified. Acting on classified information+. g., by exposing a state's actions to international attention, or by shutting down a covert supplier network-risks compromising the sources and methods by which the information was originally collected, possibly shutting off access to such information in the future. Therefore, tensions exist between collecting intelligence information and making effective use of it.

A related problem is that to the extent that relevant information must remain classified, public debate and discussion—and to some extent, international negotiations and actions-will be conducted on the basis of incomplete information.

TECHNICAL BASIS FOR MONITORING AND CONTROLLING PROLIFERATION

The various weapons of mass destruction addressed in this report are based on very different technical principles and require distinct sets of industrial capabilities. A separate background paper explores the technical pathways by which states might acquire nuclear weapons, chemical weapons, biological weapons, and delivery systems. Those analyses are intended to identify opportunities for monitoring and, if possible, controlling proliferation, as well as to note the potential implications of certain old and new technologies. They also describe the level of effort, commitment, and resources required for any state to mount such developments, thereby indicating the relative effects of increasing these costs, for example, by export controls. Nevertheless, a country-by-country analysis of potential proliferants' indigenous technical expertise and industrial infrastructure is beyond the scope of this study. So, too, is a political assessment of the incentives facing each of these states, or a thorough discussion of the many other nontechnical factors that would influence their ability to pursue weapons of mass destruction.

The bottlenecks or 'chokepoints' identified in the background paper—steps that are particularly time-consuming or difficult for proliferants to master without outside assistance-might be exploited to control proliferation. Conversely, steps that are relatively easy, or that make use of widely available know-how and equipment, make poor candidates for control efforts. It is important to understand the extent to which "dual-use" technologies or products, which also have legitimate civil applications, are involved in the development of weapons of mass destruction, since both the feasibility of controlling dual-use items and the implications of doing so depend on the extent of their other applications.

Monitoring the proliferation of weapons of mass destruction, or conversely monitoring compliance with nonproliferation agreements, depends on detecting and identifying various indicators or *signatures* associated with the development, production, deployment, or use of weapons of mass destruction. Unilateral intelligence collection efforts can seek to exploit these signatures with the use of remote or covertly placed instruments; multilateral verification regimes—typically operating within the framework of a negotiated treaty-can make provision for states to voluntarily open their facilities to cooperative

23 The U.S. State Department's list of states supporting terrorism, for example, is often accused Of reflecting political tilts, rather than firm intelligence analysis.

onsite inspection in addition to sanctioning the use of remote instrumentation.[24]

Both unilateral and cooperative approaches have their strengths. A cooperative regime might offer direct access to facilities that would be difficult to inspect in any other way. However, strict limitations may be put on that access. Moreover, since the inspected party knows the type of instrumentation and procedures to be used by inspecting parties, it may be able to defeat those inspections. Intelligence collection efforts conducted outside the framework of a negotiated agreement would probably not have the degree of access to any specific site that would be provided by a cooperative onsite inspection regime, but they might have other advantages such as breadth of coverage. Moreover, they would not be constrained by prenegotiated procedures, and they might be able to gather information about sites where onsite inspection would be denied. However, if unilateral intelligence efforts involved covert placement of sensors in the territory of the inspected party, such efforts would probably be viewed as a violation of sovereignty, creating political tensions if detected.

Unilateral and multilateral approaches are not mutually exclusive. Indeed, they will be most effective if used synergistically: unilateral intelligence efforts might trigger a challenge inspection. However, many of the signatures discussed below are likely to be ambiguous, if they are detected at all. Deciding on appropriate responses in the face of incomplete or ambiguous information will pose great challenges for nonproliferation policy, as will mobilizing effective domestic and international support for those responses.

Nuclear Weapons

MATERIAL PRODUCTION

In terms of costs, resources required, and possibility of discovery, the difficulty of obtaining nuclear weapon materials—plutonium or highly enriched uranium—today remains the greatest single obstacle most countries would face in pursuing nuclear weapons. Even straightforward methods of producing such material indigenously (such as building a small reactor and a primitive reprocessing facility to produce plutonium and recover it from irradiated reactor fuel) would require at least a modest technological infrastructure and hundreds of millions of dollars to carry out. Moreover, once such a facility became known, it could generate considerable pressure from regional rivals or the international community. The costs of a full-scale indigenous nuclear weapon program-especially if clandestine--can be substantially higher than for a program largely aimed at producing just one or two bombs and carried out in the open. Iraq spent 10 to 20 times the cost of such a minimal program-many billions of dollars-to pursue multiple uranium enrichment technologies, to build complex and sometimes redundant facilities, to keep its efforts secret, and to seek a fairly substantial nuclear capability. Few countries of proliferation concern can match the resources that Iraq devoted to its nuclear weapon program. (Iran, however, probably could.)

Since production of nuclear materials is generally the most difficult and expensive part of producing a nuclear weapon, the leakage of significant amounts of weapon-grade material from the former Soviet Union would provide a great advantage to potential proliferants. In-

24 In the strategic arms control process between the United States and the Soviet Union, each side agreed not to impede the other side's "national technical means of verification," in effect legitimizing the collection of intelligence pertinent to the treaty.

deed, the possibility of black-market sales of weapon-usable materials may represent one of the greatest proliferation dangers now being faced. Even the covert acquisition of low-enriched uranium, which can fuel nuclear reactors but is not directly usable for nuclear weapons, could be advantageous to a proliferant by enhancing the capacity of its isotope separation plants.

This ominous prospect notwithstanding, nuclear materials suitable **for weapon purposes have to date been extremely difficult to obtain from countries that already possess them.** There is no reliable evidence that any militarily significant quantities of nuclear weapon material have been smuggled out of the former Soviet Union. The vast majority of nuclear material in nonnuclear weapon states is safeguarded by a comprehensive system of material accountancy and control administered by the International Atomic Energy Agency (IAEA). These safeguards are not perfect, but they provide high levels of confidence that significant quantities of nuclear material have not been diverted from safeguarded nuclear reactors. Diversion would be more difficult to detect from facilities such as fuel fabrication plants, uranium enrichment plants, and plutonium reprocessing facilities that process large quantities of nuclear material in bulk form, as opposed to handling it only in discrete units such as fuel rods or reactor cores. At present, however, there are no large facilities of this type under comprehensive IAEA safeguards in countries of particular proliferation concern.[25] At least in the short run, the diversion of safeguarded materials poses less of a threat to the nonproliferation **regime than the black-market purchase or covert indigenous production of** nuclear materials.

Under current European and Japanese plans for reprocessing and limited reuse of plutonium from commercial reactor fuel, the current worldwide surplus of some 70 tomes of safeguarded, separated *reactor-grade* plutonium-the type produced by commercial nuclear reactors in normal operation-will likely continue to grow through the 1990s by more than 10 tonnes per year. Reactor-grade plutonium is more radioactive and more difficult to handle than *weapon-grade* plutonium, which is produced specifically for use in nuclear weapons, but it can still be used to make a crude nuclear weapon of significant (though probably less predictable) yield. Nevertheless, the states that have sought nuclear weapons have gone to great lengths to produce weapon-grade materials--either highly enriched uranium or weapon-grade plutonium-rather than reactor-grade plutonium. (Note that some types of nuclear power reactors, including ones in India, South Korea, and North Korea, can produce either reactor-grade or weapon-grade plutonium, depending on how they are operated.)

OTHER TECHNICAL BARRIERS

Unlike chemical and biological weapons, whose lethality is roughly proportional to the amount of agent dispersed, nuclear weapons will not produce any yield at all unless certain conditions are met: a minimum ‘‘critical mass’ of nuclear materials must be present, and that material must be brought together with sufficient speed and precision for a nuclear chain reaction to take place. A proliferant must master a series of technical hurdles in order to produce even a single working weapon.

Nuclear weapons are so destructive that they place few requirements on the accuracy of delivery systems for any but the most protected targets. Most proliferants would likely be able to design first-generation nuclear weapons that were small and light enough to be carried by Scud-class missiles or small aircraft. Given additional technical refinement, they might be able to reduce

[25] Brazil has a medium-sized fuel fabrication facility under IAEA safeguards, and South African enrichment facilities are coming Waler safeguards with South Africa’s announced destruction of its nuclear weapons and its accession to the NPT. Neither state is considered an active proliferation threat at present.

warhead weights to the point where the 500 kg (l,100 pound) delivery threshold originally established by the Missile Technology Control Regime no longer provides a reliable barrier to nuclear-capable ballistic or cruise missiles.[26]

Although nuclear weapons were first developed 50 years ago and the basic mechanisms are widely known, much of the detailed design information, and particularly the knowledge gleaned by the nuclear weapons states from decades of design and testing, remains classified. Much of this information can be reconstructed by a dedicated proliferant, but it will take time and money. Moreover, "weaponizing" a nuclear warhead for reliable missile delivery or long shelf-life creates additional hurdles that could significantly increase the required development effort. Therefore, having access to key individuals--such as those from the former Soviet nuclear weapon program--could significantly accelerate a nuclear program, primarily by steering it away from unworkable designs. Specific individuals could fill critical gaps in a given country's knowledge or experience, adding greatly to the likelihood that a program would succeed.

High-performance computers (so-called "supercomputers '' in the 1980s) are *not required* to design first-generation fission weapons. Thus, placing strict limits on their exports would be of minimal importance compared with limiting technologies for nuclear materials production.

MONITORING NUCLEAR PROLIFERATION

Production of nuclear materials provides many signatures and the greatest opportunity for detecting a clandestine nuclear weapon program. Even so, a large part of the Iraqi program was missed. Since members of the Nuclear Non-Proliferation Treaty (other than the acknowledged nuclear-weapon states) are not permitted to operate unsafeguarded facilities handling nuclear materials, the existence of any such facilities would probably indicate an illegal weapon program.[27]

LOS ALAMOS NATIONAL LABORATORY

Iraqi electromagnetic isotope separation (EMIS) equipment, uncovered after having been buried in the desert to hide it from United Nations inspectors. Iraq's EMIS program to enrich uranium for nuclear weapons had not been detected by Western intelligence agencies prior to the Gulf War.

Nuclear tests at kiloton yields or above would probably be detectable by various means, especially if multiple tests were conducted. However, such tests are not necessary to field a workable weapon with reasonably assured yield. Similarly, the deployment of a small number of nuclear weapons might not be easily detected.

IMPLICATIONS OF OLD AND NEW TECHNOLOGIES

Low- and medium-level *gas centrifuge technology* for enriching uranium may become increasingly attractive to potential proliferants for a variety of reasons, including availability of information about early designs, difficulty of detec-

26 Broadening its focus, the Missile Technology Control Regime now covers missiles capable of delivering chemical and biological weapons as well as those that could be used (o deliver nuclear weapons. Consequently, the payload threshold of 500 kg has been removed.

27 The exception t. this statement would be unsafeguarded facilities dedicated to military purposes unrelated to nuclear weapons, such as naval nuclear propulsion. Such uses are not prohibited by the Nuclear Non-Proliferation Treaty. They fall outside IAEA jurisdiction however, since IAEA safeguards pertain only to peaceful-e. g., nonmilitary-applications of nuclear power. See Ben Sanders and John Simpson, *Nuclear Submarines and Non-Proliferation: Cause for Concern,* PPNN Occasional Paper Two (Southampton England: Centre for International Policy Studies, University of Southampton for the Programme for Promoting Nuclear Non-Proliferation 1988).

tion, ease of producing highly enriched uranium, and potential availability of equipment from the former Soviet Union. Modem, state-of-the-art centrifuges could lead to even smaller, more efficient, and relatively inexpensive facilities that would be most difficult to detect remotely.

In the longer run, *laser isotope separation* techniques and *aerodynamic separation* may have serious proliferation potential as means of producing highly enriched uranium for nuclear weapons. Openly pursued by more than a dozen non-nuclear-weapon states, *laser enrichment* technologies use precisely tuned laser beams to selectively energize the uranium-235 isotope most useful for nuclear weapons and separate it from the more common uranium-238 isotope. Laser facilities would be small in size and could enrich uranium to high levels in only a few stages. They could therefore prove to be difficult to detect and control if successfully developed as part of a clandestine program. Nevertheless, considerable development work remains to be done before this method can be made viable or can compete with existing enrichment technologies. Even for the advanced industrialized countries, constructing operational facilities will remain very difficult. Some *aerodynamic techniques*—which use carefully designed gas flows to separate the lighter uranium-235 from the heavier uranium-238-require fairly sophisticated technology to manufacture large numbers of precision small-scale components, but they do not otherwise pose technical challenges beyond those of other enrichment approaches.

Chemical Weapons

The technology used to produce chemical weapons is much harder to identify unambiguously as weapons-related than is that for nuclear materials production technology, and relevant know-how is much more widely available. Although production techniques for major chemical weapon agents involve some specialized process steps, detailed examples can be found in the open literature and follow from standard chemical engineering principles. Unlike nuclear proliferation, where the mere existence of an unsafeguarded nuclear facility in an NPT member state is often sufficient evidence of intent to produce weapons, many legitimate chemical facilities could have the ability to produce chemical agent. Intent cannot be inferred directly from capability.

AGENT AND WEAPON PRODUCTION

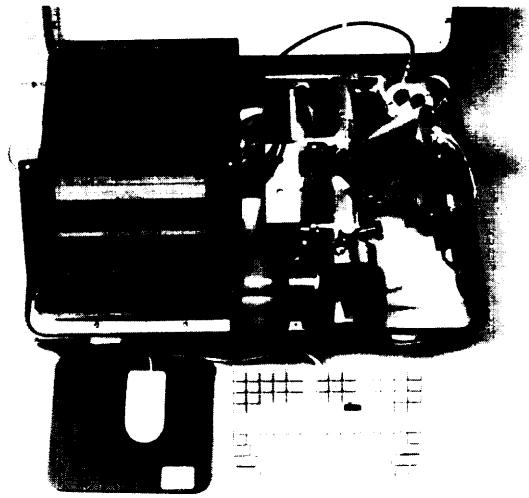
Certain chemical agents such as mustard gas are very simple to produce. Synthesis of nerve agents, however, includes some difficult process steps involving highly corrosive or reactive materials. A sophisticated production facility to make militarily significant quantities of one class of nerve agents might cost between $30 and $50 million, although dispensing with modem waste-handling facilities might cut the cost in half. Some of the equipment needed may have distinctive features, such as corrosion-resistant reactors and pipes and special ventilation and waste-handling equipment, but these can be dispensed with by relaxing worker safety and environmental standards and by replacing hardware as it corrodes. Moreover, production is easier if a proliferant country is willing to cut comers on shelf-life, seeking only to produce low-quality agent for immediate use.

Chemical-warfare agents can be produced through a wide variety of alternative routes, but relatively few routes are well suited for large-scale production. Just because the United States used a particular production pathway in the past, however, does not mean that proliferant countries would necessarily choose the same process.

In general, commercial pesticide plants lack the precursor chemicals (materials from which chemical agents are synthesized), equipment, facilities, and safety procedures required for nerve-agent production. Nevertheless, multipurpose chemical plants capable of manufacturing organo-phosphorus pesticides or flame retardants could be converted in a matter of weeks or months

to the production of nerve agents. The choice between converting a commercial plant in this manner and building a clandestine production facility would depend on the urgency of a country's military requirement for a chemical weapon stockpile, its desire to keep the program secret, its level of concern over worker safety and environmental protection, and the existence of embargoes on precursor materials and production equipment.

Agent production, however, is several steps removed from an operational chemical weapon capability. The latter requires design and development of effective munitions, filling the munitions before use, and mating them with a suitable delivery system.



Portable gas chromatograph/mass spectrometer (GC/MS) developed to support onsite analysis for the Chemical Weapons Convention. This equipment can detect and identify minute quantities of organic chemicals controlled by the CWC.

MONITORING CHEMICAL WEAPON PROLIFERATION

Direct detection of chemical warfare agents in samples taken from a production facility would be a clear indicator of weapon activity, since these agents have almost no civil applications.[28] However, considerable access to production facilities is required to ensure that appropriate samples have been collected. Moreover, some of the substances produced when chemical agents break down in the environment are also produced when legitimate commercial chemicals break down, so detection of final degradation products does not necessarily indicate agent production. Nevertheless, the suite of degradation products associated with a given chemical agent production process would provide a clear signature.

Other than the agent itself, or an ensemble of degradation products, chemical agent production has few unequivocal signatures. Moreover, highly reliable technologies to detect chemical agent production from *outside the* site are not currently available. Unlike nuclear weapon facilities, which generally exhibit fairly clear signatures, civilian chemical plants have multiple uses, are hundreds of times more numerous than nuclear facilities, and are configured in different ways depending on the process involved. Moreover, many of the same chemicals used to make chemical agents are also used to make pharmaceuticals, pesticides, and other commercial products. Since many different types of equipment are suitable for chemical agent production, plant equipment per se does not provide a reliable means of distinguishing between legitimate and illicit activities. Nevertheless, some potential signatures of chemical weapon development and production exist, and a set of multiple indicators taken from many sources may be highly suggestive of a production capability.

Indicators at suspect locations that may contribute to such an overall assessment include: visual signatures such as testing munitions and delivery systems; distinctive aspects of plant design and layout, including the use of corrosion-resistant materials and air-purification systems; presence of chemical agents, precursors, or degradation products in the facility's production line or waste stream; and biochemical evidence of chem-

28 Nitrogen mustards have some use in cancer chemotherapy, and phosgene and hydrogen cyanide have industrial applications.

ical agent exposure (including that due to accidental leaks) in plant workers or in plants and animals living in the vicinity of a suspect facility. Nevertheless, the utility of specific signatures depends on how a given weapon program operates, including the choice of production process and the extent of investment in emission-control technologies. Detection capabilities that are decisive under laboratory conditions may be rather inconclusive in the field—particularly if the proliferant has been producing related legitimate chemicals (e.g., organophosphorus pesticides) in the same facility and is willing to expend time, effort, and resources to mask, obscure, or otherwise explain away chemical agent production activities. Testing of chemical agents and training troops in their use might be masked by experiments with or training for the use of smoke screens. A robust inspection regime must therefore comprise an interlocking web of inspections, declarations, notifications, and data fusion and analysis, all of which a cheater must defeat in order to conceal his violations. Focusing monitoring efforts at a single point--even one thought to be a crucial chokepoint--would allow the cheater to focus his efforts on defeating them.

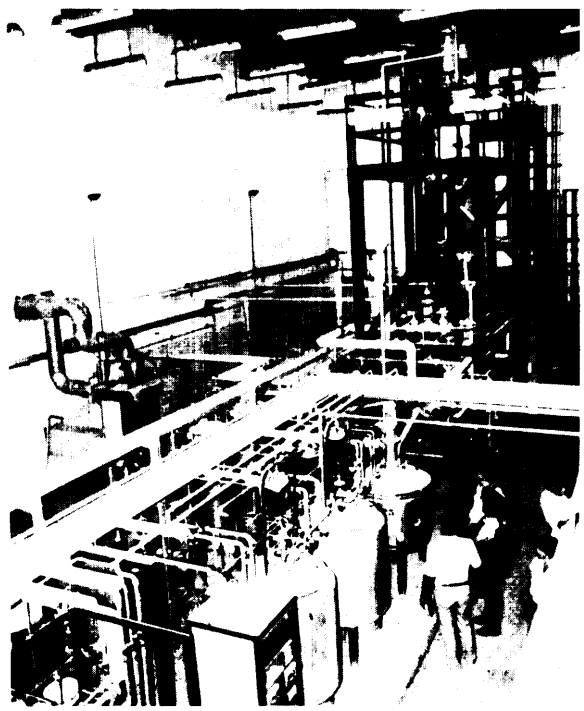
Keeping a production program covert forces other tradeoffs. Some of the simplest production pathways might have to be avoided since they use known precursors or involve known production processes. Purchasing equipment from multiple suppliers to avoid detection, or jury-rigging facilities from used equipment, might increase hazards to the workforce and nearby populations.

Biological Weapons

Biological-warfare agents are easier to produce than either nuclear materials or chemical-warfare agents because they require a much smaller and cheaper industrial infrastructure and because the necessary technology and know-how is widely available. Moreover, it would not be difficult to spread biological agents indiscriminately to produce large numbers of casualties, although it is much more difficult to develop munitions that have a predictable or controllable military effect.

AGENT AND WEAPON PRODUCTION

The global biotechnology industry is information-intensive rather than capital-intensive. Much of the data relevant to producing biological agents is widely available in the published literature and virtually impossible for industrialized states to withhold from potential proliferants. A widespread support infrastructure of equipment manufacturers has also arisen to serve the industry. Therefore, producing biological agents would be relatively easy and inexpensive for any nation that has a modestly sophisticated pharmaceutical industry. Moreover, nearly all the equipment needed for large-scale production of pathogens and toxins is dual-use and widely available on the international market.



United Nations inspectors assessing the biological weapon potential of Iraqi fermenters and other bioprocess equipment.

One technical hurdle to the production of biological weapons is ensuring adequate containment and worker safety during agent production and weapons handling, although the difficulty of doing so depends on the level of safety and environmental standards. A government that placed little value on the safety of plant workers or the civilian population might well take minimal precautions, so that a biological weapon production facility would not necessarily be equipped with sophisticated high-containment measures. Another challenge is ''weaponizing' the agents for successful delivery. Since microbial pathogens and toxins are susceptible to environmental stresses such as heat, oxidation, and dessication, to be effective they must maintain their potency during weapon storage, delivery, and dissemination.

A supply of standard biological agents for covert sabotage or attacks against broad-area targets would be relatively easy to produce and disseminate using commercially available equipment, such as agricultural sprayers. In contrast, the integration of biological agents into precise, reliable, and effective delivery systems such as missile warheads and cluster bombs poses complex engineering problems. Nevertheless, the United States had overcome these problems by the 1960s and had stockpiled biological warfare agents.

MONITORING BIOLOGICAL WEAPON PRODUCTION

Detection and monitoring of biological and toxin agent production is a particularly challenging task. Even use of biological weapons could in some cases be difficult to verify unambiguously, since outbreaks of disease also take place naturally. Thanks to advances in biotechnology, including improved fermentation equipment as well as genetic engineering techniques, biological and toxin agents could be made in facilities that are much smaller and less conspicuous than in the past. Moreover, the extreme potency of such agents means that as little as a few kilograms can be militarily significant. Since large amounts of agent can be grown up from a freeze-dried seed culture in a period of days to weeks, large stockpiles of agent are not required, although some stocks of the munitions to be filled with these agents would be.

There are no signatures that distinguish clearly between the development of offensive biological agents and work on defensive vaccines, since both activities require the same basic know-how and laboratory techniques at the R&D stage. Moreover, almost all the equipment involved in biological and toxin weapon development and production is dual-use and hence will not typically indicate weapons activity. Indeed, the capacity to engage in illegal military activities is inherent in certain nominally civilian facilities. Some legitimate biological facilities can also convert rapidly to the production of biological warfare agents, depending on the degree of sophistication of the plant and on the required scale of production, level of worker safety, and environmental containment. At the same time, however, legitimate applications of biological or toxin agents (e.g., vaccine production and the clinical use of toxins) are relatively few at present. With the exception of a few vaccine production plants, such activities are largely confined to sophisticated biomedical facilities not normally found in developing countries, and these facilities generally do not engage in production except on a small scale. Moreover, given that the global biotechnology industry is still in its infancy, the number of legitimate activities--from which the illegitimate ones would have to be distinguished-is still relatively small.

Sensitive analytical techniques such as polymerase chain reaction (PCR) analysis or use of monoclinal antibodies can identify trace quantities of biological agents and might be able to do so even after the termination of illicit activities. However, the existence of such sensitive laboratory techniques does not necessarily translate into a negotiated verification regime that might be instituted to monitor compliance with the Biolog-

ical Weapons Convention. Other factors that must be assessed in establishing such a regime include the likelihood of detecting clandestine production sites, the ability to distinguish prohibited offensive activities from permitted defensive efforts, and the risk of divulging sensitive national-security or proprietary information during inspections of U.S. facilities.[29]

Because of the difficulty of detecting clandestine biological and toxin weapon development and production, effective tracking of such programs will require integrating data from many sources, with a particular emphasis on human intelligence (agents, defectors, and whistleblowers). Some weaponization signatures (storage of bulk agents, preparation of aerosol dispensers, field testing, etc.) would probably be easier to detect than production signatures, but many such signatures could be concealed or masked by legitimate activities such as biopesticide R&D or use. Production and storage of components for BW munitions might also be masked by activities associated with conventional weapons, such as production of high explosives, bomb casings, or artillery shells. Since excessive secrecy might itself be indicative of offensive intent, greater transparency would tend to build confidence in a country's lack of offensive intentions.

IMPLICATIONS OF NEW TECHNOLOGY

Genetic engineering is unlikely to result in ''supergerms" significantly more lethal than the wide variety of potentially effective biological agents that already exist, nor is it likely to eliminate the fundamental uncertainties associated with the use of microbial pathogens in warfare. However, gene-splicing techniques might facilitate weaponization by rendering microorganisms more stable during dissemination (e.g., resistant to high temperatures and ultraviolet radiation). Biological agents might also be genetically modified to make them more difficult to detect by immunological means and insusceptible to standard vaccines or antibiotics. At the same time, genetic engineering techniques could be used to develop and produce protective vaccines more safely and rapidly.

Cloning toxin genes in bacteria makes it possible to produce formerly rare toxins in kilogram quantities. Moreover, molecular engineering techniques could lead to the development of more stable toxins. Even so, for the foreseeable future, toxin-warfare agents are unlikely to provide dramatic military advantages over existing chemical weapons. It is possible that bioregulators and other natural body chemicals (or synthetic analogues thereof) might be developed into powerful incapacitants, but means of delivering such agents in a militarily effective manner would first have to be devised. Moreover, if warning of their use were provided, chemical weapon protective gear would blunt their impact.

Delivery Systems

Although military delivery systems such as ballistic missiles, cruise missiles, and combat aircraft are not essential to deliver weapons of mass destruction, they can do so more rapidly, more controllably, and more reliably than rudimentary means such as suitcases, car bombs, or civilian ships or planes. Controlling the spread of advanced delivery systems by no means would eliminate the dangers posed by weapons of mass destruction, particularly in terrorist applications. However, limiting the availability of these delivery systems would make it harder for states to use weapons of mass destruction for military purposes, particularly against well-defended, forewarned adversaries.

29 The United States has already determined that inspection procedures under the Chemical Weapons Convention which allow the inspected party to negotiate the level of access to be provided to international inspectors, are sufficient to protect national-security information and trade secrets. However, it is not necessarily the case that the same inspection procedures would be suitable for the Biological Weapons Convention should a formal verification regime be instituted.

Unlike nuclear, chemical, or biological weapons themselves, which are not traded openly due to treaty constraints or international norms, delivery systems such as aircraft and short-range antiship cruise missiles are widely available on international arms markets, Since the late 1980s, the United States and other Western industrialized countries have had some success at delegitimizing the sale of longer range ballistic and cruise missiles by creating the Missile Technology Control Regime (MTCR), the participants in which refrain from selling ballistic or cruise missiles with ranges over 300 kilometers, or with any range if the seller has reason to believe that they may be used to carry weapons of mass destruction. However, missiles with ranges up to 300 km-and to a lesser extent, up to 600-1,000 km-are already deployed in many Third-World countries. Combat aircraft are possessed by almost all countries of proliferation concern. Cruise missiles or other unmanned aerial vehicles with ranges much over 100 km are not yet widespread outside the acknowledged nuclear weapon states, but large numbers of cruise missiles, including antiship missiles, are available at lesser ranges.

In terms of payloads that can be carried to specified ranges, the combat aircraft of virtually all countries of proliferation concern far surpass their missile capabilities. However, aircraft and missiles have different relative strengths—particularly in their ability to penetrate defenses—and the two systems are not fully interchangeable. Piloted aircraft have significant advantages over other delivery systems in terms of range, payload, accuracy, damage-assessment capability, and dispersal of chemical or biological agents. They can be used many times, usually even in the presence of significant air defenses. Missiles, however, are harder to defend against, and they offer distinct advantages for a country wishing to deliver a single nuclear weapon to a heavily defended area. Since missiles are not restricted to operating from airfields, they are also easier to hide from opposing forces. The wide range of motivations for acquiring ballistic missiles-prestige, diversifying one's forces, their psychological value as terror weapons, lack of trained pilots, and technology transfer and export opportunities-will continue to make missile technology very attractive for several countries of proliferation concern.

BARRIERS TO MISSILE AND AIRCRAFT PROLIFERATION

The spread of ballistic missiles around the world was greatly facilitated by the export in the 1970s and 1980s of Scud-B missiles from the former Soviet Union. With an increasing number of countries abiding by the MTCR, the number of potential missile suppliers has declined dramatically. Of the principal missile exporters, only North Korea has not agreed to comply. However, Ukraine poses future export concerns, since it contains much of the former Soviet missile production infrastructure, yet has not agreed to comply with the MTCR. Moreover, additional countries have learned to copy, modify, extend the range of, and produce their own missiles, and a small number have developed long-range systems-often in conjunction with space-launch programs and foreign technical assistance. Even so, MTCR constraints can slow the acquisition by developing countries of technologies associated with more advanced missiles-those having ranges


UN PHOTO, H. ARVIDSSON

United Nations inspector measuring an Iraqi Al-Husayn (modified Scud) missile in Baghdad.

in excess of 1,000 km or guidance errors of less than roughly 0.3 percent of their range.

Given the complex set of technologies and expertise used in advanced aircraft, especially high-performance jet engines, it remains virtually impossible for developing countries to acquire these systems without assistance. However, no internationally binding restrictions limit trade in combat aircraft, and such arms transfers continue to be used as an instrument of foreign policy. Moreover, overcapacity in Western defense industries, and the economic difficulties facing newly independent Soviet republics and Eastern European states, provide great incentive to develop arms export markets. Therefore, states can and probably will continue to acquire high-performance aircraft easily without having to build them. Moreover, other options short of buying aircraft or building them from scratch are available to states wishing to acquire or modify combat aircraft, such as engaging in licensed production.[30]

If they have sufficient payload and range-and if they can be procured despite export controls—commercially available unmanned aerial vehicles can be adapted to deliver weapons of mass destruction without much difficulty. Developing cruise missiles requires greater technical capability. Even so, technologies for guidance, propulsion, and airframes are becoming increasingly accessible, particularly with the spread of licensed aircraft production arrangements to many parts of the world. The most difficult technical challenges to developing cruise missiles—propulsion and guidance--do not pose much of a hurdle today. The highest performance engines are not required for simple cruise missiles, and many sources are available for suitable engines. Guidance requirements can be met by satellite navigation services such as the U.S. Global Positioning System (GPS), possibly the Russian Glonass system, or commercial equivalents. Inexpensive, commercially available GPS receivers are becoming available to provide unprecedented navigational accuracy anywhere in the world. Although GPS receivers would have only limited utility to emerging missile powers for ballistic missile guidance, they could be used to reduce uncertainty in the launch location of mobile missiles.

MONITORING DELIVERY VEHICLES

Although individual missiles can be very difficult to detect, a program to develop ballistic missiles is much more visible. Test firing and launching ballistic missiles can be readily seen. Development of intermediate and long-range ballistic missiles requires extensive flight testing, making it particularly noticeable. Although states pursuing both military and civil space technology may wish to hide their military programs, civilian space-launch programs are usually considered a source of national prestige and proudly advertised.

Even a purely civilian space-launch program provides technology and know-how useful for ballistic missiles. The most important aspects of a missile capability for weapons of mass destruction—range and payload-can usually be inferred from a civil program. (A civil space-launch booster does not need to have high accuracy, but neither does a missile carrying weapons of mass destruction for use against populations.) On the other hand, certain attributes desired for military applications, such as reliable reentry vehicles, mobility, and ease of operation in the field, suggest distinct technical approaches for military and civil applications. Although solid-fueled boosters are in some ways more difficult to develop and build than liquid-fueled boosters, they are easier to use in mobile and time-urgent applications. Liquid-fueled boosters were the first

30 The routes various states around the world have taken to develop defense industries, including aircraft industries, are discussed in U.S. Congress, Office of Technology Assessment, *Global Arms Trade*, OTA-ISC-460 (Washington, DC: U.S. Government Printing Office, June 1991).

used in military applications and are still more common. (The seemingly ubiquitous Scud missile and its modifications, such as were launched by Iraq against targets in Israel and Saudi Arabia, are liquid-fueled.)

Since combat aircraft are widely accepted as integral to the military forces even of developing countries, there is no reason to hide their existence. Individual planes, however, can be hidden. Moreover, modifications made to aircraft to carry weapons of mass destruction, or training given to pilots for their delivery, might be difficult to detect without intrusive inspections.

Of the three delivery systems, cruise missile development and testing will be the hardest to detect. Several types of unmanned aerial vehicles are being developed and marketed for civil purposes, and without inspection rights it will be difficult to discern whether such vehicles have been converted to military purposes. **Therefore, monitoring of delivery systems capable of carrying weapons of mass destruction will continue to be an uncertain exercise, having most success with missiles and highly capable aircraft. Nevertheless, the risk posed by other delivery systems cannot be dismissed. The full range of delivery technology must be taken into account when evaluating a country's overall proliferation capabilities and behavior.**