Princeton University
Woodrow Wilson School of Public and International Affairs
Graduate Program

TOPICS IN INTERNATIONAL RELATIONS

Protection Against Weapons of Mass Destruction (WMD)

(WWS-556d, Spring 2006)
Draft: 12/11/05
Sessions: Mondays, 1:00-4:00 PM
Room ??

Professor **Frank N. von Hippel** (fvhippel@princeton.edu), Dr.**Alexander Glaser** (aglaser@princeton.edu), and Dr. **Zia Mian** (zia@princeton.edu) Program on Science and Global Security, 221 Nassau St, 2nd floor

This course surveys and assesses the threats and the different approaches to protection against WMD. It provides essential technical, historical and organizational background for students interested in getting involved in WMD policy.

Schedule

Date D=Draft PM F= Final PM	**Unit/**Topic (Possible guest lecturers)
Feb. 6	1. History of the different approaches to protection against WMD
	Discuss proposed paper with one of us during second week
Feb. 13	2. Nuclear weapons
Feb. 20, D1	3. Nuclear proliferation, Atoms for Peace, export controls & the NPT
Feb. 27	4. Biological weapons (Kahn)
	Defenses
Mar. 6, F1	5. Missile proliferation and defense (Postol?)
Mar. 13, D2	6. Deterrence and/or preemption (Blair)
	break
Mar. 27	7. Defenses against biological weapons (Chyba)
	Diplomacy
April 3, F2	8. Multilateral arms control: CTBT and the Fissile Cutoff, export controls (Li Bin?)
Apr. 10	9. Dealing with the legacy of the Cold War (Diakov?)
	Submit draft papers and begin presentations
Apr. 17	10. Cooperative threat reduction (S. Weiner)
Apr. 24	11. Student paper presentations and debate on proliferation
May 1	12. The goal of nuclear-weapon policy: abolition or not? (Goldemberg?)

Nuclear and biological weapons represent the only large-scale military threats to U.S. security. Chemical weapons are often described as WMD. However, they fall in a

lesser range of threats shared by attacks on chemical and nuclear-power plants, dispersal of radioactivity (dirty bombs) and aircraft crashes into buildings and are not a major focus of this course. The consequence of biological weapons use ranges from the trivial to the pandemic -- which can also happen naturally. They must therefore be considered.

Since September 11, 2001 attacks and the fall-2001 anthrax letters, the world, especially the U.S., has become preoccupied with the dangers of acquisition and use of nuclear or biological weapons by terrorist groups.

In his January 2002 State of the Union speech, President Bush threatened preemptive attacks against hostile states with WMD programs – naming Iran, Iraq and North Korea in particular, and actually carried out the threat in the case of Iraq (which turned out to be the only one without a WMD program). The international community has successfully pressed Iran and Libya to reveal their nuclear programs and to agree to the "Additional Protocol" to the Nonproliferation Treaty, which allows the International Atomic Energy Agency to carry out intrusive inspections. However, North Korea re-started its nuclear-weapons program, while expressing a willingness to scrap it if it receives assurances against attack and economic assistance, including nuclear power reactors.

The greatest threat, however, may still be from the Cold War arsenals. Sixteen years after the fall of the Berlin Wall and fourteen years after the disintegration of the Soviet Union, Russia and the U.S. keep missiles carrying thousands of thermonuclear warheads on alert ready to launch at each other within 15 minutes. Furthermore, many thousands of surplus warheads and surplus fissile materials sufficient to make many thousands more; millions of artillery shells filled with nerve gas, and seed stocks for biological-weapon agents are scattered across Russia in many locations with varying levels of security. The security of U.S. nuclear weapons and materials may be better but it is far from impregnable.

The US response to these security threats has included arms control and nonproliferation treaties, financial assistance for securing and destroying nuclear materials and biological-weapons facilities; and unilateral defensive measures ranging from anti-missile and civil defenses to threats of preemptive attacks.

The purpose of this course is to provide students with the information to be able to assess the effectiveness and the limits of these various ways of dealing with WMD and also to provide some orders of magnitude and simple back-of-the-envelope (BoE) approaches to assessing the threats and alternative defenses.

Course requirements and deliverables. No prerequisites other than a serious interest in arms control. Undergraduates may enroll with permission from the instructor. Two short (less than1000 word) policy memos (PMs) due in draft February 20 and March 13. Feedback will be provided within a week and the memos are due in final form March 6 and April 3. One policy memo, at least, should include some BoE quantitative analysis (advice will be provided as needed). One 4000-6000 word research paper on an agreed topic to be presented in draft and oral as well as in final written form. The draft paper is

due during the week of April 10. Two volunteer student presentations on the readings each week. No final.

Reading Materials. For those readings for which URLs are not supplied, copies will be available on e-reserve and/or on reserve in the WWS library in the basement of Wallace Hall. *Deadly Arsenals: Nuclear, Biological, and Chemical Threats, 2nd edition,* by Joseph Cirincione *et al* (Carnegie Endowment for International Peace, 2005) is recommended for purchase and can be purchased at http://www.carnegieendowment.org/publications/index.cfm?fa=view&id=16650&prog=zgp&proj=znpp Additional reading and reference materials are provided for those interested in exploring a particular topic more deeply.

Useful web sites:
Arms Control Association/Arms Control Today: www.armscontrol.org
Bulletin of the Atomic Scientists: www.thebulletin.org. See especially the NRDC nuclear notebook: http://www.thebulletin.org/nuclear_weapons_data/index.htm
Carnegie Endowment for Peace Nonproliferation Program: www.carnegieendowment.org/npp/
Disarmament Diplomacy: www.acronym.org.uk
Global Security: http://www.globalsecurity.org/wmd/index.html
Institute for Science and Global Security: http://www.isis-online.org/
International Atomic Energy Agency: http://www.iaea.org/
Nuclear Threat Initiative: www.nti.org
Nonproliferation Review: www.cns.miis.edu/pubs/npr
Russian-American Nuclear Security Advisory Council: www.ransac.org

I. OVERVIEW

1. History of the different approaches to protection from WMD

The U.S. has spent enormous sums acquiring nuclear weapons and on defenses against them: about $5 trillion on the weapons and the means to deliver them, $1 trillion on bomber and missile defense, and $20 billion on civil defense as of 1996.[1] **[Footnotes are references not readings.]** Smaller amounts have been spent on chemical and biological weapons in the past and defenses against them more recently. Efforts to control the spread of WMD include nonproliferation treaties, export controls and preemption. Where weapons exist, means to limit and reduce them include arms control and cooperative threat reduction.

Deterrence. In the case of nuclear weapons, the primary emphasis has been on the threat of nuclear retaliation to deter nuclear attack because, for most of the nuclear era, effective defense has been seen as infeasible. During the Cold War, the U.S., France and U.K. also used nuclear threats to deter a perceived threat of massive Soviet conventional attack

[1] In 1996 dollars [*Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons Since 1940,* Stephen Schwartz, ed. (Brookings, 1998)]. For a summary and excerpts, see http://www.thebulletin.org/issues/1998/so98/so98schwartz.html

and, since the Cold War, a weakened Russia has similarly invoked nuclear deterrence against massive conventional attack by NATO, China, Turkey and other neighbors.

Since the U.S. decided to eliminate its chemical and biological weapons, the U.S. DoD has also used the threat of nuclear retaliation to deter chemical and biological as well as nuclear attacks. This policy contradicts commitments made by the State Department as part of its nonproliferation policy that the U.S. will not use nuclear weapons against non-nuclear-weapon states unless they attack the U.S., its forces or its allies in concert with a nuclear-armed state.

Defense. There have also been periodic major debates in the U.S. over the feasibility of defense against nuclear weapons. Einstein wrote in 1947, "there is no secret and there is no defense." However, the U.S. Government has periodically mounted major and often controversial efforts: in the 1950s, defense against Soviet strategic bombers; in 1968-72, 1983-88, and since 2002, defense against strategic ballistic missiles; and, in the 1960s and 1980s civil defense. Today, a major effort is being mounted to prepare civil defenses against biological attack.

Nonproliferation Treaties. Major attempts have also been made to stem proliferation through international treaties under which countries have renounced WMD.[2] These include:

- The [Nuclear-weapons] Nonproliferation Treaty of 1970, under which all non-nuclear weapon states have committed not to acquire nuclear weapons and to accept International Atomic Energy Agency monitoring of their nuclear activities in exchange for commitments by the U.S., Russia, Britain, France and China to eventual nuclear disarmament. (Israel, India, Pakistan and North Korea are outside the treaty);

- The Chemical Weapons Convention (CWC) of 1993, under which all signatories have agreed to eliminate their chemical weapons by specified dates and to accept inspections by the Organization for the Prohibition of Chemical Weapons of facilities that could produce or are suspected of producing CW; and

- The Biological Weapons Convention (BWC) of 1972, which bans biological weapons but without any arrangements for verification.

Compliance with these commitments has been impressive but far from perfect. The State Department's most recent (August 2005) report, *Adherence to and Compliance With Arms Control, Nonproliferation, and Disarmament Agreements and Commitments* gives the U.S. Government view on these issues. [3]

Export controls. Attempts have therefore been made to reinforce the WMD regimes with agreements between the industrialized and some other countries possessing relevant technologies not to export technologies that could facilitate WMD or long-range missile

[2] For the texts of the treaties see http://www.state.gov/www/global/arms/bureau_ac/treaties_ac.html
[3] *http://www.state.gov/t/vci/rls/rpt/51977.htm*.

programs in suspect countries: the Nuclear Suppliers Group,[4] the Australia Group (for chemical and biological equipment),[5] and the Missile Technology Control Regime.[6]

Preemption. There have been periodic debates about the possibility of carrying out "preemptive" attacks to prevent the development of WMD threats – and occasional decisions to do so. In 1981, Israel bombed Iraq's Osirik reactor before it could be used to produce plutonium. Following Iraq's expulsion from Kuwait in 1991, the U.N. required it to accept IAEA and UNSCOM inspectors who rooted out its WMD production programs.[7] Iraq expelled these inspectors in 1998 and five years later U.S. and allied forces invaded Iraq out of concern that Iraq had reconstituted its WMD programs.[8]

The U.S. almost mounted an attack on North Korea's plutonium-production facilities in 1994. The crisis was defused, however, after Jimmy Carter mediated an agreement under which North Korea shut down these facilities in exchange for heavy oil for its power-plant boilers and the construction of two nuclear power reactors by the multinational Korean Peninsula Energy Development Organization. (Construction was officially put on hold on Dec. 1, 2003.)[9]

In December 2002, the Bush Administration issued an unclassified version of its report, "National Strategy to Combat Weapons of Mass Destruction," which asserts that "U.S. military forces and appropriate civilian agencies must have the capability to defend against WMD-armed adversaries, including in appropriate cases through preemptive measures."[10]

Arms control. In addition to the nonproliferation regimes, a number of U.S.-Soviet/Russian treaties were negotiated in attempts to limit the nuclear arms race during the Cold War and reduce nuclear arsenals afterwards: the Strategic Arms Limitation Treaty and the Treaty on the Limitation of Anti-Ballistic Missile (ABM) Systems (1972); the Intermediate Nuclear Forces Treaty (1987); the Strategic Arms Reduction Treaty (1994) and the Moscow Treaty (2002). A Comprehensive [nuclear] Test Ban Treaty has been ratified by 120 countries but will only come into force when the 44 countries with nuclear reactors in 1996 have all ratified it. Eleven, including the U.S., have not.[11]

Arms control and weapon-ban agreements have always controversial in the U.S. Critics worry about constraining U.S. options and lulling the U.S. with a false sense of security. They also discount the values of constraints on U.S. opponents by arguing that that they will cheat. During the Cold War these arguments were balanced by concerns

[4] http://www.nsg-online.org/
[5] http://www.australiagroup.net/index_en.htm
[6] http://www.mtcr.info/english/index.html
[7] International Atomic Energy Agency < http://www.iaea.org/worldatom/Programmes/ActionTeam/nwp2.html > and UN Special Commission http://www.un.org/Depts/unscom.
[8] For the U.S. post-war reassessment of the basis of that concern, see *Comprehnsive Report of the Special Advisor to the DCI on Iraq's WMD,* 30 Sept. 2004, http://www.cia.gov/cia/reports/iraq_wmd_2004/
[9] http://www.kedo.org
[10] http://www.whitehouse.gov/news/releases/2002/12/WMDStrategy.pdf, p. 3.
[11] http://www.armscontrol.org/factsheets/ctbtsig.asp

about what an unconstrained Soviet Union would do. With the end of the Cold War, however, concerns about what other countries might do if unconstrained have declined. The Chemical Weapons Convention received the two thirds Senate vote required for ratification in 1993 only in exchange for the elimination of the U.S. Arms Control and Disarmament Agency and special limitations on international inspections in the U.S. The Senate refused to ratify the Comprehensive Test Ban Treaty in 1999. In 2001, the Bush Administration rejected the proposed Verification Protocol for the Biological Weapons Convention because it would bring unwelcome inspections to the U.S. pharmaceutical industry and DoD biodefense programs. In 2002 it withdrew from the ABM Treaty that limited U.S. and Soviet/Russian missile defenses. The Moscow Treaty of 2003, which mandates further cuts in Russian and U.S. deployed nuclear warheads has no verification arrangements and will be in force for only one day (December 31, 2012). In 2004, the Bush Administration declared that the previously internationally agreed objective of a Fissile Material Cutoff Treaty with "effective verification is not achievable." (The FMCT would end the production of plutonium and highly enriched uranium for weapons.)

Cooperative Threat Reduction. After the end of the Cold War, a number and of "cooperative threat reduction" (CTR) programs were organized to help Russia downsize and the other fSU countries eliminate the WMD arsenals and production facilities that they had inherited from the Soviet Union and to employ their excess WMD experts to prevent them from becoming sources of materials and expertise for terrorists or would-be WMD states. More recently, CTR programs have been established in Iraq and Libya.

Presentations: Overview and history (FvH). Perspectives (ZM and AG).

Read

- "The Thinkable" by Bill Keller, New York Times Magazine, May 4, 2003.

- "Global Trends" (pp. 3-25) in *Deadly Arsenals: Nuclear, Biological, and Chemical Threats* by Joseph Cirincione *et al* (Carnegie Endowment for International Peace, 2005. (The chapter is also at http://www.carnegieendowment.org/publications/index.cfm?fa=view&id=16650&prog=zgp&proj=znpp.)

- "Uncooperative America" (pp. 1-10) in *Hang Separately: Cooperative Security between the United States and Russia, 1985-1994* by Leon V. Sigal (Century Foundation Press, 2000)

- "Stigmatizing the bomb: Origins of the nuclear taboo" by Nina Tannenwald, *International Security 29 #4* (Spring 2005), pp. 5-49.

- Mohamed ElBaradei – Nobel Lecture, Oslo, December 10, 2005http://nobelprize.org/peace/laureates/2005/elbaradei-lecture-en.html

- "America, the Bomb, and Bin Laden" by Pervez Hoodbhoy and Zia Mian, *Peace Now: The Bulletin of the Coalition for Nuclear Disarmament and Peace*, http://www.cndpindia.org/peace-now!/PN-hiroshima-spl05.pdf, p. 50.

Related material of interest (aka [below] "References")

- "Working in the White House on nuclear nonproliferation and arms control" by Frank von Hippel, *Federation of American Scientists Public Interest Report*, March/April 1995, (http://www.fas.org/faspir/archive/1990-2000/March-April1995.pdf).

- *Americans on WMD Proliferation* (poll) April 2004, http://www.pipa.org/OnlineReports/WMDProliferation/WMD_Prolif_Apr04/WMDProlif_Apr04_rpt.pdf

2. **Nuclear weapons**

Fissile materials. The essential material for the production of nuclear weapons is fissile material (material that can sustain an explosive fission chain reaction). The two fissile materials that have been used in the production of nuclear weapons thus far are uranium enriched to about 90% in chain-reacting U-235 (from the natural level of 0.7%) and the artificial element, plutonium.

Uranium is enriched by technologies that use the weight difference of the chemically identical isotopes. This technology is still beyond the practical reach of subnational groups.

To produce a nuclear explosion, one must assemble a super-critical mass of fissile material so that about two of the approximately 3 neutrons produced by each fission is absorbed by fissile material so that each fission will cause two fissions, resulting in an exponentially growing fission chain-reaction. All nuclear weapons contain fission triggers ("primaries"). In advanced designs, the yield of these fission triggers is "boosted" by neutrons from the thermonuclear fusion of deuterium-tritium gas inside the fission "primary." There may also be a thermonuclear "secondary" compressed and heated to fusion temperatures by X-rays from the primary and perhaps also fissionable material within the secondary..

Plutonium is produced in nuclear reactors by neutron capture on the abundant, non-chain-reacting isotope, U-238 (the remaining 99.3% of natural uranium).[12] At slow speeds, neutrons develop a strong preference for absorption by U-235. "Slow neutron" reactors therefore can be fueled with natural uranium. In order for a large enough fraction of the neutrons to be absorbed by the 0.7% U-235 to sustain the chain reaction, however, the neutrons have to be slowed by collisions with materials that do not absorb neutrons – in practice, very pure graphite or heavy water.

[12] Other artificial fissile materials can be made in this way -- notably U-233 by neutron capture on Th-232.

Fissile material is detected through its weak emissions of penetrating gamma rays and neutrons associated with the continuous radioactive decay of an infinitesimal fraction of its atoms. In the absence of effective shielding, this radiation can be detected outside containers or vehicles -- or even from a low-flying helicopter by a Nuclear Emergency Search Team.

Nuclear-weapon effects. The major effects of nuclear explosions are direct neutron and gamma radiation at short range, blast and heat out to distances that depend upon yield, and radioactive fallout downwind if the explosion's fireball touches the ground and sucks up and contaminates dirt and debris. The protective value of the concrete and dirt around a fallout shelter stems from the fact that these materials attenuate the penetrating gamma radiation emitted by the fission products in fallout (about a factor of ten per foot).

Tutorials: Design of the Hiroshima and Nagasaki bombs (FvH). Nuclear-weapon effects (AG).

Read

- *Hiroshima* by John Hersey (1946).

- Recommendation of the General Advisory Committee to the Atomic Energy Commission against the development of the H-bomb, October 30, 1949, reprinted in *The Advisors: Oppenheimer, Teller, and the Superbomb* by Herbert York, Stanford University Press, pp. 159-162.

- *The U.S. Nuclear War Plan: A Time for Change* (NRDC, 2001) http://www.nrdc.org/nuclear/warplan, Powerpoint file, slide show and chapter 3 of the report.

- *The Nuclear Almanac: Confronting the atom in war and peace,* Jack Dennis, ed., Addison-Weley, 1994, pages to be assigned.

References

- "South Africa and the affordable bomb" by David Albright, *Bulletin of the Atomic Scientists,* July/August 1994, pp. 37-47. http://www.thebulletin.org/issues/1994/ja94/ja94Albright.html.

- "Nuclear physics" (pp. 25-39) and "Plutonium production in nuclear reactors" (pp. 43-64) and "Bomb assembly" (pp. 126-133) in *The Politics and Technology of Nuclear Proliferation* by Robert F. Mozley (University of Washington Press, 1998),

- "Nuclear weapons" (pp. 58-65) in *Megawatts and Megatons* by Richard Garwin and Georges Charpak (Alfred A. Knopf, 2001).

- The USG's basic reference on nuclear-weapons effects is *The Effects of Nuclear Weapons,* Samuel Glasstone and Philip J. Dolan, eds, (U.S. Government Printing Office, 1977) – comes complete with Dr. Strangelove bomb-effects computer. Scanned version at http://www.princeton.edu/~globsec/publications/effects/effects.shtml

- The basic reference on fission-weapon design is *The Los Alamos primer: the first lectures on how to build an atomic bomb* by Robert Serber (University of California Press, 1992).

- The basic reference on the nuclear fuel cycle is *Nuclear Chemical Engineering, 2nd edition* by Manson Benedict, Thomas H. Pigford and Hans Wolfgang Levi (McGraw Hill, 1981).

- If you want to understand some of the issues relating to the effect of the isotopic difference between weapon-grade and reactor-grade plutonium on the yield of a fission explosive, see J. Carson Mark, "Explosive properties of reactor-grade plutonium" in *Science & Global Security 4* (1993), pp. 111-128, http://www.princeton.edu/~globsec/publications/pdf/4_1Mark.pdf

- For a primer on the detection of nuclear warheads, see "Detecting Nuclear Warheads" by Steve Fetter et al, *Science & Global Security 1* (1990), pp. 225-302), http://www.princeton.edu/~globsec/publications/pdf/1_3-4FetterB.pdf.

Radiological weapons. Radiological weapons are weapons that disperse radioactive materials in order to inflict radiation doses. This might be done by dispersal of a radioisotope source or by precipitating an accident in a nuclear power plant or spent-fuel storage pool. As the Chernobyl accident illustrates, such an event would be unlikely to kill many people by high radiation doses. However, it could contaminate large areas and slightly increase the cancer risk in a very large population.

Reference

- "Exposures and effects of the Chernobyl accident," Annex J in *Sources and Effects of Ionizing Radiation* (UN, 2000) http://www.unscear.org/pdffiles/annexj.pdf

3. Nuclear proliferation, the NPT, and "Atoms for Peace"

The Nonproliferation Treaty. The U.S. conducted its first nuclear test in 1945, Russia in 1949, the U.K. in 1952, France in 1960 and China in 1964. After China's test, the U.S. and Soviet Union discovered a joint interest in nuclear nonproliferation. The Nonproliferation Treaty (NPT) which came into force in 1970, divides parties to the treaty into two classes: five "nuclear-weapon states" (U.S., Soviet Union, U.K., France, China) that carried out nuclear explosions prior to 1967 and "non-nuclear-weapon states" that committed to carry out their nuclear activities under International Atomic Energy Agency (IAEA) safeguards designed to provide international assurance that no fissile material was being diverted to weapons use. A number of other states stayed outside the treaty because they had nuclear ambitions.

The NPT constitutes a bargain between the nuclear weapon and non-weapon states. The non-weapon states commit not to acquire nuclear weapons and to allow the IAEA to inspect their nuclear programs in order to verify their compliance. The weapon states commit: i) to "cessation of the nuclear arms race at an early date and to nuclear disarmament," and ii) "exchange…equipment, materials and scientific and technological information for the peaceful uses of nuclear energy…without discrimination."

Today Israel, India, North Korea and Pakistan are the only states outside the treaty and are *de facto* nuclear-weapon states. (North Korea joined in 1985 but never

allowed full IAEA inspections to verify its compliance and, after a long series of crises, withdrew from the Treaty in 2003.) South Africa acquired nuclear weapons in 1979 but then gave them up and joined the NPT in 1991. Argentina and Brazil both had clandestine nuclear-weapons programs when they had military governments but the successor civilian governments jointly renounced these programs in 1991. Belarus, Kazakhstan and Ukraine inherited nuclear weapons when the Soviet Union disintegrated in 1991 but renounced them in 1993 and 1994. Iraq and Libya had clandestine nuclear-weapon development programs but gave them up as a result of international pressure. A struggle is going on about the future of Iran in the treaty.

On the disarmament side, the high-water mark in a shared vision of steps toward nuclear disarmament were contained in the "13 steps" agreed to by the original five nuclear-weapon states at the Nonproliferation Treaty Review Conference of 2000.

Atoms for Peace. The idea of exchanging nuclear-energy technology for commitments to nonproliferation and acceptance of IAEA inspection was first put forward officially in 1953 in President Eisenhower's "Atoms for Peace" speech, where he proposed to

> "encourage world-wide investigation into the most effective peacetime uses of fissionable material, and with the certainty that they had all the material needed for the conduct of all experiments that were appropriate…The Atomic Energy Agency could be made responsible for the impounding, storage, and protection of the contributed fissionable and other materials. The ingenuity of our scientists will provide special safe conditions under which such a bank of fissionable material can be made essentially immune to surprise seizure."[13]

This was a drastic departure from the view put forward in the first analysis of the problem of preventing weapons use of fissile materials, the 1946 Acheson-Lillienthal Report (p. 4):

> "We have concluded unanimously that there is no prospect of security against atomic warfare in a system of international agreements to outlaw such weapons controlled only by a system which relies on inspection and similar police-like methods."[14]

During the 20 years following President Eisenhower's speech, the U.S. and Soviet Union exported to approximately 50 countries research reactors fueled by weapon-grade highly-enriched uranium (HEU) and the U.S. promoted the development of plutonium-breeder reactors and plutonium recycle worldwide.

Article IV of the 1970 Nonproliferation Treaty assured the non-weapon states of their "inalienable right…to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with articles I and II of this Treaty [which contain the basic commitment not to acquire nuclear weapons]." (Today,

[13] http://www.eisenhower.utexas.edu/atoms.htm
[14] http://www.learnworld.com/ZNW/LWText.Acheson-Lilienthal.html#text

Iran frequently cites its inalienable right and the U.S. and other countries express skepticism about Iran's commitment to not acquire nuclear weapons.)

Export controls. The period of lack of concern about the spread of reactor fuel-cycle facilities that give direct access to weapon-useable highly-enriched uranium and plutonium came to an end in 1974 after India used nuclear training and technology provided by the U.S. and Canada to produce and separate the plutonium that it used for its "peaceful nuclear explosion."[15]

The U.S. changed its export policy dramatically after the Indian nuclear explosion but the export policies of other countries developed more gradually. In 1976, France supplied Iraq with the high-powered HEU-fueled research reactor that Israel bombed in 1981. More recently, Pakistan supplied Iran, Libya and North Korea with centrifuge-enrichment technology.

In the early 1970s, the Non-Proliferation Treaty Exporters Committee (Zangger Committee) was formed to coordinate the export policies of supplier countries. In 1976, following India's test, the unofficial Nuclear Suppliers Group (NSG) was established to develop stronger limitations on the export of uranium-enrichment and plutonium-separation technologies. Following the Gulf War, export controls were extended to "dual-use" technologies as well. In addition the NSG agreed not to export nuclear technologies at all to countries outside of the NPT. [16] (President Bush has recently proposed making an exception of India for reactor technology and nuclear fuel.[17])

IAEA safeguards. The purpose of the original IAEA safeguard system was to verify that nuclear materials were not diverted from declared nuclear programs. Following the discovery of Iraq's massive clandestine program in 1991, an "Additional Protocol" to the NPT was developed, which requires signatories to "declare the location of nuclear-fuel-cycle related research and development activities, not involving the use of nuclear material and authorizes the IAEA to perform environmental sampling to detect clandestine reprocessing and enrichment facilities and conduct surprise inspections with as little as two hours notice.[18] As of the end of 2005, the Additional Protocol had been ratified and brought into force in 69 countries. Both Iran and Libya have recently signed the protocol and it is in force in Iran on a provisional basis. [19]

Tutorials: Making plutonium (FvH), highly-enriched uranium (AG), IAEA safeguards (ZM)

Read:

---

[15] Israel received similar assistance from France, which had full knowledge of its interest in nuclear weapons. Pakistan obtained the uranium centrifuge technology that it used to make highly-enriched uranium for weapons clandestinely from a Dutch civilian nuclear enrichment facility.
[16] http://www.nsg-online.org/
[17] http://www.whitehouse.gov/news/releases/2005/07/20050718-6.html
[18] www.iaea.org/Publications/Documents/ Infcircs/1998/infcirc540corrected.pdf
[19] http://www.iaea.org/OurWork/SV/Safeguards/sg_protocol.html

- *The Spread of Nuclear Weapons: A Debate Renewed* by Scott Sagan and Kenneth Waltz (W.W. Norton, 2002). Read at least the first two chapters: "More may be better" by Waltz, and "More will be worse" by Sagan.

- "North Korea" (pp. 279-294) and "Nuclear supplier organizations" (pp. 443-450) in *Deadly Arsenals.*

- "Turning a Blind Eye Again? The Khan Network's History and Lessons for U.S. Policy" by Leonard Weiss, *Arms Control Today,* March 2005, http://www.armscontrol.org/act/2005_03/Weiss.asp

- "The centrifuge connection: After Iran's first story of how it acquired uranium enrichment technology was rejected, evidence of a more complex procurement network began to emerge" by David Albright and Corey Hinderstein, *Bulletin of the Atomic Scientists,* March/April 2004, http://www.thebulletin.org/article.php?art_ofn=ma04albright

- Presentation by Iran's Ambassador to the U.N. Javad Zarif at the Liechtenstein Colloquium on "Iran's security challenges and the region," March 2005.

- "13 Steps" excerpts from the NPT 2000 Review Final Document, http://www.reachingcriticalwill.org/legal/npt/13point.html

- "Nuclear-weapon states and the grand bargain" by Leonard Weiss, *Arms Control Today,* December 2003, http://www.armscontrol.org/act/2003_12/Weiss.asp

- "Politics and protection: Why the 2005 NPT Review Conference failed" by Rebecca Johnson, *Disarmament Diplomacy 80* Autunm 2005, http://www.acronym.org.uk/dd/dd80/80npt.htm

References

- "In Focus: IAEA and Iran," http://www.iaea.org/NewsCenter/Focus/IaeaIran/index.shtml

- "Introduction" (pp. 23-35) in *Nuclear Safeguards and the International Atomic Energy Agency* (U.S. Congressional Office of Technology Assessment, 1995), http://www.wws.princeton.edu/~ota/ns20/alpha_f.html

- "Uranium enrichment technologies" in *Technology and the Proliferation of Nuclear Weapons* by Richard Kokoski (Oxford University Press, 1995), pp. 9-54. [An alternative treatment which discusses some of the physics and the difficulties in more detail can be found in "Uranium Enrichment" in *The Politics and Technology of Nuclear Proliferation* by Robert F. Mozley (University of Washington Press, 1998), pp. 77-125).

4. **Biological and chemical weapons**

(mostly biological weapons)

Approaches to defense against both chemical and biological weapons are generally well known: gas masks and suits, filters on the air intakes of buildings, and antidotes.

We have recently learned more than we wanted to about anthrax. Because of the durability of its spore form, this has been the prototypical BW agent since WWII. Both the U.S. and Russia developed huge production capacities for anthrax and several other biological agents during the Cold War.[20] Iraq produced a considerable amount.

The Biological Weapons Convention. In 1969, President Nixon decided to unilaterally end the U.S. BW program. This led to the negotiation of the Biological Weapons Convention. Unlike other arms control treaties, however, the BWC has no arrangements for verification.

In 1991, after the revelation of cheating on a massive scale by both Russia and Iraq, the Third Review Conference of the BWC set up an Ad Hoc Group of Experts to develop the basis for a verification protocol. In 1994, on the basis of this group's report, negotiations on a Protocol were launched. These negotiations led to a final negotiating draft on a protocol but, in August 2001, the Bush Administration insisted that the negotiations be abandoned as hopeless.[21] In November 2001, President Bush proposed an alternative approach to strengthening the BWC based on the encouragement of unilateral national initiatives.[22]

Chemical weapons. 124,000 tons of chemical agents were dispersed in World War I, resulting in over a million casualties and over 90,000 deaths. Note that the casualties were comparable to the number that might have been caused by a similar weight of conventional shells or bombs. More powerful nerve gases were developed after WW I but chemical weapons are still orders of magnitude less lethal on a weight basis than nuclear and biological weapons.

Chemical weapons were not used in World War II. In the 1960s Egypt used chemical weapons against Yemen, and in the 1980s they were used by Iraq in the Iraq-Iran War. During the Cold War, the U.S. and Soviet Union built up huge stockpiles of weapons and of nerve gas and other chemical-weapons agents, which they are now struggling to destroy. Iraq built up a considerable chemical-weapons stockpile. In 1995, the Japanese terrorist group, Aum Shinrikyo produced and used sarin nerve gas in an attack on the Tokyo subway system.[23]

---

[20] For popular accounts, see: J. Miller, S. Engelberg and W. Broad, *Germs: Biological Weapons and America's Secret War* (Simon and Schuster, 2001); *The Biology of Doom: The History of America's Secret Germ Warfare Project* by Ed Regis, (Henry Holt, 1999); and *Biohazard: The chilling true story of the largest covert biological weapons program in the world* [*the Soviet Union's*] *told from inside by the man who ran it* by Ken Alibek with Stephen Handelman (Random House, 1999).
[21] http://www.state.gov/t/ac/rls/rm/2001/index.cfm?docid=5497
[22] http://www.whitehouse.gov/news/releases/2001/11/20011101.html
[23] "A case study of the Aum Shinrikyo" in *Global proliferation of weapons of mass destruction,* Hearings before the Permanent Subcommittee on Investigations of the U.S. Senate Committee on Governmental Affairs, Oct. 31, Nov. 1, 1995, pp. 47-102.

WW I Mustard gas is not very difficult to make –especially given supplies of the industrial chemical thiodiglycol. Nerve gases such as sarin are related to organophosphorus pesticides. The production processes of these agents and their difficulties are well known. Their degradation products are also well known and can be detected at extremely low levels. The Australia group of industrialized countries has attempted to block the export of dual-use technologies that could be useful to states suspected of interest in chemical or biological weapons.

After 20 years of negotiations in the Geneva-based Conference on Disarmament, the Chemical Weapons Convention (CWC) was signed in 1993. The Convention requires countries to declare their stockpiles and production facilities and to destroy them. Six countries (the U.S., Russia, India, South Korea, Libya and Albania) have declared stockpiles and five more declared production facilities. The CWC also requires countries to declare data on the production sites, processing, consumption, acquisition, import or export of above-threshold quantities of chemical-weapon precursor chemicals. It subjects production facilities to international inspections and also contains elaborate arrangements for challenge inspections in case accusations of violations are found credible by the compliance-monitoring inter-governmental Organization for the Prohibition of Chemical Weapons OPCW), headquartered in the Netherlands at the Hague.[24] However, the U.S. and OPCW governing board subsequently have weakened the abilities of the inspectors to do their jobs.

Despite delays due to technical problems and public concerns about safety, the U.S. is now well underway in an $18+ billion program to destroy its 31,000 -tons stockpile of chemical-weapons agents. Russia's program to destroy its stockpile of 40,000 tons has been stalled by public concerns about safety and lack of funds, however, the U.S. and EU have begun to supply funds for a nerve-gas destruction facility.

Tutorials. Biological agents (LK). How to estimate casualties, based on quantities released, toxicity, weather conditions and population density (FvH). Public-health approaches to preventing disease spread using smallpox as an example (LK).

Read

- "Biological and chemical weapons, agents and proliferation" (pp. 57-68), *Deadly Arsenals*

- "The Cult" (pp. 151-164) and "Evil Empire" (pp. 165-182) in *Germs: biological weapons and America's secret war* by Judith Miller, Stephen Engelberg, and William Broad (Simon & Schuster, 2001).

- "A farewell to germs: the U.S. renunciation of biological and toxin warfare, 1969-70" by Jonathan B. Tucker, *International Security 27,* Summer 2002, pp. 107-148;

---

[24] http://www.opcw.org

http://thesius.ingentaselect.com/vl=25061372/cl=73/nw=1/fm=docpdf/rpsv/cw/mitpress/01622889/v27n1/s5/p107

- ”Anthrax powder: state of the art?” by Gary Matsumoto, *Science 302,* November 28, 2003, pp. 1492-7.

- “Recharging the Chemical Weapons Convention” by Amy Smithson, *Arms Control Today,* March 2004, p. 6, http://www.armscontrol.org/act/2004_03/Smithson.asp?print

- “A geneology of the chemical weapons taboo” by Richard Price, *International Organization 49, No. 1* (1995), pp. 73-103.

References

- "The growing threat of biological weapons," Steven Block *American Scientist,* Jan-Feb. 2001, http://www.sigmaxi.org/amsci/articles/01articles/Block.html

- “Nuclear Blindness: An overview of the biological programs of the former Soviet Union and Iraq” by Christopher Davis, http://www.cdc.gov/ncidod/EID/vol5no4/davis.htm

- The 1972 Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxic Weapons (BWC) http://www.state.gov/www/global/arms/treaties/bwc1.html

- “Technical Aspects of Biological Weapon Proliferation” in *Technologies Underlying Weapons of Mass Destruction* (Congressional Office of Technology Assessment, 1993), pp. 71-117, http://www.wws.princeton.edu/~ota/ns20/alpha_f.html

- Jonathan Tucker and Raymond A. Zilinskas, “Assessing U.S. proposals to strengthen the Biological Weapons Convention, ” *Arms Control Today,* April 2002, pp. 10-14, http://www.armscontrol.org/act/2002_04/tuczilapril02.asp

- For a history of the evolution of the U.S. BW program and policy until 1990, see Barton Berstein, “Origins of the U.S. biological warfare program (pp. 9-25); and Susan Wright, “Evolution of Biological Warfare Policy, 1945-1990” (pp. 26-48) in *Preventing a Biological Arms Race,* Susan Wright, ed. (MIT Press, 1990).

- “The Sverdlovsk Anthrax Outbreak of 1979” by M. Meselson, J. Guillemin, M. Hugh-Jones, A. Langmuir, I. Popova, A. Shelokov, and O. Yampolskaya in *Biological Weapons: Limiting the Threat,* Joshua Lederberg, ed. (MIT Press, 2000) pp. 193-209. In 1979, an accidental release of perhaps less than a gram of anthrax spores in the Soviet city of Sverlovsk (now Nizhni Novgorod) caused a reported 64 deaths downwind out to the edge of the city (4 km). (The dispersal pattern is a classic example of a down-wind plume which will be used to illustrate the calculation of plumes for both chemical and biological agents.)

- Chapter 3, “Biological and chemical agents” and Annex 3: “Chemical agents” in *Public health response to biological and chemical weapons: WHO guidance* (World Health Organization, 2004) http://www.who.int/csr/delibepidemics/biochemguide/en/index.html

- “A chemical weapons atlas” by E.J. Hogendoorn, *Bulletin of the Atomic Scientists,* Sept./Oct. 1997, http://www.thebulletin.org/issues/1997/so97/so97hogendoom.html.

- "Technical Aspects of Chemical Weapon Proliferation" in *Technologies Underlying Weapons of Mass Destruction* (Congressional Office of Technology Assessment, 1993), pp. 15-69, http://www.wws.princeton.edu/~ota/ns20/alpha_f.html.

- *Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction,* http://www.opcw.org/.

- Website of the Australia Group, http://www.australiagroup.net.

- "Study assesses risk of attack on chemical plant," *Washington Post,* March 12, 2002, p. A8.

III. DEFENSE

5. Missile Proliferation and Defense

Aerial warfare in World War II was dominated by mass bombings and efforts to shoot down the bombers. After the Allies won dominance of the air in the Battle of Britain, however, Germany began to attack Britain with unmanned V-1 and V-2 missiles. These missiles were respectively the forbearers of modern cruise and ballistic missiles. Indeed, the V-2 is still with us in the form of the Scud missile that the Soviet Union produced and exported in great numbers and that North Korea, Iraq, Iran and other countries learned how to produce.

Ballistic missiles. Staging, i.e. jettisoning structural weight as fuel is consumed, made it possible to develop ballistic missiles of intercontinental range. During the Cold War, U.S. and Soviet Union ultimately each deployed about 2000 long-range land-based ballistic missiles, equipped with an average of 3-4 warheads each.

Prior to the late 1980s, a large number of countries had 300-500 km Scud missiles but only the five NPT nuclear-weapon states had long-range multistage ballistic missiles that are much more efficient for ranges beyond about 1500 km. Since that time, however, a number of additional countries mastered staging and deployed 2-stage intermediate-range missiles with ranges up to about 3,000 km: India (Agni, 1989), Israel (1990), North Korea (Taepo Dong I, one test in 1998), and Pakistan (Shaheen II, 2005), and Iran is reportedly working on a multi-stage Shahab-4.[25]

The G-7 countries (Canada, France, Germany, Italy, Japan, U.K., and U.S.) established the Missile Technology Control Regime in 1987 to restrict the export of ballistic and cruise-missiles and associated technologies. In 2005, the MTCR had 34 member states.[26] It focuses especially on controlling the proliferation of missiles that could carry a 500-kg payload (i.e. a first-generation nuclear warhead) more than 300 kilometers.

---

[25] http://www.globalsecurity.org/wmd/world/iran/shahab-4.htm
[26] http://www.mtcr.info/english/

Ballistic missile defense. Both the U.S. and Soviet Union had missile-defense R&D programs from the time of Russia's launch of the first earth satellite "Sputnik" in 1957. In the 1960s, systems were actually deployed. Russia started with a system to defend Moscow. In 1967, despite the skepticism of his technical advisors, President Johnson decided in 1967 it was politically necessary for him to deploy a national defense for the U.S. However, opposition developed in the suburbs where the nuclear-tipped missiles were supposed to be deployed, the Senate turned against the idea after President Nixon was elected. Although he had originally forced Johnson's decision, Nixon was forced to agree to the ABM Treaty of 1972, which banned national missile defenses.[27]

President Reagan rebelled against the ABM Treaty and launched his Strategic Defense Initiative in 1983 but the Senate again refused to go along. In 1996, a Republican Congress established a Commission to Assess the Ballistic Missile Threat to the United States chaired by Donald Rumsfeld.[28] The Commission reported back in 1998 that North Korea, Iran and/or Iraq might, with foreign assistance, secretly and rapidly develop missiles that could reach the U.S. North Korea appeared to give this threat credibility by attempting to launch a satellite a few months later. After G.W. Bush was elected President, Rumsfeld became Secretary of Defense. In 2002, the Bush Administration took the U.S. out of the ABM Treaty, ramped up missile-defense expenditures to $9 billion/year – more than any other military R&D program -- and committed the nation to deploy at least a few interceptor missiles by the presidential election of 2004. This mission was accomplished.

The Administration argued – unconvincingly to some – that the "Axis of Evil" countries could not be deterred from launching nuclear missiles at the U.S., even though they would know that such an attack would be suicidal. Others suggested that the real concern was that the U.S. might be deterred from using its conventional military superiority against these countries if they could attack the U.S. or its allies with nuclear missiles.

Many technical critics remain unconvinced that a missile-defense system will be capable of discriminating potential decoys and "penetration aids," deployable by even unsophisticated attackers, from the real warheads that could be hidden among them.

Tutorials: Rocket range/payload. Radar and infrared detection, decoys and discrimination.

Read

- "Missile proliferation" (pp. 83-118) in *Deadly Arsenals.*

---

[27] "Stopping Sentinel" (pp. 178-195) in *Advice and Dissent: Scientists in the Political Arena* by Joel Primack and Frank von Hippel (Basic Books, 1974). For a discussion of the role of the discussions between U.S. and Soviet scientists in reversing the Soviet conventional wisdom that "defense is good" see "'Not a Fool': Brezhnev and the ABM Treaty" (pp. 193-232) in *Unarmed Forces: The Transnational Movement to End the Cold War* by Matthew Evangelista (Cornell University Press, 1999).

[28] "Executive Summary," *Report of the Commission to Assess the Ballistic Missile Threat to the United States* (Donald Rumsfeld, Chairman), July 15, 1998, www.fas.org/irp/threat/bm-threat.htm

- "Anti-ballistic-missile systems" by Richard Garwin and Hans Bethe, *Scientific American,* March 1968, p.

- "The Continuing Debate on National Missile Defenses," Lisbeth Gronlund, George N. Lewis, and David C. Wright, *Physics Today*, December 2000, p. 36, www.physicstoday.com/pt/vol-53/iss-12/p36.html.

- Letter from MIT Prof. Theodore Postol to White House Chief of Staff, John Podesta, May11, 2000 alleging fraud in the DoD's one test of an interceptor against decoys, http://www.fas.org/spp/starwars/program/news00/postol_051100.html

References

- "U.S. Policy on Ballistic Missile Proliferation: The MTCR's First Decade (1987-1997)" by Wyn Q. Bowen in *Nonproliferation Review,* Fall 1997, p. 21, http://cns.miis.edu/pubs/npr/vol05/51/bowen51.pdf

- *The physics of space security* by David Wright, Laura Grego and Lisbeth Gronlund, American Academy of Arts and Sciences, 2005, http://www.ucsusa.org/assets/documents/global_security/Space_Security.pdf

- "Free flight of a ballistic missile" by Albert D. Wheelon, *ARS Journal,* Dec. 1959, pp. 915-926

- "Long-range nuclear cruise missiles and stability" by George Lewis and Theodore Postol, *Science &Global Security 3* (1992), pp. 49-99.

- "Rhetoric or reality? Missile defense under Bush" by Philip Coyle, *Arms Control Today,* May 2002, pp. 3-8.

- *Foreign Missile Developments and the Ballistic Missile Threat Through 2015,* Unclassified Summary of a National Intelligence Estimate, National Foreign Intelligence Board, December 2001, http://www.cia.gov/nic/pubs/other_products/Unclassifiedballisticmissilefinal.htm

- *Countermeasures*, Andrew Sessler et al (April 2000), http://www.ucsusa.org/index.html

- "Decoy rejection gains Pentagon's attention," *Aviation Week,* Sept. 16, 2002, p. 31.

6. Deterrence and/or Preemption?

Counterforce. In the 1950s, the U.S. threatened "massive [nuclear] retaliation" in response to fears of a Soviet invasion of Western Europe. By 1963, this would have meant the deaths of several hundred million people in the Soviet Union and China plus perhaps one hundred million in allied countries killed by the radioactive fallout, depending upon the wind direction. As U.S. intelligence concerning Soviet military-related facilities improved during the 1970s and U.S. missiles became more accurate, the emphasis shifted to "counterforce" targeting. Russian and U.S. land-based missiles became each-others' highest priority targets, which made them "time-urgent" targets and put them in a hair trigger, launch-on-warning status which persists today, . Many tens of

millions of civilians would still have been killed as a result of "collateral damage."

Despite their rapprochement, India and Pakistan seem to be moving slowly but steadily toward a similar missile confrontation – but in a situation where the two countries have a history of war, a continuing conflict over Kashmir, and much shorter missile flight times.

A Princeton PhD thesis (2001) provides compelling evidence that nascent nuclear powers often provoke thoughts of preemptive strikes by established nuclear powers with which they have confrontational relationships. Historical case studies include U.S. considerations of preemptive attacks on the Soviet Union and China, Soviet consideration of a preemptive attack on China, and Israel's actual preemptive attack on Iraq. Contemporary cases are: U.S.-North Korea, India-Pakistan and perhaps still U.S.-China.

Tutorials: Stable/unstable nuclear balances; early-warning systems

Films (optional): *Dr Strangelove; 13 Days* (2000, 147 minutes);

Read:

- "JFK's first-strike plan" by Fred Kaplan, *Atlantic Monthly,* October 2001, p. 81.
- "The false god of nuclear deterrence" by Lee Butler, *Global Dialogue,* Autumn 1999, p. 74.
- "The next Nuclear Posture Review?" (pp. 243-283) in *The Nuclear Turning Point,* Harold Feiveson, ed. (Brookings, 1999).
- *Nuclear Posture Review* (leaked excerpts from a classified document submitted to Congress, December 31, 1994), http://www.globalsecurity.org/wmd/library/policy/dod/npr.htm
- "National Strategy to Combat Weapons of Mass Destruction," http://www.whitehouse.gov/news/releases/2002/12/WMDStrategy.pdf
- "Pentagon Revises Nuclear Strike Plan; Strategy Includes Preemptive Use Against Banned Weapons" by Walter Pincus, *Washington Post*, September 11, 2005, A01; "Pentagon May Have Doubts on Preemptive Nuclear Moves," by Walter Pincus, *Washington Post*, September 19, 2005, A05.
- "The Role of U.S. Nuclear Weapons: New Doctrine Falls Short of Bush Pledge" by Hans M. Kristensen, *Arms Control Today,* September 2005, http://www.armscontrol.org/act/2005_09/Kristensen.asp#bio
- "The new calculus of pre-emption" by Robert Litwak, *Survival 44, no. 4* (winter 2002-03), pp. 53-80.

- "Taking nuclear weapons off hair-trigger alert" by Bruce Blair, Harold Feiveson and Frank von Hippel, *Scientific American,* November 1997, pp. 74-81. For the reaction of the then Commander in Chief of the U.S. Strategic Command, see "General Eugene E. Habiger, Commander in Chief, US Strategic Command, Interview with Defense Writer's Group, Wash DC 31 March 1998, fourth question: http://www.fas.org/news/usa/1998/03/980331-dwg.htm

References

- "Intercontinental ballistic missiles" and "Nuclear missile submarines" (pp. 137-193) in *Science, Technology and the Nuclear Arms Race* by Dietrich Schroeer (John Wiley & Sons, 1984)

- For updates on current Russian, U.S. and other-country nuclear forces, see the "Nuclear notebook" of the *Bulletin of the Atomic Scientists,* http://www.thebulletin.org/issues/nukenotes/nukenote.html

- Chapter 2, "The single integrated operational plan and U.S. nuclear forces;" Chapter 4, "Attacking Russia's nuclear forces," and Chapter 5, "Attacking Russian Cities" in *The U.S. Nuclear War Plan: A Time for Change* (NRDC, 2001) http://www.nrdc.org/nuclear/warplan.

7. Defense against biological weapons

The response to the anthrax letters demonstrated how poorly prepared the U.S. was for a even a small biological attack. One reason was that the "first responders" to a biological attack would be doctors and hospitals, not the police, fire departments, national guard, and the military.

Since the fall of 2001, the U.S. Government has begun to pour billions of dollars into biodefense and biodefense R&D. These investments include:

- Computers and communications systems for public health departments to facilitate early detection of unusual patterns of illnesses;

- Sensors in subways to detect biological agents;

- Regional stockpiles of antibiotics and vaccines;

- Programs to develop better detectors and vaccines for viruses that might be used by bioterrorists; and

- "Threat assessment" R&D to assess possible tactics that bioterrorists might use to disperse BW agents, and engineer them to enhance their virulence and to eliminate their susceptibility to vaccines and countermeasures to these tactics. These activities tend to be secret and are controversial, since the U.S. might create new threats in this way and/or be seen by other countries as developing an offensive BW program.

The concern that published life-sciences research might be used by bio-terrorists to create enhanced agents has created a great deal of debate about the appropriate

response. The leadership of the life-sciences community is concerned that government restrictions on publication would damage essential processes of information sharing and peer review within the community and has urged that it be allowed to deal with the problem itself. The first proposals for how to do this was contained in the National Academy of Sciences report, *Biotechnology Research in an age of terrorism: Confronting the dual use dilemma* (2004). Recently, a National Science Advisory Board for Biosecurity was established to advise the federal government on these issues.

Tutorials. The determinants of disease spread (A.G.).

Read

- "Bioterror: What Can Be Done?" by Matthew Meselson in *The New York Review of Books*, December 20, 2001, http://www.nybooks.com/articles/14971

- "Biotechnology and bioterrorism: An unprecedented world" by Christopher Chyba and Alex Greninger, *Survival 46, No. 2* (2004), pp. 143-162.

- "The Future" (pp. 287-314) in *Germs: biological weapons and America's secret war* by Judith Miller, Stephen Engelberg, and William Broad (Simon & Schuster, 2001).

- "Executive Summary," *Biotechnology Research in an Age of Terrorism,* http://www.nap.edu/books/0309089778/html/

- "Biodefense crossing the line" by Milton Leitenberg, Ambassador James Leonard and Richard Spertzel, *Politics and the Life Sciences 22 #2* (2004), p. 1, http://www.politicsandthelifesciences.org/Contents/Contents-2003-9/PLS2003-9-22-02-0002.pdf

Reference Sections 6.1 and 6.2 (pp. 122-127) of Chapter 6, "The basic model: dynamics" in *Infectious diseases of humans: Dynamics and Control* by Roy. M. Anderson and Robert M. May ((Oxford University Press, 1991).

IV. DIPLOMACY

8. Multilateral nuclear arms control

Aside from the 1970 Nonproliferation Treaty, multilateral negotiations on nuclear weapons control have focused on steps toward a Comprehensive [nuclear weapons] Test Ban Treaty and a Fissile Cutoff Treaty that would ban the production of more fissile materials for nuclear weapons.

The Comprehensive Nuclear Test Ban (CTB). The international test-ban movement began in 1954, after the radioactive fallout from the U.S. 10-megaton "Bravo" test blanketed a Japanese fishing boat, causing the death of one of its crew. In 1963, after the

Cuban Missile Crisis scared both the Soviet and U.S. leaderships as well as the world public, and under pressure from international concern about the worldwide radioactive fallout from atmospheric testing, the U.S., Soviet Union and U.K. signed the Partial Test Ban Treaty ending their nuclear testing everywhere but underground. Subsequently, all other potential nuclear-weapon states joined. In 1974, during the Watergate hearings, President Nixon signed the Threshold Test Ban Treaty, which limits U.S. and Russian underground nuclear tests to less than 150 kilotons. In 1992, following a series of testing moratoria called by Gorbachev and Yeltsin, Congress forced an end to U.S. nuclear testing by 1996 as long as no other country tested. In 1996, after prolonged negotiations in the Geneva-based U.N. Conference on Disarmament, most countries signed a Comprehensive Test Ban. However, in 1999, the U.S. Senate refused to ratify the treaty.

Central issues in the debate over the CTB Treaty were (and are) whether:

- The U.S. can maintain the reliability of its nuclear weapons without testing;
- The U.S. needs new types of nuclear weapons, which would have to be tested;
- Other countries could gain significant advantage by cheating below the detection threshold.[29]

Subsequently, the National Academy of Sciences published an analysis of these issues.

Despite the Senate rejection of the CTB Treaty, there has been a global testing moratorium since 1996 except for the Indian and Pakistani nuclear tests of May 1998 and many believe that those were carried out because India and Pakistan thought that a Comprehensive Test Ban was imminent and that they had a closing window of time in which to check their untested nuclear weapons.

The G.W. Bush Administration opposes ratification of the CTBT but says that it sees no current need to test. However, the leaderships of both the Department of Defense and Energy have called into question U.S. capability to maintain its nuclear stockpile without testing and have promoting new nuclear weapons – especially a nuclear earth penetrating "bunker buster." There was a great debate in the Senate on May 20-21, 2003 over the earth-penetrator and the repeal of a 1993 law[30] banning the development of new nuclear weapons with yields less than 5,000 tons of TNT equivalent ("mini-nukes"). The focus of the opponents was on the implication that nuclear weapons could be used for any other purpose than deterrence. After two more years of debate, the bunker buster proposal was zeroed out by the Congress in 2005. It has been replaced, howver, by a program to develop a new "Reliable Replacement Warhead" that is supposed to be developed and deployed without testing.

---

[29] The Senate debate, including much information submitted for the record, may be found in the *Congressional Record* of Oct. 8, 1999, pp. S12257-316; Oct, 12, pp. S12329-405; Oct. 13, pp. S12505-550, http://thomas.loc.gov.

[30] Spratt-Furse amend: http://www.ucsusa.org/global_security/nuclear_weapons/page.cfm?pageID=1182

Ending the production of fissile materials for weapons. During the 1950s and '60s, while the U.S. was ahead, it repeatedly proposed a bilateral halt with the Soviet Union of the production fissile materials for weapons. During the 1990s, this effort resumed as an international effort to negotiate in the UN standing Conference on Disarmament in Geneva, a global ban on the production of fissile material for nuclear weapons, a. k. a. as the "Fissile Material Cutoff Treaty (FMCT)." However, negotiations were blocked from 1994-2003 by demands of linkages by various countries to negotiations first of nuclear disarmament and then the non-weaponization of space – and by U.S. refusal to agree to such linkages. In 2004, after demands from other countries for strong linkages had been dropped, the Bush Administration announced that it did not think that an FMCT would be effectively verifiable and proposed a declaratory treaty such as the Biological Weapons Convention.

Despite the lack of negotiations, in the early 90s, the U.S., Russia, Britain and France all announced that they had ended production of fissile material for weapons. China also let it be known that it had embarked on a moratorium. This would leave only Israel, India, Pakistan and North Korea still producing fissile material for weapons.

Tutorials: How well do we know that other countries are not testing (ZM)? Can we know that nuclear weapons work without testing them (FvH)? The rise and fall of the nuclear bunker buster (RN?). Verifying a ban on fissile-material production for weapons (RSK)

Read

- "The Comprehensive Test Ban Treaty" by Jeremiah D. Sullivan, *Physics Today,* March 1998 http://www.aip.org/pt/vol-51/iss-3/vol51no3p24-29part1.pdf; http://www.aip.org/pt/vol-51/iss-3/vol51no3p24-29part2.pdf

- "The Death of a Treaty" by Terry L.Deibel, *Foreign Affairs,* Sept.-Oct. 2002, 142-161.

- "Nuclear Bunker Busters, Mini-Nukes, and the US Nuclear Stockpile," Robert Nelson, *Physics Today,* November 2003, http://www.physicstoday.org/vol-56/iss-11/p32.html

- *Nuclear weapons: The reliable replacement warhead program* by Jonathan Medalia, Congressional Research Service, July 20, 2005, Executive Summary, http://www.fas.org/sgp/crs/nuke/RL32929.pdf

- "The Fissban: Time for a Renewed Commitment or a New Approach?" by Jean du Preez, *Disarmament Diplomacy 79,* April/May 2005, http://www.acronym.org.uk/dd/dd79/79jp.htm

References

- *Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty* (National Academy of Sciences, 2002), Executive Summary at http://www.armscontrol.org/act/2002_09/nassept02.asp; full text at http://www.nap.edu/catalog/10471.html

- "Statement of C. Paul Robinson, Director, Sandia National Laboratories, Senate Committee on Armed Services, Oct. 7, 1999, http://www.fas.org/spp/starwars/congress/1999_h/991007pr.pdf

- "That old designing fever" by Greg Mello, *Bulletin of the Atomic Scientists,* January/February 2000, http://www.thebulletin.org/issues/2000/jf00/jf00mello.html;

9. **Dealing with the legacy of Cold War: Arms control**

U.S. & Russian Strategic Nuclear weapons. In1946, the U.S. offered to eliminate its nuclear weapons if other countries first opened themselves to international verification that they were not pursuing nuclear weapons. Negotiations quickly reached an impasse with the Soviet Union insisting that the U.S. eliminate its nuclear stockpile before the Soviet Union opened itself to international inspection. However, starting in 1972, the two countries did begin to sign treaties to at first limit their arms buildup and then later to reduce their nuclear weapons.

The first U.S-Soviet agreement limiting nuclear weapons was the 1972 U.S.-Soviet SALT I Interim Agreement with Respect to Limitation of Strategic Offensive Arms. This agreement was followed by:

- The un-ratified but complied with 1979 SALT II Treaty, which limits numbers of warheads per missile as well as missile launchers;

- The 1987 Intermediate-range Nuclear Forces Treaty that eliminated land-based missiles with ranges between 500 and 5500 km; and

- The 1994 Strategic Arms Reduction Treaty [START]), which limits Russia and the U.S. to a total of 1600 intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs) and heavy bombers each, and a total of 4900 warheads deployed on the ballistic missiles.[31] START implementation was completed on Dec. 5, 2001.

In May 2002, Presidents Bush and Putin signed the Strategic Offensive Reductions Treaty (a.k.a. "The Moscow Treaty"), according to which the U.S. and Russia will limit the number of their deployed strategic warheads to less than 2200 by Dec. 31, 2012. The Treaty has no requirements to destroy warheads taken off deployment or weapon-delivery systems and is to remain in force only through the end of 2012 but can be extended by "subsequent agreement."[32] The Treaty has no verification arrangements

[31] http://www.armscontrol.org/factsheets/start1.asp
[32] http://www.state.gov/p/eur/rls/or/2002/10471.htm

of its own but could be verified by the detailed verification arrangements in the START Treaty -- if START is extended beyond 2009.

The SALT Treaties were verified only by "national technical means:" imaging satellites and long-range radars for tracking missile tests. The INF and STAR Treaties include inspections at missile, ballistic-missile submarine and heavy-bomber bases and even the removal of the nose cones from randomly selected ballistic missiles to enable inspectors from the other country to check the that the number of warheads carried is in agreement with the number declared.

Warhead reductions. Beginning with the INF Treaty, proposals were made to limit non-deployed as well as deployed nuclear warheads. Such proposals have been the subject of nongovernmental and official U.S.-Russian technical studies but no negotiations have been launched. Instead reductions have been accomplished by unverified unilateral initiatives.

Only about half the nuclear weapons produced during the Cold War were long-range. The other half were short-range, "tactical" or "battlefield" nuclear weapons: nuclear artillery shells; short-range land-based, ship-based and aircraft-based missiles; bombs for fighter-bombers; nuclear-armed anti-aircraft missiles, torpedoes, and depth charges; atomic demolition mines, etc. These weapons have never been subject to verified limitations. However, in 1991, Presidents Bush I and Gorbachev issued parallel, unilateral statements in which they pledged to eliminate the nuclear weapons that had been assigned to the U.S. and Soviet armies; to reduce and keep nondeployed the tactical nuclear weapons that had been assigned to the surface navies and attack submarines, and to reduce the numbers of tactical nuclear weapons that had been assigned to aircraft. As a result, it is generally believed that the number of Russian and U.S. tactical weapons has been reduced from the tens of thousands to low thousands.

In 2004, under pressure from Congress to reduce the number of non-deployed U.S. strategic nuclear warheads to reflect reductions in deployed warheads, the Bush Administration announced a reduction by "almost half." Based on non-governmental estimates, this would correspond to a reduction from about 11,000 to about 6,000 total U.S. strategic and tactical nuclear warheads.

Tutorials: Using satellite images for verification (ZM). Verifying warhead elimination (FvH).

Read:

- "Nuclear arms control at a crossroads" (pp. 3-14) and "A strategy of staged reductions and de-alerting of nuclear forces" (pp. 15-27) in *The Nuclear Turning Point,* Harold Feiveson, ed. (Brookings, 1999).

- "The 1991-1992 [Presidential Nuclear Initiatives] and the elimination, storage, and security of tactical nuclear weapons" by Joshua Handler (pp. 20-41) in *Tactical Nuclear Weapons,* Brian Alexander and Alistair Millar, eds, (Brasseys, 2003).

- "What's behind Bush's Nuclear Cuts" by Robert Norris and Hans Kristensen, *Arms Control Today,* October 2004, pp. 6-12, http://www.armscontrol.org/act/2004_10/NRDC.asp.

References

- "A Comprehensive Transparency Regime For Warheads and Fissile Materials" by Steve Fetter, *Arms Control Today*, January/February 1999, http://www.armscontrol.org/act/1999_01-02/sfjf99.asp

- *Monitoring Nuclear Weapons and Nuclear-Explosive Materials: An Assessment of Methods and Capabilities* (National Academy Press, 2005).

10. Cooperative Threat Reduction

With the end of the Cold War, a new danger emerged: that the oversized WMD complexes that Russia could no longer support might become a sources of nuclear or biological weapons materials or expertise for terrorists or states. The U.S. therefore launched a number of programs to assist Russia in downsizing its production complexes, converting excess WMD personnel and disposing of the materials.

The name of one of these programs, the DoD "Nunn-Lugar" or Cooperative Threat Reduction program, is often used loosely as a label for all these programs. However, the largest nuclear assistance programs are located within the DoE's National Nuclear Security Administration (NNSA) and U.S. involvement in the International Science and Technology Center (ISTC), which provides R&D contracts to needy fSU scientists, is managed by the State Department. The total annual budget for the NNSA is about $800 million, for DoD about $400 million, and for State about $150 million.[33]

The U.S. and Russia also made a commercially-based agreement in 1994 under which the U.S. Enrichment Corporation is purchasing 30 tons of excess Russian weapon-grade uranium per year for resale for nuclear-power-reactor fuel after it is blended down to low-enriched uranium. The annual income of Russia's nuclear complex from this deal is about $500 million and it fuels about one half of U.S. nuclear-power capacity.

The largest NNSA program is the Materials Protection, Control and Accounting program (over $400 M in FY06). This program works to strengthen the security of Russian warheads, and fissile and radiological materials, provides radiation detectors at border crossings and megaports, and works to eliminate excess Russian civilian HEU. Other programs include conversion of U.S. and Soviet-designed HEU-fueled reactors ($25 M) and return to Russia of HEU fuel exported by the Soviet Union ($15 M); non-

[33] www.ransac.org

weapons R&D for Russian nuclear scientists ($40 M), shutting down Russia's last 3 plutonium-production reactors by providing alternative sources of heat and electricity for the local populations ($174 M), and assistance for the dispostion of excess Russian weapons plutonium ($35 M).

The DoD programs[34] include: chemical-weapon destruction ($100 M), elimination of strategic delivery vehicles (missile submarines, etc., $80 M), warhead security upgrades ($100 M), and WMD & BW proliferation prevention ($100 M).

The State Dept. programs include: non-weapons R&D for Russian WMD scientists ($60 M), and training of border-control personnel ($10 M). The major conduit of funding to support non-weapons R&D by Russian WMD experts is the International Science and Technology Center in Moscow, which is co-funded with a consortium of other nations.[35]

Cooperative efforts to upgrade fissile-material security have been attempted with other countries as well. The collaboration with China was suspended after the unproven Wen Ho Lee spy accusations.[36] During the Afghanistan war, the U.S. offered to help Pakistan to upgrade the security of its nuclear weapons and materials. Pakistan refused out of fear that the U.S. might try to seize or destroy these strategic assets if it knew where they were.

Tutorial: Corralling the nuclear terrorist's choice, highly-enriched uranium.

Read

- "Potatoes were guarded better…" by Oleg Bukharin and William Potter, *Bulletin of the Atomic Scientists,* May-June 1995 http://www.thebulletin.org/issues/1995/mj95/mj95.bukharin.html

- "Nuclear Roulette" (pp. 231-279) in *Hang Separately: Cooperative Security between the United States and Russia, 1985-1994* by Leon V. Sigal (New York: The Century Foundation Press, 2000).

- "Reducing the threat of HEU-fueled nuclear terrorism" by Alexander Glaser and Frank N. von Hippel, *Arms Control Today,* January, 2006 .

References

- *Controlling Nuclear Warheads and Materials* by Matthew Bunn and Anthony Wier (Nuclear Threat Initiative) http://www.nti.org/e_research/cnwm/overview/cnwm_home.asp

---

[34] http://www.defenselink.mil/pubs/ctr/
[35] http://www.istc.ru/
[36] "Scientist, fisherman, gardener, spy" by Stephen Schwartz in *The Bulletin of the Atomic Scientists,* November/December 2000, p. 31.

11. **Student paper presentations and a debate on proliferation**

12 **The future of U.S. nuclear-weapons Policy**

U.S. nuclear-weapons policy has two main dimensions:

- Deterrence of nuclear attacks and any other actions by other countries that the current administration thinks are credibly deterrable by nuclear threats, and

- Persuasion of other countries not to acquire nuclear weapons.

There is obviously some tension between these two objectives and much debate revolves around the degree to which other countries are influenced by the U.S. example versus the security threats that they perceive in their neighborhoods.

In the past, the proliferation situation was less volatile because most countries that felt threatened were under either the Soviet or the U.S. nuclear umbrella, which meant giving up nuclear ambitions of their own. Today, few countries ally themselves with Russia and a number feel the need to have a deterrent against threats of intervention from the U.S. The proliferation situation has therefore become more volatile.

Abolition. What about abolition? The Chemical Weapons Convention attempts to ban chemical weapons. The Biological Weapons Convention attempts to ban biological weapons. The Nonproliferation Treaty commits the nuclear-weapon states to pursue nuclear disarmament in good faith.

Some are profoundly skeptical, however, about the goal of eliminating WMD. They believe that the existence of nuclear weapons prevented World War III. They do not believe that the elimination of WMD is verifiable or that a zero-WMD world would be stable to a breakout. In short, they believe that WMD abolition is neither feasible nor desirable.

Some who are not comfortable with the idea of living with WMD indefinitely and who do not see how nations can remain indefinitely divided between a few WMD haves and the rest WMD have-not countries have postponed engaging in the debate because they think that, whether we are aiming for small or zero stockpiles makes little difference today. Others worry about fudging what they see as a profoundly moral issue.

Read

- “Bush’s Nuclear Revolution” by George Perkovich, *Foreign Affairs 82,* March/April 2003, pp. 2-8 and addendum “Taming Teheran” November 24, 2004; http://fullaccess.foreignaffairs.org/

- “Its dangerous to disarm” by Richard Haas (subsequently head of the State Department’s Policy Planning office and now President of the Council on Foreign Relations), *New York Times,* Dec. 11, 1996.

- “The road to abolition: how far can we go?” (pp. 287-301) in *The Nuclear Turning Point.*

- “Why Do We Have to Keep the Bomb?” by Kathleen Bailey, *Bulletin of the Atomic Scientists,* January/February 1995, http://www.thebulletin.org/article.php?art_ofn=jf95bailey

- “Zero Tolerance” by Lee Butler (former Commander in Chief of the U.S. Strategic Command), *Bulletin of the Atomic Scientists,* January/February 2000, pp. 20-21, http://www.thebulletin.org/article.php?art_ofn=jf00butler