Technical Challenges to Nuclear Policy
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The top priority for U.S. nuclear weapons policy is to keep dangerous nuclear weapons and fuel out of the hands of very dangerous leaders in rogue nations and sub-national entities, including suicidal terrorists. As President Bush stated in 2002: "The gravest danger this nation faces lies at the crossroad of radicalism and technology."

This presents both a political and technical challenge. Technically we must do what is needed to ensure that our nuclear deterrent remains safe and reliable and appropriate for the new challenges posed by terrorism and the nexus of radicalism and technology. At the same time as the United States reviews its nuclear policy in the face of newly emerging threats, we should also strive to strengthen international efforts to reinvigorate a nonproliferation regime that has recently come under severe challenge.

Limiting the spread of nuclear weapons to no more than a handful of nations was a major success during the darkest days of the Cold War. A norm of non-possession of these weapons was established, and also one of their non-use in military combat extending over 59 turbulent years. (See Fig. 1) This record belies a frequently expressed view by those who disparage the value of negotiated arms control treaties. By our words as well as deeds the U.S. has to be careful not to weaken the nonproliferation regime. We have no better alternative to it.

The most effective means for minimizing the risks of terrorists or other radical, sub-state entities from acquiring nuclear weapons is to keep the nuclear fuel, enriched uranium and plutonium, out of their hands. This also applies for states that have no uranium ore on their territory and for whom, like the terrorists, theft or illegal purchase

may be the only way to get their hands on that material. For them acquiring nuclear fuel is the most difficult step enroute to a nuclear weapon.

As to denying a nuclear capability to nations with uranium deposits within their borders, the challenge is quite stark: to keep them from developing the infrastructure for enriching U to make a simple gun-type bomb, which is less challenging than manufacturing Pu and building implosion weapons. A blue print meeting this challenge is contained in the Bush-Putin Declaration of Moscow dated May 2002. It calls on all nations to strengthen and strictly enforce export controls, interdict illegal transfers, prosecute violators, and tighten border controls to prevent the proliferation of nuclear weapons (as well as biological or chemical), and creating regional facilities for multi-lateralizing the nuclear fuel cycle. Similar constructive and important proposals have been made by Dr. El Baradei, Director General of the IAEA. I list them in Fig. 2. This program presents a considerable intelligence challenge requiring technical and human resources, and also a diplomatic one requiring broad international cooperation to monitor such compliance measures, to share information and cooperate in interdiction operations and to apply and enforce sanctions when all else fails.

[We might be talking about North Korea in this case. The modern technology of gas centrifuge uranium enrichment which is all that would be required for an uranium gun-type bomb is making the challenge increasingly difficult as the efficiency of the process increases. The plant and energy needed to produce fuel for several weapons during a year is an order of magnitude smaller than what would be required to fuel a GW nuclear power reactor – not a major facility. This emphasizes the importance of being able to monitor from the very beginning of construction and insisting on authority for on-site challenge inspections of suspicious activity. As difficult at this challenge may be, we can have a measure of confidence that our technology can succeed based on our experience

with Iran and North Korea and the fact that their efforts at covert programs did not escape detection for very long.]

So far all these measures I have mentioned for ensuring compliance with the nonproliferation regime come in the form of sticks or demands upon countries to accept new restrictions and more intrusive and comprehensive inspection measures. The technical requirements for carrying out the desired inspections are straightforward. The diplomatic ones for obtaining agreement for NNWS to forego nuclear programs are more difficult. Absent a compensating offer of diplomatic carrots that address legitimate security concerns and motivations for countries to seek a nuclear capability, they are hardly likely to be accomplished in the near future.

Already at the extension of the NPT into the future in 1995, which was signed on to by 185 – all but 4 of the 189 nations in the world at the U.N., the discriminatory regulations and restrictions between the nuclear and non-nuclear weapons states were cause of great concern. It was apparent that rather than insisting that our nuclear weapons are OK but yours are bad, and you may not have them, we are going to have to address motivations for acquiring nuclear weapons, be they security concerns, or political/economic ones, for negotiations to succeed. That is the topic for our follow-on panel.

But on a technical side, there was also a very broad call by the NNWS for a reduction of reliance on nuclear weapons by nuclear powers, a continued moratorium on underground testing leading to a Comprehensive Test Ban Treaty, and further reductions in the numbers in the nuclear forces remaining as a legacy of the Cold War. In this context it is very disturbing to find statements in the 2002 Nuclear Posture Review and to hear public statements by senior government personnel that have highlighted a specific need for the U.S. to develop a new generation of low-yield earth penetrating nuclear

weapons or so-called mini-nukes for bunker busters "to defeat emerging threats such as hard and deeply buried targets" (from Nuclear Posture Review, 2001). Such targets are of growing military interest as their numbers are increasing. These low-yield weapons will not add to the technical ability of the U.S. to hold such targets at risk – our current nuclear arsenal already meets such a need. They are proposed as more useable because of the reduced collateral damage they will cause.

Aside from a fundamental question of whether the U.S. really wants to deploy weapons that lower the nuclear threshold for limited military missions beyond their role for defensive last resort, a decision by the world's only superpower to develop and test such presumably more useable nuclear weapons for new military missions would send a clear and negative signal about U.S. commitment to nuclear nonproliferation efforts. If the United States, the strongest nation in the world, concludes that we cannot protect our vital interests without relying on nuclear weapons for use against military targets and limited war situations it would be a clear signal to other nations that nuclear weapons are necessary for their security purposes too. We can anticipate strong questions of our motivations and commitment to nonproliferation next year in the upcoming five-year review of the NonProliferation Treaty.

I am well aware that the United States has not yet begun construction of such new weapons nor has it committed to resuming UGTs for developing them at this time. And I appreciate fully the statements to that affect from the leadership of the NNSA and the Department of Energy. However the words from the White House remain on the record. They need clarification, from actions by the Congress in its funding decisions if not from the administration itself.

Independent of potential new weapons programs to develop bunker busters, we need strong technical programs at our national labs to ensure that we retain an effective

nuclear deterrent. The first order of business under the current moratorium on underground nuclear explosive tests is to ensure that our present nuclear arsenal remain safe and reliable. This requires sustained support for the nuclear laboratories stewarding and maintaining the nuclear stockpile. The current multifaceted program of enhanced surveillance, forensics, extensive simulations with new computers, and experiments with advanced facilities that has been strongly supported for the past nine years is meeting that challenge very well. It is enhancing confidence in our stockpiles by providing a deeper understanding of the weapons. We are ensuring robust performance margins. We are identifying and fixing design flaws and other significant findings. We are learning how the bomb materials age and what to do about it. With this program we sustain and support an excellent cadre of engineers and scientists capable of sounding a warning bell should serious or unforeseen problems arise as the stockpile ages. Hopefully Los Alamos will soon be able to recover from its regrettable security incidents and the two design laboratories together with Sandia, which has the responsibility for the multi-components outside of the physics package, will continue to lead a strong program which is central to our security. (QMU) Support for these laboratories and their broad science program is essential to their overall intellectual health and leadership, and for U.S. security. I believe the program so far has been very successful. I know of no leader at the laboratories who says that there is a need at present for nuclear testing. Looking ahead, I see no need for the foreseeable future. The testing moratorium is not impeding our maintaining a healthy arsenal, and resumed testing is not called for. This has been affirmed by a number of studies, most recently by the National Academy of Science study in 2002.

As for the military need or desirability of new bunker busters, their value against hardened buried targets should not be exaggerated. Among the underground targets of

most concern are very hardened structures built, at depths of 1,000 feet or more, with reinforced concrete capable of withstanding up to 1,000 atmospheres overpressure.

Destroying such targets requires knowing exactly where they are and then precisely delivering a warhead that can penetrate into the earth without damage before detonating. The warhead must also have a sufficiently large explosive yield to transmit a strong shock. The United States after >1000 tests has already designed and tested a variety of low-yield nuclear devices that could be adapted for delivery in structurally strengthened warheads for destroying underground targets at shallow depths. Recently, it adapted a high-yield weapon, the B61-11 bomb, with yields that exceed a hundred kilotons, in this manner. A key technical challenge is to develop the means to deliver such a bomb intact to depths of 10 feet or so before detonation. Detonation at such depths increases, by a factor of 10 to 20 relative to a surface burst, the energy of the explosion that is delivered into the ground instead of into the atmosphere. The warhead therefore hits the target – a hardened, buried bunker or tunnel – with a much stronger shock than an identical warhead that is detonated on or above the surface.

Taking into account realistic limits on material strengths, about 50 feet is the maximum depth to which a warhead dropped from the air into dry rock soil could maintain its integrity until detonated. This is true even with impact at supersonic speeds. For the shock to reach down to 1,000 feet with enough strength to destroy a hard target in dry rock, the yield of the warhead must be significantly larger than 100 kilotons. Certainly not a low-yield weapon. As to the collateral damage produced by such bunker busters, particularly if used in or near urban settings, which can be the preferred locales for hardened underground targets, the blast of even a very “low-yield,” one-kiloton earth penetrator would eject vast amounts of radioactive debris, and would be quite devastating in a city. The radioactive containment from a one-kiloton warhead (just 1/13 the yield of

the bomb that destroyed Hiroshima) detonated at a depth of 20-50 feet would eject more than 1 million cubic feet of radioactive debris from a crater about the size of ground zero at the World Trade Center – bigger than a football field. Indeed the Hiroshima bomb was detonated at an altitude of close to 1,900 feet in order to minimize radioactive fallout by not digging any crater. And against really deep targets, yields in the hundreds of kilotons would be required. A nuclear weapon with a yield capable of destroying a target 1,000 feet underground – a yield well over 100 kilotons – would dig a much larger crater and create a substantially larger amount of radioactive debris. (Dimensions scale roughly as $Y^{1/3}$ and volume and mass of debris closer to Y).

Accuracy is also crucial. Do very well with GPS and laser-guide. But most difficult challenge for destroying hardened underground targets is the ability to locate, identify, and characterize such targets. The payoff of accuracy in underground target location, not just in delivery of a weapon is enormous (lacking in Iraq). It is also important to find any vulnerable points such as tunnel entrances or air ducts.

Nuclear weapons are also of limited value against biological and chemical weapons stored in underground bunkers. When detonated underground their effective range in destroying the deadly effects of pathogens and gases is limited by the fact that their blast effects extend beyond the area of very high temperatures and radiation they create for destroying such agents. This area extends not much further than the range of neutrons and prompt gamma rays emitted during the explosion, or only a few meters for a kiloton weapon and increasing only as the cube root for higher yields. Therefore they would be more likely to spread these agents widely, rather than to destroy them completely. As an alternative to destroying such localized HDBTs, the United States should pursue effective means to put them out of business – that is, to functionally defeat them – using conventional forces and tactics. This would require improving the ability to locate and

seal off their points of access and exit for equipment, resources, and personnel; and, when possible, to establish area control and denial around them, as well as improving penetration capabilities of existing weapons – especially conventional munitions. (For 30 years there has been important work on this problem at Sandia National Lab led by William Patterson and C. Wayne Young).

A positive action by the United States against nuclear proliferation would be to affirm our continuing support for the moratorium on testing and working toward bringing into force the Comprehensive Test Ban Treaty.

All U.S. allies in NATO, including Great Britain, Germany, and France, have signed and ratified the CTBT, as have Japan and Russia. Israel has signed the CTBT and is participating energetically in the work of setting up a verification system. Others, including China, have indicated they will work to bring the treaty into force once the United States has ratified it. Currently 32 of the 44 states that have build nuclear reactors, the so-called "nuclear-capable states," that must ratify the treaty for it to enter into force have done so. In all, 112 states have ratified and 171 have signed. It is time for the U.S. to reconsider the issue of ratifying the CTBT. The White House and the Senate should enter into a serious debate to clarify the underlying issues, both the concerns and opportunities. This debate was not adequately joined in 1999 when the CTBT first came before the Senate for its advice and consent to ratification, and regrettably the Bush administration has thus far refused to reopen the question.

Why is the United States reluctant? In addition to the dubious need to develop "concepts for follow-on nuclear weapons better suited to the nation's needs," including nuclear earth penetrators against HDBTs, opponents of the CTBT have raised two questions: (1) "How can we be sure that many years ahead, we will not need to resume yield testing in order to rebuild the stockpile?"; and (2) "How can we monitor

compliance by other CTBT signatories to standards consistent with U.S. national security?"

The answer to the first question is that total certainty can never be achieved. But the United States can be assured that the CTBT is consistent with the ability to retain high confidence in the reliability of its existing nuclear force for decades. As I already argued it has been demonstrated by a number of detailed technical analyses. Requires good labs – good science at labs. A strong SBSS has enhanced confidence in stockpile.

Concerning the question of compliance, there is a broad agreement that the United States could monitor CTBT compliance to standards consistent with its national security. Based on its technical analysis, the National Academy of Sciences study group concluded that

> The worst-case scenario under a no-CTBT regime poses far bigger threats to U.S. security – sophisticated nuclear weapons in the hands of many more adversaries – than the worst-case scenario of clandestine testing in a CTBT regime, within the constraints posed by the monitoring system.

When fully implemented under a CTBT, the verification system becomes more robust and difficult to evade, by acquiring challenge rights to check out data initially derived from remote sensors by conducting short-notice, on-site inspections of suspicious events. A further strengthening of the sensitivity of the CTBT to detect covert, treaty-violating activities could be negotiated by adding appropriate bilateral transparency and confidence-building measures with the other nuclear powers, Russia and China in particular. These would permit on-site sensors to be introduced at their instrumented test sites to monitor for signals – seismic and radiological – from possible underground tests that are banned by the CTBT. The Bush administration should clearly state its

willingness to initiate such an arrangement, reciprocally with the Russians, at Novaya Zemlya and the Nevada Test Site.

The CTBT does not increase the requirements for the U.S. to monitor and identify underground testing. The U.S. will want all information on testing activities, with or without the treaty. It does, however, add to the difficulties for a country to evade the treaty not only by strengthening the system but also by adding the inspection rights. Furthermore, given that the United States has the most advanced and sophisticated diagnostic, analytical, experimental, and computation facilities, it is in a stronger position than other nations to maintain a deterrent under a test ban. As General Shalikashvili concluded in this study, "I believe that an objective and thorough net assessment shows convincingly that U.S. interests, as well as those of friends and allies, will be served by the Treaty's entry into force."

Finally, at the same time as we work to prevent the most dangerous weapons from getting into the hands of the most dangerous people, we must also intensify efforts to reduce the threat of unauthorized or accidental launch of existing weapons, particularly in the Soviet Union that remain as a legacy of the Cold War. Beyond accelerating the Nunn-Lugar Cooperative Threat Reduction Program to provide secure protection and control of existing arsenals in the former Soviet Union, we should be expanding efforts with the G8 nations to provide safe keeping for nuclear fuel around the globe. The recommendations in this regard of the 2001 Report by the Russia Task Force of the Secretary of Energy Advisory Board co-chaired by Howard Baker and Lloyd Cutler on the Department of Energy's NonProliferation Program with Russia should be implemented. In addition steps to reduce the threat of unauthorized and accidental launch of long-range missiles should be negotiated with Russia by an agreement to

immediately stand down all missiles slated for reduction under the Treaty of Moscow (Strategic Offense Reduction Treaty May 2002).

The passage of time should not erode our appreciation of the fundamental difference between nuclear and non-nuclear weapons. Their use must be restricted for purposes of defensive last resort. Our policy actions should honor the spirit and commitment in the NonProliferation Treaty calling for reductions in the number of nuclear weapons and in our reliance on them, as we work, over the long haul, toward their eventual elimination. The ultimate challenge that they present was summarized powerfully by Father Bryan Hehir, the former Dean of the Harvard Divinity School, at a conference at Stanford University in 1987:

> For millennia people believe that if anyone had the right to call the ultimate moment of truth, one must name that person God. Since the dawn of the nuclear age we have progressively acquired the capacity to call the ultimate moment of truth and we are not gods. But we must live with what we have created.

Figure 1

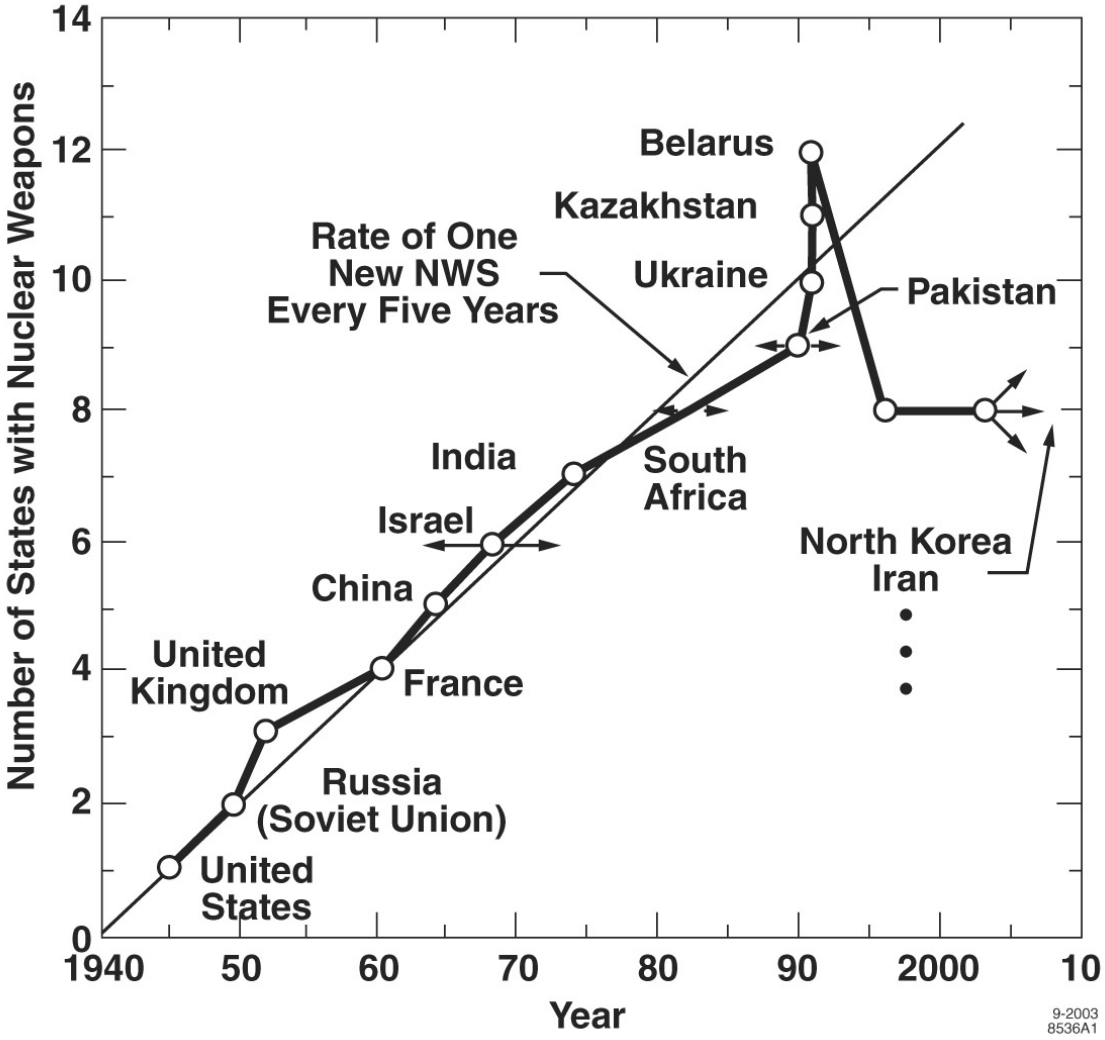
Number of States with Nuclear Weapons
Year
Belarus
Kazakhstan
Ukraine
Pakistan
Rate of One
New NWS
Every Five Years
India
South
Africa
Israel
China
North Korea
Iran
United
Kingdom
France
Russia
(Soviet Union)
United
States
9-2003
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Figure 2

NEW INITIATIVES TO STRENGTHEN NUCLEAR NONPROLIFERATION TREATY

●PROLIFERATION SECURITY INITIATIVE (PSI)
cooperative interdiction efforts against nuclear technology

●ADDITIONAL PROTOCOL (AP)
IAEA challenge inspections of clandestine activities

●NO ACQUISITION OF NEW COMPLETE FUEL CYCLES
guarantee access to regional centers

●EXPAND COOPERATIVE THREAT REDUCTION PROGRAM (NUNN-LUGAR)
G-8 and beyond for material protection, control and accountability

●CRIMINALIZE PROLIFERATION
UN Security Council Resolution requiring strict export controls and sensitive materials security

●STRENGTHEN IAEA
special committee on safeguards and verification

●PROHIBIT STATES UNDER INVESTIGATION FOR VIOLATIONS
from serving on IAEA Board of Governors or new committee