The Future of Nuclear Arms Control

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It's a great privilege for me to be invited to join this very distinguished panel. As you can tell from the color of my hair, I represent the next generation of physicists involved in public policy. Rather than talk about the history of physics in national defense, I'll talk about the future—in particular, the future of nuclear arms control.

As you've heard during this session, physicists have made many important contributions to U.S. security and international peace during the last half century. Ever since they invented nuclear weapons, physicists have supported efforts to control nuclear arms and prevent their use. They've helped explain to the public and to political and military leaders how the existence of nuclear weapons has forever changed the nature of warfare, making large-scale war transparently irrational. Physicists have been instrumental in formulating arms control and nonproliferation agreements and in laying the technical foundation for their verification.

During the last decade these efforts have borne much fruit, fertilized by the disintegration of the Soviet Union. The START I Treaty, which today is almost fully implemented, cut strategic arsenals roughly in half, to 6000 "accountable" warheads. The START II Treaty, which was signed in 1993 but has not yet been ratified by Russia, promises to reduce the number of deployed strategic warheads by another factor of two, to 3500 warheads. Two years ago in Helsinki, the U.S. and Russia agreed to negotiate a START III Treaty that would reduce the total to 2500. During this time both countries promised to unilaterally reduce tactical nuclear forces, to take bombers off alert, and to end the production of fissile material—plutonium and high-enriched uranium—for weapons.

There has also been great progress in nonproliferation. Brazil, Argentina, and South Africa ended their nuclear weapons programs; and Belarus, Kazakhstan, and Ukraine returned all of the nuclear weapons on their territory to Russia; and all of them joined the Non-Proliferation Treaty—the NPT—as nonnuclear-weapon states. Iraq's nuclear program was dismantled and North Korea's was frozen. In

1995 the NPT was renewed indefinitely; and in 1996 the Comprehensive Test Ban Treaty was signed by all the nuclear-weapon states. Nuclear-weapon-free zones now cover the entire southern hemisphere, from Latin America to Africa to Southeast Asia and the South Pacific.

If ten years ago someone had told me that all this would happen in the next decade, I probably wouldn't have believed them. Given this recent track record of success, there's an understandable temptation to conclude that everything's under control, that we don't have to worry about nuclear weapons any more.

Unfortunately, there's still much cause for concern. Nuclear weapons remain a real and present danger to the security of the United States—the largest threat, and, in some sense, the only significant threat.

There's the danger posed by the huge Russian nuclear arsenal in a period of intense political and economic turmoil. The threat of premeditated strikes has been replaced by the risk of accidental, unauthorized, or erroneous use of nuclear weapons, and by worries that nuclear weapons, fissile materials, or nuclear technologies and expertise might flow from Russia to other countries or even to subnational groups. Over the longer term, I'm concerned about the stability of Russian democracy and the possibility of a return to hostile relations.

We also should be worried about the long-term stability of the nuclear nonproliferation regime. I don't share the widespread assumption in the U.S. that the current regime can endure forever—the regime in which five countries (or eight countries, depending on who you count) are allowed to possess nuclear weapons while all other countries are not. Our ability to build coalitions and marshal world opinion against the spread of nuclear weapons depends at least in part on continued progress in reducing the size and salience of our own arsenal. It requires that we take seriously our commitment, in Article VI of the NPT, to work toward nuclear disarmament.

To deal with these concerns, I would advocate a two-part agenda for future. First, we should reduce dramatically the size and readiness of U.S. and Russian nuclear arsenals, while increasing substantially the transparency and security of warhead and fissile-material stockpiles. Second, we should lay the technical foundation for the prohibition of nuclear weapons. Physicists can play a vital role in this agenda.

Regarding the size of nuclear arsenals, we should begin with the realization that a single nuclear warhead can destroy a large city and kill a million people. One hundred warheads can destroy the U.S. and civilization as we know it. Even after START II is fully implemented, the U.S. plans to retain about 10,000 warheads, each of which is roughly 10 times more destructive than the bomb that devastated Hiroshima. In addition, the U.S. will retain nuclear components to build another 5,000 warheads. Russia probably has similar plans. Such vast stockpiles increase fears of rapid breakout from treaty restrictions; increase the consequences of any use of nuclear weapons; and increase the risk of unauthorized or erroneous use or theft of nuclear weapons.

But the U.S. and Russian nuclear arsenals are not only immense, they are ready for nearly instant use. Today, each can launch over 2000 warheads within a few minutes of a decision to do so. Even after START II is fully implemented, the U.S. will be able to launch 1500. Both sides continue to watch the other, ready to "push the button" if it believes the other side has launched an attack.

This high state of readiness is dangerous and unnecessary—dangerous because it increases the chance of accidental, erroneous, or unauthorized use; unnecessary because the threat of instant attack isn't required to deter a deliberate nuclear strike. A deliberate Russian strike has, in any case, become so unlikely as to be almost unthinkable.

Because U.S. forces remain at high states of alert, conservative Russian planners will consider a worst-case scenario: a massive U.S. attack with little or no warning. Today, Russia has only a handful of missiles that are poised to survive such an attack—perhaps one regiment of mobile missiles out of garrison and one or two submarines at sea. Russia reportedly guards against the possibility of surprise attack by keeping its other nuclear forces—silo-based ICBMs and some pier-side SLBMs—ready to launch on warning.

Maintaining nuclear forces on constant alert, in a launch-on-warning posture, is difficult and dangerous enough in the best of conditions, with the best technical systems and the most reliable chain of command. But these aren't the best of conditions. Russia is in the midst of a extended political and economic crisis that could worsen rapidly.

Within the armed services, wages go unpaid for months. Morale is low and corruption is widespread. Facility maintenance and personnel training are deferred. On several occasions electrical power has been cut off to strategic nuclear facilities because bills were not paid. Communications have been disrupted because thieves were "mining" cables for valuable metals.

Russia's attack warning system is seriously fragmented and degraded. Only three of its nine modern radars are working at all, and seven of the ten older Hen House radars lie outside Russian territory. Two of the nine slots in its constellation of early warning satellites are empty, and Russia appears to lack satellite coverage of ocean areas from which U.S. (or British or French) submarine missiles could be launched. For reasons of safety, the U.S. requires "dual-phenomenology" for attack warning—that is, we require that missiles be detected both by satellite sensors and by radars before we conclude that we're under attack. Russia lacks dual phenomenology for certain missile corridors.

The dangers of this hair-trigger posture were illustrated when the launch of a harmless Norwegian scientific rocket triggered the first-ever activation of Yeltsin's "nuclear briefcase." Although Russia detected the error in time, one wonders what might happen if such an event occurs during a period of political or military crisis.

The economic turmoil in Russia has also raised the specter that nuclear warheads or nuclear materials might be stolen. Guards who haven't been paid for months have left their posts to forage for food. And guards without winter uniforms are reluctant to man unheated posts in sub-freezing conditions and patrol facility perimeters.

There's a long list of incidents in which personnel with responsibilities for nuclear weapons have gone on strike or have stolen equipment or nuclear materials. In a few cases, desperate or deranged soldiers have shot their comrades or have taken hostages. For example, in one 16-day period in September:

- five soldiers from the 12th Main Directorate of the Ministry of Defense (the unit in charge of security for nuclear weapons) killed a guard at Novaya Zemlya (the nuclear test site) and tried to hijack an aircraft;

- a 19-year-old sailor went on a rampage aboard a nuclear attack submarine, killing 7 with an AK-47 and a chisel before barricading himself in the torpedo bay and committing suicide.

- a Ministry of Internal Affairs sergeant at Mayak, where 30 tons of plutonium are stored, shot two comrades and wounded another before escaping. Fortunately, he was more interested in the stealing guns than the plutonium.

There probably are many more such incidents that we don't know about. When you set events like these in the larger political and economic context, it's not an exaggeration to say that anarchy is real possibility in Russia—anarchy in the midst of thousands upon thousands of nuclear weapons, and fissile material for thousands more.

In short, ten years after the end of the cold war, there are too many nuclear weapons, too ready for use. The threat of deliberate attack by an implacable, ideological adversary has been superseded by the threat of theft, anarchy, and erroneous or unauthorized use.

This is why I'm concerned about nuclear weapons. But what can we do about it?

Because many of these risks result from the economic situation in Russia, there are limits to what we can do on our own. We can, however, lead by example, and give Russia incentives to do the sorts of things that would improve our own safety and security. We can do this through a combination of formal agreements, such as START III, new reciprocal unilateral initiatives, such as the reductions in tactical forces, and assistance programs (such as the Nunn-Lugar program), in which we help Russia dismantle its weapons and improve safeguards on nuclear weapons and materials.

First, we should reduce the size of nuclear arsenals dramatically. During the START II negotiations, Russia argued for a limit of 2000 to 2500 deployed strategic warheads, but the U.S. insisted on 3500. Today, knowledgeable Russians say that Russia will be hard-pressed to deploy more than 1000 strategic warheads, but the Pentagon wants to deploy 2500 under a START III agreement. I think we should go as low as Russia is prepared to go. Why do we need to deploy more than 1000 warheads?

In reducing the size of arsenals, we have to go beyond the focus on deployed strategic warheads. The START agreements do nothing to limit the number of reserve warheads or tactical warheads, but these generate a number of concerns. Russia worries that the U.S. could rapidly replace the warheads that would be removed from Trident and Minuteman missiles under START II, doubling the size of our force in a matter of months. The United States is concerned about the security of Russia's warhead stockpiles and about Russia's increased reliance on tactical nuclear weapons to offset the conventional forces of NATO and China. Russia worries about the deployment of tactical warheads in an expanded NATO.

At the high force levels permitted by START I and START II, the stability of the nuclear balance is insensitive to the total number of warheads each side has. But as the number of deployed warheads moves from 3,500 to 1,000 or less, uncertainties about the total number of warheads—and the amount of fissile material available to make new warheads—would loom much larger. For this reason, in the future nuclear arms control must focus on limiting warhead and fissile-material stockpiles.

As a first step, the US and Russia should exchange detailed information about their inventories of nuclear warheads, and the dismantling of warheads and the disposition of the nuclear materials. Today, our estimates of Russian stockpiles are highly uncertain—the CIA has testified that the uncertainty is plus or minus 5,000 warheads. Our estimates of fissile material stockpiles are even more uncertain. Russia tells us that excess warheads are being dismantled and that warheads and materials are safe and secure, but we have little hard information. A data exchange, followed by inspections to verify its accuracy, would give us the information we need to help Russia improve its security, and confidence that its nuclear arsenal is being reduced irreversibly.

Inspections or transparency measures to confirm the accuracy of a data exchange will present a number of challenges, but several technical innovations could make this job easier. For example, a tagging system could greatly simplify inspections. If one ever found a warhead without a valid tag, that would be unambiguous evidence of a violation. Tags also would allow a chain of custody, in which excess warheads could be tracked from deployment to storage to dismantling sites. Tags would permit statistical sampling, reducing inspection effort and intrusiveness. A random sample of only 20 or 30 warheads at a particular site would give high confidence that the declaration is accurate.

But how would one know that an object which is said to be a warhead really is a warhead, or a warhead of a particular type? This could be done by developing "fingerprints" or templates of warhead types. For example, Russia could present one or more SS-18 warheads for fingerprinting, or warheads could be selected from a deployed missile by U.S. inspectors. A set of agreed characteristics could be measured, such as mass, the strength of neutron or gamma-ray emissions, or heat output. A fingerprint of this type would be extremely difficult to spoof. To protect sensitive design information, an automated system could be devised to give a simple "yes" or "no" answer to the question, "Is this an SS-18 warhead?" I believe that such a system has already been developed by Argonne National Lab.

A more difficult problem is knowing that the declaration is complete—that there are no hidden stockpiles of warheads or fissile material. Anytime-anywhere inspections are often mentioned as one way to detect hidden stockpiles if they exist, but a well-designed plan to hide warheads or materials would give few clues about where to look. A better approach is to exchange detailed historical information on the nuclear stockpiles as part of the initial declaration. These records could be examined for internal consistency, for consistency with the current stockpile declaration, and they could be compared to archived intelligence information. This is the method that was used by the IAEA to verify that South Africa's declaration was complete.

In some cases, inspections might be able to confirm the completeness of the declaration. For example, measurements of isotope ratios in the permanent structural components of plutonium-production reactors (e.g., graphite) can verify declarations of the total production of plutonium at that reactor. Recent tests of this concept show that this is accurate to within a few percent. Knowing the amount of plutonium produced would, in turn, validate declarations about the production of warheads. Similarly, isotope ratios in depleted uranium can confirm declarations about HEU production. These are examples of what I like to call "nuclear archaeology." I hope it will be a growth industry.

It will also be necessary to verify the dismantling of warheads without revealing sensitive information. DOE has developed several options for this. One option is simply to verify that a plutonium pit has been put in monitored storage. If the weapon to be dismantled was exposed to a neutron pulse, it would be possible to say that the pit came from a particular warhead. Another method is to use perimeter-portal monitoring at dismantling facilities, and count warheads going in and pits coming out. DOE and the national labs are to be commended for thinking about such schemes and technologies well in advance of an agreement with Russia.

All of this has to do with reducing the size of the arsenals. But we should also reduce the readiness of nuclear forces. The current situation, in which both countries stand ready to launch thousands of nuclear weapons in a few minutes, is unnecessary and dangerous, particularly given the state of Russian nuclear forces and command and control. Deterrence requires only the ability to retaliate, not the ability to retaliate immediately. Both countries should take their vulnerable forces—their silo-based and in-garrison mobile missiles and pier-side SLBMs—off alert. Alert forces—submarines at sea and mobile missiles out of garrison—should be reduced to the minimum required for deterrence. Russia has already done this out of economic necessity; the US should follow suit.

The US and Russia should take steps to assure each other that their forces are not capable of surprise attack. The agreement to exchange launch warning data is a good first step, but more could be done. We could, for example, consider using various technical devices to assure each other than ICBMs and SLBMs have not been made ready for attack. I have heard several ideas along these lines. For example, I believe Dick Garwin suggested that subs could be asked to surface from time to time, to demonstrate that they were patrolling out of range of targets in the U.S. or Russia.

Let me end by saying a few words about nuclear disarmament. I try to avoid the topic because it's divisive, and because I'm afraid that debate about disarmament will distract us from the important work that I've outlined above—work that should be done whether or not we believe that disarmament is the ultimate goal; work that probably will take us 20 or more years to complete.

So why bring the subject up? As I mentioned earlier, we've already signed a treaty that commits us to work toward nuclear disarmament. The International Court of Justice ruled that this commitment is not a theoretical or rhetorical statement—it's a solemn obligation requiring action on our part. It's part of the NPT bargain. Most of the countries that signed the NPT don't expect the division between nuclear "haves" and "have-nots" to last forever.

Lurking behind the legal issue is a moral problem. In 1983, the Catholic bishops issued a statement that allowed for the morality of nuclear deterrence on the condition that it only be an interim measure tied to progressive disarmament. Last year, concerned that nuclear deterrence was being institutionalized, the bishops issued a new statement that called for a concrete policy of nuclear elimination.

Under generally accepted international laws and humanitarian principles, any use of force or threat of force must be limited to, and necessary for, self defense; it must not be directed at civilians, and it must be capable of distinguishing between civilian and military targets; and it must not cause unnecessary suffering, or harm greater than that required to achieve a legitimate military objective. It seems to me extremely unlikely that any use, or any threat of use of nuclear weapons could meet these criteria. The United States led they way in prohibiting chemical and biological weapons largely because these weapons failed this test. Are nuclear weapons any better? Can we stockpile nuclear weapons forever and never see them used? Will my grandchildren live under this shadow?

I am well aware of the arguments against prohibiting nuclear weapons. Obviously, the world isn't ready for such a step today. Although the international system has changed in ways that make nuclear deterrence far less important in preventing major war, additional changes are necessary. For example, I believe that we won't be able to achieve a durable prohibition of nuclear weapons until all of the major industrial states, and perhaps all of the countries with nuclear facilities and that are capable of building nuclear weapons, are peaceful, stable democracies.

But that doesn’t mean that we shouldn’t be giving serious thought to the issue. To the contrary, we should be laying the technical foundation for prohibition. Prohibition will require confidence that all nuclear warheads have been dismantled and that all stockpiles of fissile materials are under safeguards. So I would frame our efforts to control and account for nuclear warheads and fissile materials in this light. Prohibition is, I hope, the future of nuclear arms control, and I hope that some of you will work to make it a realistic possibility.