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SPECIAL REPORT

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About the Report

On January 19, 2011, the National Academy of Sciences Committee on International Security and Arms Control, with cooperation and financial support from the United States Institute of Peace, held a symposium titled "From Reykjavik to New START: Science Diplomacy for Nuclear Security in the 21st Century." Participants were distinguished experts from the United States and Russia, including scientists, diplomats, and high-level government officials. The meeting identified lessons from past science diplomacy, but focused on what can be accomplished today and in the future through science diplomacy. This report summarizes the main ideas offered during the symposium. The opinions expressed here are those of the author and do not necessarily represent the views of all symposium participants, the National Academy of Sciences Committee on International Security and Arms Control, or the United States Institute of Peace. Micah Lowenthal is director of the Committee on International Security and Arms Control of the National Academy of Sciences.

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Science Diplomacy for Nuclear Security

Summary

- The history of science diplomacy for nuclear security is rich and includes, for example, establishing confidence in the verifiability of the Threshold Test Ban Treaty, paving the way to many nonproliferation efforts, and damping potentially drastic responses to actions perceived by adversaries as provocative.
- The ingredients for success in science diplomacy may be summarized in terms of seven factors: openness to new possibilities, vision and leadership, good science, human connections, communication, time, and self-interest.
- Experts from Russia and the United States have identified topics that would benefit from or demand science diplomacy: nuclear energy and nonproliferation, nuclear arms reductions, countering nuclear terrorism, cooperation on ballistic missile defense, and the Comprehensive Nuclear Test Ban Treaty. Differing perspectives on goals in these areas, however, provide new opportunities to work together to promote security.
- A variety of policy measures and physical safeguards have been put in place to prevent nuclear proliferation and nuclear terrorism. Because of the technical complexities of nearly every aspect of the nuclear fuel cycle and its potential for exploitation and terrorism, science diplomacy can continue to make substantial contributions on these topics.
- Verification of treaties, including nuclear arms reductions and test bans, is perhaps the topic within arms control most susceptible to technical options. Joint exploration and development of technical options to enable proposals for verification of treaties is a valuable topic in which science diplomacy has an essential role to play.
- Cooperation on ballistic missile defense (BMD) is an area of tension between the United States and Russia today. Such cooperation has technical and political dimensions. So far, the political discussions have resurfaced underlying suspicions, suggesting that science diplomacy is the stronger option for building confidence and identifying technical options that enable BMD cooperation.

- Although the Cold War is over, the variety of nuclear and other threats has grown, and science diplomacy is needed now more than ever to address those threats.
- Science diplomacy practitioners who are daunted by the sensitivity of the topics of the day must remember the successes in science diplomacy between the United States and the Soviet Union concerning nuclear weapons. The topics are important in part because they are so sensitive, and today's generations owe it to future generations to take on the challenge of science diplomacy to address the new and vexing security challenges the world faces in the twenty-first century.

Introduction

"In the tragic situation which confronts humanity, we feel that scientists should assemble in conference to appraise the perils that have arisen as a result of the development of weapons of mass destruction, and to discuss a resolution in the spirit of the appended draft." So began the Russell-Einstein Manifesto, issued in July 1955. Some of the most prominent scientists of the time, seeing a dire threat to humanity, called upon their fellow scientists to meet and reach agreement on a course of action to alleviate the threat from nuclear weapons. At times, it seems miraculous that the world survived the Cold War without a nuclear attack, either accidental or intentional. Perhaps it was indeed a miracle, but whatever other forces were at play, it must be said that science diplomacy played its part in reducing tensions, enhancing mutual understanding, and promoting technical solutions to problems of international security.

The global community faces other major nuclear threats today. In the words of former secretary of defense William Perry,

> The most dangerous issue facing the world today is a confluence of these two dangerous trends: proliferation of nuclear weapons and the rise of catastrophic terrorism. . . . What remains to be done is much more difficult than what we have done so far. . . . Time is not on our side, and having helped build the nuclear arsenal, we have a special responsibility to work to eliminate these threats.

Secretary Perry spoke these words on January 19, 2011, when the National Academy of Sciences (NAS) Committee on International Security and Arms Control (CISAC), with cooperation and financial support from the United States Institute of Peace's Center of Innovation: Science, Technology, and Peacebuilding, called together a distinguished group of scientists and policymakers for a one-day symposium titled "From Reykjavik to New START: Science Diplomacy for Nuclear Security in the 21st Century." Four weeks after the U.S. Senate provided its advice and consent on ratification of the new Strategic Arms Reduction Treaty (New START), nearly twenty-five years after the historic Reykjavik Summit, where U.S. and Soviet leaders flirted with the abolition of nuclear weapons, and fifty-six years after Bertrand Russell and Albert Einstein called on scientists to work for peace, these experts from the United States and Russia focused on science diplomacy in support of international nuclear security, drawing from the lessons of the past, but focusing on what can be accomplished today and in the future.

What is science diplomacy? Alan Leshner of the American Association for the Advancement of Science described science diplomacy as international science cooperation to foster communication and cooperation among peoples of diverse nations and to promote greater global peace, prosperity, and stability.[1] This can include science informing diplomacy and diplomacy supporting science, but in the context of the work of CISAC and other similar nongovernmental organizations (NGOs), it can also mean providing an alternative channel for international communication through the discussion of scientific aspects of international issues. Such discussions have the advantage of being fact based, potentially more objective than typical diplomatic discussions, and in many cases less susceptible to the vicissitudes of standard diplomatic relations.

Many of the symposium participants have engaged in science diplomacy through CISAC, which was formed in 1980 as a standing committee of the NAS to "act as a vehicle for discussions with comparable bodies in other countries," specifically the Soviet Academy of Sciences. Those interactions began in 1981. Richard Garwin, William Perry, Rose Gottemoeller, Evgeniy Avrorin, Roald Sagdeev, Raymond Jeanloz, Christopher Chyba, John Ahearne, Norman Neureiter, Stephen P. Cohen, Nikolai Ponomarev-Stepnoi, Viktor Firsov, and Viktor Yesin (all current or former CISAC members) spoke at the event, as did William Colglazier, Richard Solomon, Thomas Cochran, C. Paul Robinson, Thomas D'Agostino, Sheldon Himelfarb, Cathleen Campbell, and David Albright. Only Gottemoeller, as U.S. assistant secretary of state and chief negotiator of New START, and D'Agostino, as U.S. under secretary of energy for nuclear security, spoke in an official capacity; the others' remarks were provided in a personal capacity and may not reflect the views of their home governments or organizations.

This report summarizes the main ideas offered during the symposium. Several major themes emerged from the symposium talks and the discussions that followed. This report is organized to identify what some participants characterized as essential ingredients for successful science diplomacy on nuclear security and promising areas for science diplomacy to contribute to nuclear security in the twenty-first century.[2]

Major Lessons for Success in Science Diplomacy

> "We have to remember that science is the foundation for the development of all weapons of mass destruction, and scientists also create the basis for monitoring and verification technologies for reducing arsenals. International science cooperation can create a basis for trust and confidence, and the climate of confidence is the key element needed to eliminate nuclear weapons. So we have to deal with nuclear proliferation and nuclear disarmament."
> —Evgeniy Avrorin

A sense of responsibility motivates many of the scientists engaged in science diplomacy who are working to increase security by building greater mutual confidence. Diplomats, military leaders, politicians, religious leaders, NGO experts, and others all have valuable capabilities they can bring to bear on these challenges. At their best, scientists acknowledge other points of view and evaluate ideas based on the ideas' merits, not on who proposes them. This is fundamental to science. Avrorin said that in experiments "we understand that the results are unpredictable, there are various opinions, and the results must be tested." Scientists and science diplomacy have this to offer, an important and valuable perspective that can temper the mix of competing positions on such important issues.

The key ingredients for success in science diplomacy include the following:

Being Open to New Possibilities

> "I was not convinced that the Cold War really was over. But just one year later, one year after Reykjavik, I did become convinced that the Cold War was over. I was attending a meeting of American and Russian scientists . . . the fifth in a series of meetings we've held since 1981. Some of you, in fact, were at that meeting."
> —William Perry

Secretary Perry described his early 1980s belief that nuclear weapons were a necessary danger, required to maintain an uneasy peace in the Cold War. He noted that in years of meetings between U.S. and Soviet experts, the Soviets had followed a tight script dictated by the Kremlin, and the Kremlin's position was bellicose and uncompromising. The first indication that Secretary Perry got that the Cold War might be coming to an end and that nuclear weapons might not be necessary in the future occurred during a U.S.-Soviet science diplomacy meeting around 1987. For the first time, he witnessed disagreements among the Soviet participants, more in fact than between the U.S. and Russian delegations. He could see that glasnost was real, meaningful dialogue was possible, and the Cold War was winding down.

Having a Vision and Exercising Leadership

> "If you're constantly mired in what is and you never look at what ought to be, you're never going to really get anywhere."
> —former U.S. secretary of state George Shultz[3]

A few years after Secretary Perry's observation of new openness in Russia, that same openness was exhibited in dramatic fashion in an exercise that would have been hard to reconcile with the common understanding of the Cold War rivalry, which was beginning to fall apart. The Soviet Union arranged for the Soviet Academy of Sciences and the Natural Resources Defense Council (NRDC), an NGO in the United States, to carry out a set of measurements of the radiation from a real warhead on a Soviet Navy ship in 1989. (The experiments are described in the next section.) Roald Sagdeev said that the importance of this experiment was "displaying that the Gorbachev government was ready to provide such a transparency, plus Glasnost extended to gamma rays and neutrons even" from nuclear weapons.

Thomas Cochran of the United States and Evgeny Velikhov, a Soviet Academy member and scientific adviser to General Secretary Mikhail Gorbachev, conceived this experiment, known as the Black Sea Experiment as a next step after the U.S.-USSR Test Ban Verification Project—a joint Soviet Academy-NRDC effort using seismic monitors to measure chemical explosions adjacent to U.S. and Soviet test sites. Dr. Cochran credits Dr. Velikhov, a bold scientist and a risk taker who had Gorbachev's ear, and Gorbachev, himself, for having the vision and exercising the leadership to make the Black Sea Experiment a reality. Dr. Velikhov and Dr. Cochran knew the value of conducting the experiment as a demonstration of what Dr. Sagdeev, Frank von Hippel, and others had calculated in studies. The demonstration provided a publicly known technical reference point for political debate over nuclear reductions and verification. The fact that this was a joint effort, too, helped illustrate that cooperation and joint understanding were possible.

Secretary Perry publicly talked about his work toward nuclear arms elimination with Secretary Shultz, former senator Sam Nunn, and former secretary of state Henry Kissinger, in an op-ed piece in the *Wall Street Journal* in January 2007. "We were amazed at the worldwide response to that op-ed. . . . It stimulated the creation of comparable groups in many other countries. We came to be called "the gang of four" in the United States, but there were gangs of four formed all over the world, in Germany, in England, in France, and even in Russia and China." The vision of these four men to pursue this goal now, even though its realization may be many years in the future, constitutes leadership, evidenced in the inspiration it has provided to others.

Pursuing Good Science

> "The [Joint Verification Experiment] was a success because we had a clearly defined purpose, preliminary analyses of the working conditions at test sites, detailed scenarios—like a phonebook—and thorough preparation of personnel and equipment."
> —Evgeniy N. Avrorin

> "The [Joint Verification Experiment] was path breaking at its time, and it set the gold standard for government-to-government efforts."
> —Rose Gottemoeller

Viktor Firsov extolled the value of joint measurements of nuclear explosions at Semipalatinsk and Nevada (the main Soviet and U.S. test sites, respectively) to understand the transmission of seismic signals through the geologic media and formations at the sites. Differences in the characteristics at the sites had led some to question whether the Soviet Union was complying with its commitments under the Threshold Test Ban Treaty (TTBT), which in turn led the U.S. Senate to withhold its consent for ratification of the treaty. The relatively soft rock at the Nevada Test Site (NTS) absorbs more of the energy from a nuclear explosion than the hard rock at Semipalatinsk, dampening slightly the seismic waves from U.S. nuclear explosions. Therefore, an explosion of a given magnitude in Russia produced a larger signal, which without proper calibration was misinterpreted by the Americans as a larger explosion.

For the Joint Verification Experiments (JVE), three measurement stations were built in each nation. Dr. Firsov carried out seismic background measurements and recorded data from the U.S. nuclear test explosion at the Black Hills station. U.S. and Soviet colleagues shared data from measurements at the various stations and shared historical data from measurements of explosions at the two test sites. They worked out their own methods for evaluating yields at the two sites and reconciled them. These experiments conducted in 1988 made possible the technology of mutually agreed seismic monitoring of nuclear explosions.

The scientists had two months of discussion in Geneva after the JVE. Dr. Avrorin described this open discussion of every possible error and explanation of every detail as the most important part of the activity. Working through disagreements with sometimes heated discussions to reach high confidence in the results also raised the level of trust and confidence between the U.S. and Soviet experts, which built the foundation for future dialogue.

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The Black Sea Experiment, discussed in the previous section, was actually a set of seven experiments to study whether a variety of radiation detectors could detect a nuclear warhead on a ship. The flagship of the Soviet Black Sea Fleet was made available with a nuclear armed missile in one of the launch tubes. The measurements were taken on July 5, 1989, near Yalta. The question at hand was whether an agreement to limit or ban sea-launched cruise missiles (SLCMs) could be verified. A government-to-government agreement to conduct such experiments had not led to action.

Ironically, part of the impetus for the Black Sea Experiment was a response to bad science. Professor Sagdeev explained that a Soviet institute had claimed that neutrons emitted by nuclear weapons containing plutonium would create argon-42 in the air around them and that detectors one hundred kilometers away could detect the radioactive argon carried by the wind. Although this claim is demonstrably false (the neutron flux is too small, the argon concentration is too small, and air transport over even a relatively small distance would dilute the argon to levels indistinguishable from background), the idea had captured the imagination of some people in leadership positions. The Black Sea Experiment put to test several detectors—germanium, sodium iodide, helium-3—positioned in different locations relative to the nuclear weapon. Some were handheld and operated on the ship, some were in a helicopter, some were on a nearby boat, and some were on the dock farther away. Only the nearest detectors (on the ship and in the helicopter) detected the weapon and acquired sufficient data to verify the number of weapons on the ship.

As a one-time experiment with limited measurements and no opportunity to evaluate the sensitivity of the results or to follow up with additional experiments, the Black Sea Experiment is not a model for scientific research. However, as a model of science diplomacy, it was a success. Dr. Avrorin described the Soviet scientists' concerns that gamma-detector measurements could reveal information about the design of the nuclear explosive. The chief designer of Soviet nuclear weapons personally oversaw the experiment and confirmed that the detectors could verify the presence of the weapon but could not show technical details or the configuration of the nuclear explosive. As noted, this is important because it opened the way to transparent dismantlement of nuclear weapons, demonstrating verification by nonintrusive technology.

Making a Human Connection

> "The lesson of the importance of human nature, of people working together on a common goal, also is a key takeaway from this. When we started, the tensions of the Cold War made everybody nervous about every step of the way. When we finished, we not only understood the material and the capabilities of the verification measures, but we understood the people who had been working in great secrecy on the other side. And that mutual respect that grew, I think, has led to a lot of other areas, such as lab-to-lab collaborations, and the initial efforts on safe, secure dismantlement, and I believe it can continue on to bolster future efforts as well."
> —C. Paul Robinson

Scientists in the nuclear-weapons establishments of the United States and the Soviet Union studied the same topics, grappled with the same problems, and dedicated themselves to cloistered careers developing devastating weapons whose destructive capabilities most of them hoped would never be used. The secretive work was carried out walled off from everyday life, isolating the community of weapons scientists if not the individuals. These scientists, from nations that stood as adversaries and deployed vast numbers of nuclear weapons to counter each other's forces, found as they worked together that they had a great deal in common. Through joint work, they built respect for each other as peers and colleagues and established connections at a personal level. These are the ingredients for trust and confidence, which are foundations for peacebuilding.

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In the context of the JVE, Dr. Avrorin described the development of antiintrusive equipment to forgo exploiting the opportunity to take measurements of data that were out of bounds. This deliberate effort to not acquire unnecessary information and to establish equality where neither side felt that the other was gaining advantage illustrated a measure of trust and confidence and provided useful technical information.

Can the trust and confidence associated with science diplomacy be abused? Gerald Epstein of the American Association for the Advancement of Science (AAAS) asked precisely this question. The answer was, of course, yes. Examples were given showing that it is a particular problem with clandestine programs, but not necessarily a categorical problem for science diplomacy itself.

David Albright, president of the Institute for Science and International Security (ISIS), has used science to promote progress on the international stage in security matters by using scientific analysis to establish a public baseline of facts. His approach, however, relies on open-source information. For example, he and his colleagues have used commercially available satellite imagery to examine supposedly clandestine nuclear production facilities and to evaluate the operating status and capacity of known facilities. In the case of Iran, he and his colleagues figured out that an undeclared nuclear site was actually a gas centrifuge plant. Public disclosure of the images pushed Iran to allow the IAEA to visit the site. This showed that, at least in this case, Iran could be pressured to open up and that "images broadcast with analysis can be a very powerful tool to further diplomacy."

Unlike the science diplomacy described throughout the rest of the symposium, Dr. Albright's approach is not a cooperative effort between scientists from countries in conflict. With Iran, Albright said, "you almost have to have conflict with them to have an honest discussion. There have been many, many efforts by the Iranians to draw scientists in to take positions that really are aimed at creating division here, particularly with U.S.

government positions. You have to be extremely careful in interacting with Iranians on nuclear issues."

Communicating

> "[A]mong practitioners, science is a global enterprise, scientists have a common language; they have common bonds that transcend cultures and transcend political differences. And because of that, scientists can be very effective ways to communicate between the different countries even when relations between different governments might be very difficult."
> —William Colglazier

There are two major barriers to communication, both of which were mentioned during the symposium. First, if the parties engaging in science diplomacy have different native languages, high-quality interpretation is critical to success. Dr. Avrorin emphasized this point, saying that "the questions were complex, and the discussions were sometimes heated." The interpreters in these cases must be very precise. Second, even if the words are translated precisely, their meaning—the subtext and underlying assumptions—might only be communicated implicitly. It is through joint work and indeed arguing over the results and their meaning that some of these implicit understandings work their way toward explicit statements whose meanings are understood by both sides.

There is, however, a common starting point. As Colglazier pointed out, the science itself has a common language rooted in verifiable facts that should be independent of the observer and the practitioner. This is what makes science such a promising basis for building understanding and agreement.

Building in the Needed Time

> "It is so critical in all of these relationships if you are going to make any progress, you have to have trust. There is a process for building it. If you go way back and there is no trust, you have to find some way of engaging. That is the secret—to find a way and engage it. You cannot jump in and say we are coming to engage on your nuclear weapons program. You have got to find some way that the science—in my opinion, find some way that you can engage in the science community."
> —Norman Neureiter

In part because of the need to establish a strong scientific basis, a human connection, and good communication, effective science diplomacy takes time. Trust and confidence do not arise immediately and automatically, especially between ostensible adversaries. Richard Garwin noted that the terms of membership in CISAC have necessarily been longer than the terms for those serving on other Academy standing committees. This is so that those within CISAC could establish trusting relationships and hold effective bilateral discussions. Drs. Firsov, Robinson, Ponomarev-Stepnoy, and Avrorin all noted the time and joint efforts that were needed under the JVE and the U.S.-Russian lab-to-lab program to establish trust.

Because of the need to establish a strong scientific basis, a human connection, and good communication, effective science diplomacy takes time.

Likewise, Norman Neureiter of the AAAS and Glenn Schweitzer of the NAS have led science engagement efforts in Iran. Of these efforts, which stay away from the controversial issues, Dr. Schweitzer said that if the emphasis is on science ("big science and little diplomacy") then fraud is uncommon. But, "when people try to use the science as the excuse for penetrating the security barriers, then I think you have real problems." Neureiter described how to work from a deficit of trust, establishing a process for building trust. Beginning with some noncontroversial topic for engagement in the science community, "You really kind of start it off with the hope that this will diffuse around the society, have an impact on other people, and there may be a time politically when you will talk to the nuclear people. Or there may be a time not politically when it will just diffuse. Other people in the other country will begin to say, hey, there really is a problem here and maybe we need to take advantage of this trustworthy dialogue between the science communities to carry it a little bit further."

Understanding Self-Interest

> "The Indians quietly let it be known that they did not want America to be trying to pace their relationship with Pakistan."
> —Norman Neureiter

Sovereign nations make their own decisions. They might be pressured, cajoled, or reasoned with, but on critical matters of national interest, they make their own decisions based on what they see as being in their best self-interest. This self-interest places limits on how much they can be told what to do. Commenting on what India and Pakistan can learn from the Cold War experience of the United States and the Soviet Union, Stephen Cohen of the Brookings Institution said, "I think that people learn from their own mistakes. They do not learn from the mistakes of others."

Dr. Avrorin made an argument for using positive incentives to persuade nations not to create nuclear weapons. "Assistance and technical support and economic and financial support in the creation of systems of control, and the systems in the creation of the nuclear energy in the countries that can guarantee that they are not aiming to create nuclear weapons." This approach, favoring carrots over sticks, was discussed further in the context of Pakistan. Although the United States has spent billions of dollars in Pakistan, Pakistan is increasing its nuclear arsenal and might conduct further nuclear explosions to modernize its weapons before entering into the Comprehensive Nuclear Test Ban Treaty (CTBT). Dr. Cohen remarked that "the biggest carrot would have been a nuclear deal for Pakistan." Such an incentive might or might not have been possible, but it suggests that diplomacy has an opportunity to give alternative paths when nations conclude that it is not in their overriding self-interest to escalate nuclear competitions.

Areas for Future U.S.-Russia Science Diplomacy

Recent progress in the U.S.-Russia relationship provides fertile ground for science diplomacy between the two nations, as do the areas where there has not been progress. As Assistant Secretary Gottemoeller noted, the U.S.-Russian Agreement for Cooperation in the Field of Peaceful Uses of Nuclear Energy, also known as the U.S.-Russia 123 Agreement, came into force on January 11, 2011. The agreement normalizes and expands cooperation in nuclear energy and enables cooperation on technology development for nuclear nonproliferation programs, nuclear forensics, and safeguards and monitoring programs. The 123 Agreement is only a legal framework authorizing such work, so it is now up to the parties to identify the substantive work to be done under the agreement and to take the steps necessary to make that joint work successful.

Secretary Perry listed a set of technical issues the world will face as it moves toward a follow-on arms control treaty and lower numbers of nuclear weapons, or zero nuclear weapons. They range from cooperation on ballistic missile defense to verification of warheads and treaties. Secretary Perry called these technical challenges special challenges to CISAC and others in the technical community engaged in science diplomacy. His list, as well as issues highlighted by Dr. Garwin and others, are as follows:

Safeguarding Nuclear Power and Contributing to Nonproliferation Regimes

> "When we are considering the export of nuclear reactors and fuel to third countries, we need to make sure that we arrive at a solution that will not contribute to proliferation."
> —Nikolai N. Ponomarev-Stepnoy

Nuclear power is inextricably linked to a risk of proliferation because of the materials and technologies involved. Some nuclear-fuel-cycle technologies and some nuclear materials are less attractive or less effective for nuclear-weapons applications, but some level of risk always remains. For this reason, a variety of policy measures and physical safeguards has been put in place, and numerous others are being analyzed and considered. International agreements and commitments to physical safeguards, technologies, efforts for detection of undeclared facilities, and export controls for sensitive technologies, all contribute to a healthy nuclear nonproliferation regime. Because of the technical complexities of nearly every aspect of the nuclear fuel cycle and its potential exploitation for proliferation, science diplomacy can continue to make substantial contributions on this topic.

Verifying Nuclear Arms Reductions

> "These negotiations [over reductions in strategic and nonstrategic arsenals] will only be fruitful or productive if the parties are successful in establishing mutually acceptable verification mechanisms."
> —Viktor I. Yesin

> "Establishing the verification measures in transparency tools . . . will help us ensure confidence as we move from step to step. This isn't going to happen without a strong scientific and technology base, because we have to have confidence that we collectively, the big we, know what's going on in this area."
> —Under Secretary of Energy Thomas D'Agostino

In the debate over advice and consent on the ratification of the New START, the U.S. Senate made clear that the next step for nuclear arms control must include nonstrategic (tactical) nuclear weapons in Russia. Assistant Secretary Gottemoeller noted that the United States and Russia are preparing for a dialogue on nonstrategic nuclear weapons, and she highlighted the role of NGOs in providing analysis and ideas for this dialogue, "providing much, very welcome food for thought for those of us working these matters inside the government." Under Secretary D'Agostino noted that a prominent challenge among the many associated with including tactical nuclear weapons in an arms control or reduction treaty is verification. Verification is also perhaps the topic most susceptible to technical options.

General Viktor I. Yesin, former chief of staff of the Strategic Rocket Forces in Russia, proposed a course of action for verification of reductions in tactical nuclear weapons: (1) declare the number of existing weapons, (2) categorize the weapons into an active stockpile (deployable) and an inactive reserve subject to elimination, (3) agree that inactive reserve weapons cannot be made active, and (4) separate the storage facilities for the two categories. If these conditions are met, there could be on-site inspections of storage sites of both categories of weapons. The goal of each on-site inspection would be to ensure that the number of warheads in each storage facility does not exceed what is declared. The number in each category sent to elimination is also verifiable based on the amount of nuclear material obtained from elimination.

There are technical details in General Yesin's ideas that would require further development and refinement, as lingering doubts about possible undeclared sites and shielded weapons, among other issues, would need to be addressed. The same is true for nearly any such proposal. Secretary Perry said that the verification of warheads, as distinct from missiles and deployments, is a great technological challenge. Joint exploration and development of technical options to enable proposals for verification of declarations and reductions is a valuable topic where science diplomacy has an essential role to play.

Countering Nuclear Terrorism

> "Should we really wait for nuclear terrorism, compared to which 9/11 will appear an innocent joke?"
> —Evgeniy Avrorin

> "[T]he stocks [of highly enriched uranium (HEU) and plutonium] have grown. Terrorism has become a serious problem. But the sense of danger seems to be muted, except perhaps for some people here today."
> —John Ahearne

It has been noted that the knowledge of how to build a crude nuclear explosive is within the reach of many, and that the difficulty in acquiring the fissile material for the nuclear explosive is the main obstacle to nuclear terrorism. Little progress has been made on the Fissile Material Cutoff Treaty (FMCT), and even this measure would only stop future production of fissile material, not address nuclear material already in existence. In discussing disposition of HEU and plutonium, Ahearne expressed his view that the sheer quantity of HEU and plutonium in storage is a hazard. Some aspects of verification of an FMCT and declarations of existing stocks are difficult, but for those who share Dr. Ahearne's concern about stocks, the challenges cannot be avoided. D'Agostino and Gottemoeller both highlighted additional joint activities, such as nuclear forensics, which could work to curb nuclear terrorism.

Cooperating on Ballistic Missile Defense

> "I can't imagine that at this confidence level we would help each other to intercept intercontinental weapons. But as far as intercepting the missiles that we don't have, midrange and short range, here we have wide horizons and open opportunity for cooperation. That cooperation especially is important because other countries did not follow Russia and United States in their INF treaty, despite the fact that this goal was approved by the General Assembly of the United Nations."
> —Viktor Yesin

U.S. president Ronald Reagan was willing to pursue significant reductions in strategic weapons and even consider the elimination of nuclear weapons, but he was totally committed to developing a U.S. ballistic missile defense (BMD). General Secretary Gorbachev and many others considered BMD to be a destabilizing factor: few believed it would work effectively, but war planners tend to assume the worst. To ensure that sufficient damage could be done in a response to a BMD-equipped adversary who has launched a first strike, a war planner would tend to require a larger nuclear arsenal. President Reagan offered to share the technology with the Soviet Union but, as Roald Sagdeev noted, this offer rang hollow to the Soviets given that under Reagan's administration, the United States would not even share milking machines with the Soviets.

Gorbachev and Reagan's disagreement on BMD was one of the reasons why agreements on nuclear reductions or elimination were not reached at the Reykjavik Summit. START was agreed to five years later, and research on BMD, which was permitted under the Anti-Ballistic Missile (ABM) Treaty, also continued. But in 2001, President George W. Bush withdrew from the ABM Treaty and increased efforts on BMD, which remains a continuing source of tension and an irritant within U.S.-Russian relations. Once again, the idea of a cooperative or shared system has been broached.

Secretary Perry, Assistant Secretary Gottemoeller, General Yesin, and Dr. Garwin all highlighted BMD cooperation as an area of tension between the United States and Russia today. Having both technical and political dimensions, BMD cooperation is a topic that naturally calls for science diplomacy.

Secretary Perry noted that there has been movement from both sides on the political issues and expressed the hope that joint control and design is possible. If the technical people can come up with a reasonable way of cooperating meaningfully and participating in design, this could avoid the political problem of joint control. Assistant Secretary Gottemoeller said that her deputy is actively talking with Russian counterparts and that there is positive momentum coming out of the Lisbon summit.

General Yesin, however, gave a less positive perspective on the outlook, saying that NATO and Russia have not established the necessary mutual trust to create a mutual system, in which launch decisions are made mutually. He did suggest a path, beginning with a joint surveillance capability providing data to two Early Warning Centers, one in Moscow and one in Brussels, as Vladimir Putin suggested in 2007. The missile counter forces, he thought, would need to be under separate controls to eliminate the "double key." By dividing geographic responsibilities, the system would avoid striking the same targets at the same time. Such a system could, when the political foundation is there, be turned into a fully joint system. An essential first step in such negotiations would be agreement on the types of missiles the system is meant to intercept. Implicit in General Yesin's provisions is the lack of trust between the two sides. Fully mutual operation would suggest greater confidence that the system would not be used by one partner against the other. A system that targets only intermediate-range ballistic missiles is the most likely to be politically acceptable, because these were eliminated from the United States and Russia under the INF treaty.

Cooperating on the Comprehensive Nuclear Test Ban Treaty

> "I am just surprised at how the United States was successful in chasing itself up a tree."
> —Viktor Firsov

> "The monitoring, transparency, and verification challenges alone are daunting, but we have talent available to address these challenges, and that talent is quite formidable. We are definitely looking forward to partnership with the scientific community both here in the United States, in Russia, and with partners around the world to tackle these important challenges."
> —Rose Gottemoeller

Secretary Perry cited technical issues associated with the CTBT, including verifiability, as another area for science diplomacy, but he noted that reaching agreement on the CTBT in the United States would not be easy. In the 2009 report of the Congressional Commission on the Strategic Posture of the United States,[4] which Perry co-chaired, the CTBT was the only topic on which the commission was unable to reach consensus. This division was apparent in the symposium, as Paul Robinson expressed his view that the CTBT is flawed and unverifiable and Drs. Firsov, Cochran, and Sagdeev characterized the remaining issues as political and logistical rather than technical. According to Dr. Firsov, "The detectors, the devices, and methods can be developed to verify the treaty."

The Russian Federation has already ratified the CTBT. The U.S. Senate denied its consent to ratify the CTBT in 1999. President Barack Obama has said that he intends to resubmit the CTBT to the Senate, a position that Secretary of State Hillary Clinton reaffirmed at the NPT Review Conference in 2010. The State Department recently indicated that the process of educating senators about CTBT will start soon, and the actual ratification debate and vote in the Senate is likely to follow after the general election in 2012. Assistant Secretary Gottemoeller argued that much has changed in the decade since the treaty was last considered in 1999, including major improvements in the systems available for monitoring and verifying the treaty and in the United States' ability to ensure the reliability of its nuclear stockpile without explosive nuclear testing. The administration has commissioned a new National Intelligence Estimate and an NAS study on the technical aspects of the CTBT. The latter will allow the administration to engage with Congress and the expert communities on the CTBT, its verification regime, and related issues.

Some believe that Russia and other countries could help allay some concerns about the CTBT in the United States and other countries through technical cooperation. In making a different point, Dr. Robinson pointed out that "by sharing this yield data, it was felt that this would set the basis for agreement and resolve the pattern of fifteen years of demarches

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back and forth. On the U.S. side, we used an analogy that . . . the philosophy at the core of the JVE is that this was try-before-buy verification." Dr. Garwin suggested that transparency measures at the existing nuclear test sites and further mapping and enhancement of the capabilities of the sensors used in the surveillance regime for the CTBT might also assist with ratification in the U.S. Senate.

Conclusion

> "If you have an apple and I have an apple and we exchange these apples then you and I will still each have one apple. But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas."[5]
> —Evgeniy Avrorin

Science diplomacy is needed now more than ever to address terrorism, the proliferation of nuclear and other potentially dangerous technologies, regional rivalries and conflicts, and a set of other critical matters.

Some important lessons were learned from the practice of science diplomacy in difficult times between the United States and the Soviet Union/Russia over the past twenty-five years. Although the issues faced today are more complex, these lessons are still pertinent. The Cold War may be over, but the variety of threats has grown. Science diplomacy is needed now more than ever to address terrorism, the proliferation of nuclear and other potentially dangerous technologies, regional rivalries and conflicts, and a set of other critical matters. Some of these topics are quite sensitive and officials and scientists today may wonder how the topics can be discussed in bilateral or multilateral settings, but they have to remember what has already been accomplished. Because of nuclear weapons' terrible destructive power, nations consider information about them and their potential use to be highly sensitive. But it is precisely this terrible destructive power that makes discussion including sharing of information and analyses—and that makes science diplomacy—so important. Indeed, this destructive power is what motivated those practitioners quoted in this report to succeed. This inspires practitioners of science diplomacy to continue to work together on the critical issues for nuclear security today and to find ways to reduce the threats that the world faces. All parties owe that to future generations. Science diplomacy played such a key role in helping to bridge important gaps to bring an end to the Cold War; it is time to call upon this powerful tool to address the new and vexing security challenges the world faces in the twenty-first century.

Notes

1. Alan I. Leshner, written testimony, House Committee on Science and Technology, Subcommittee on Research and Science Education, July 15, 2008.
2. An audio recording of the meeting is at http://sites.nationalacademies.org/PGA/cisac/PGA_060004
3. This quote comes from the documentary movie *Nuclear Tipping Point,* a clip Secretary Perry shared as part of his presentation. Secretary Shultz quotes former adviser Max Kampelman.
4. The Congressional Commission on the Strategic Posture of the United States delivered its report to the U.S. Congress on May 6, 2009. The commission was supported by the United States Institute of Peace, which also issued the report. Congressional Commission on the Strategic Posture of the United States, *America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States* (Washington, DC: United States Institute of Peace Press, 2009), www.usip.org/programs/initiatives/congressional-commission-the-strategic-posture-the-united-states.
5. This saying is attributed to George Bernard Shaw, but it has also been described as a Russian proverb.

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