THE DISPOSITION OF FISSILE MATERIALS: AN EXTENDED INTERVIEW WITH OLEG BUKHARIN, THOMAS COCHRAN, AND WOLFGANG PANOFSKY

Conducted by Betsy Perabo

In December 1993, a number of experts from both the nuclear industry and the nonproliferation community met to discuss the problems of the disposition of plutonium and highly-enriched uranium (HEU) at the Future of Foreign Nuclear Materials Symposium, sponsored jointly by the Naval Postgraduate School, the Monterey Institute of International Studies and the U.S. Department of Energy's Office of Intelligence and National Security. A study released in January 1994 by the National Academy of Sciences, "Management and Disposition of Excess Weapons Plutonium," also addressed this topic. Within the past few years, fissile material disposition has become a more visible issue because of the necessity of managing materials retrieved from nuclear warheads that the United States and Russia have agreed to dismantle. However, as there is no adequate long-term solution for the disposition of nuclear waste from civilian reactors, efforts are being made to resolve the two issues in tandem.

In order to gather their collective insights on these issues, The Nonproliferation Review interviewed three of the conference participants: Oleg Bukharin, a Visiting Researcher at Princeton University's Center for Energy and Environmental Studies; Thomas Cochran, Senior Scientist at the Natural Resources Defense Council; and Wolfgang Panofsky, Director Emeritus of the Stanford Linear Accelerator Project, who recently served as chairman of a National Academy of Sciences study. The participants were interviewed individually by Betsy Perabo of the Program for Nonproliferation Studies. Their comments have been combined and edited.

NPR: What has been done towards solving the problem of the disposition of fissile materials?

Thomas Cochran: The weapons dismantling process has been under way for a couple of years. In the United States, warheads have been moved to the Pantex facility and have been dismantled at a rate of about 1,800 per year. The matter of where they are going to put the parts for the components of something like 20,000 warheads is creating a problem at Pantex in terms of intermediate storage. Beyond that, very little has been done--a number of studies, primarily outside of the government, to identify what to do with the materials ultimately--but there's been very little movement within the government.

On the Russian side, it's a very similar situation. Warheads are being dismantled at four sites, and they allegedly have storage problems as well. They have requested U.S. financial assistance to build a central storage facility, primarily for the plutonium components, and Russia has agreed to sell 500 tons of HEU to the U.S. There is a piece of Congressional legislation, the Markey Amendment, which prohibits the United States from providing financial assistance for the storage facility unless President Clinton can certify that Russia is committed to shutting down its plutonium production reactors. We'll have to see how that plays out. The Russians claim they are committed to doing this, but it's a fairly long timetable that they have instituted for shutting these down. My sense is that the primary reason to continue is the jobs issue. There is very little government effort on the U.S. side in terms of trying to influence how the Russians ultimately dispose of their plutonium, and I think that's one of the major shortcomings of the U.S. program.

Oleg Bukharin: In the United States, four studies have been commissioned. The first was done by the U.S. Congress' Office of Technology Assessment. Its conclusion was that the U.S. executive branch doesn't pay much attention to the issue, and it is not managed very well. The second study was an internal DOE study; its conclusion was that plutonium will be in storage for at least the next 20 to 30 years and that the most effective way to dispose of plutonium is probably to burn it in advanced (LWRs). The third and fourth studies are being done by the National Academy of Sciences and the RAND corporation.

In Russia, Minatom [the Russian Ministry of Atomic Energy] is the only institution that has been involved in drafting the plutonium disposition strategy. Minatom has worked out several scenarios, and the principal scenario is based on burning the plutonium up in fast reactors. As in the United States, the plan in Russia is to put the plutonium in storage for at least 20 to 30 years. I sense that the real fabrication of plutonium in fuel will not happen until at least 2010.

Wolfgang Panofsky: There are many classes of plutonium that must be considered when looking at the disposition issue. First, there is plutonium withdrawn from nuclear weapons. Then there is weapons plutonium, which is lying around in various pipelines--quite a significant fraction of the whole amount--which is weapons plutonium not in weapons; and then there's civilian plutonium. The civilian plutonium is partially in the form of spent fuel rods, and partially in reprocessed materials. So all of those classes are important. At this point, civilian plutonium is all stored in various sites near the reactors. The reprocessed material is stored at the reprocessing facilities.

To put things in perspective, the military plutonium is around some 200 tons worldwide, while the civilian plutonium is somewhere around 1,000 tons, of which maybe 70 to 80 tons have been separated or reprocessed. All of the plutonium presents a proliferation risk because you can make nuclear weapons of both reactor grade and weapons grade plutonium. That's where it is at present. There is no disposition of any kind. One thing which is very clear is that whatever decisions will be made about disposition, they will have no impact on the total inventories for at least a decade or maybe two. So the world is condemned to babysit whatever materials exist for at least a decade. So we have to pay attention not only to disposition, but also to the management of the material until such time as disposition can do anything.

NPR: What are the primary issues that need to be considered when looking at the disposition of nuclear materials?

Oleg Bukharin: Arms control, proliferation, and security in general. Some sort of transparency needs to be put in place. There should be a declaration of stockpiles and verification that the material is in there. Also, any disposition option needs to account for material protection. This is an important consideration for the choice of technology, because any processing of material would increase the potential for its diversion. But on the other hand, processing may make the material more proliferation resistant. Incorporation of the material into high-level waste and vitrification would make it virtually inaccessible to a would-be terrorist. Also, we need to address the so-called "break-out" scenario. In a time of major crisis, the United States or Russia could take plutonium out of storage and refabricate it into weapons.

Another aspect is what the environmental safety and health impact is going to be. Disposition is also a large problem in terms of economics. It is going to be costly anyway. But because very large sums of money are involved, it's necessary to optimize the solution, to spend less. Finally, institutional issues--who will manage the program, who will draw up the disposition options and programs, who will evaluate them, to what degree the public is involved in the process--must be resolved.

NPR: Which issue requires more attention, highly-enriched uranium or plutonium?

Oleg Bukharin: Theoretically speaking, HEU is not a problem. We know what should be done with it. Some of it will be converted to reactor fuel in the near future. Consequently, the process of HEU conversion, and the economic and security issues related to the process, need immediate attention. Plutonium, which so far has gotten most of the attention, presents more of a long-term conceptual problem. The problem needs to be thoroughly investigated, but we don't need to make any quick decisions. It is, of course, important to address the plutonium problem in an aggressive way, rather than putting it off and forgetting it.

NPR: How should this issue be handled, and what mistakes have been made in handling it in the past?

Thomas Cochran: The real risks are in Russia, with respect to potential for diversion of materials and even warheads. Therefore, in my view, rather than focusing on what to do with American plutonium, the principal focus ought to be on how we can influence what the Russians do with their materials. Under the old Soviet regime, there was essentially no material accounting and control. They relied entirely on physical security measures to protect the warheads and materials. There needs to be major assistance throughout the former Soviet Union on building a safeguards regime.

The first step--and I think there is universal agreement among the experts who are looking at this--should be a data exchange between the United States and Russia, so that we can get a handle on how many warheads they have and of what types, how fast they're dismantling the warheads, and on how much fissile material there is and where it is. At the moment, the United States, including the intelligence community, doesn't know those figures with any reasonable certainty. The second step, once you have established this baseline, would be to start instituting a verification regime that would allow us to confirm that these figures are true, and would give us some independent means of either confirming or denying these now fairly frequent allegations that materials have been diverted at some particular site in Russia. At the moment, we rely entirely on whatever the ministry officials say happened, which may or may not be the case.

In my view, the logical way to approach this verification problem is to begin with a small lab-to-lab or DOE-to-Minatom research program, which would also provide some assistance in terms of the "brain drain" problem by giving weapons designers some alternative work. We could move from there into demonstrating technologies for tagging warheads or components. One of the arguments that is often heard in Washington is that the START I treaty took nine years to negotiate because there were such elaborate verification provisions in it, and therefore the administration doesn't want to get into that mess again and slow the process of dismantlement. In my view, there's no reason one cannot move on two tracks, particularly given the good relationship between the countries. On one track, you would continue negotiating reductions in the operational stockpile, and on another track, you would start building a verification regime, and not tie the two together. The way to avoid having this bog down in a huge interagency review process within our own government is to initiate it through DOE and through the lab-to-lab interactions. One should always have one's eye on the ultimate goal, which is not just a regime involving the United States and Russia, but a global regime for tracking all warheads and fissile materials. To get to the global regime, you can do it as a step-by-step process. You can begin with Russia on a small scale and slowly build up to the program you ultimately want.

Oleg Bukharin: Personally, I think that the level of technology, as well as the economic and political dimensions of the problem, basically justifies the actions that have been taken so far by the United States and Russia. The material will be in storage for 20 to 40 years. What I would suggest is for the countries to move on more mutual transparency and to incorporate transparency measures on the level of weapons dismantlement. Also, it is also necessary to revise the plutonium production program in Russia. Russia still produces both military and civilian plutonium. There's not much sense in building plutonium storage and producing plutonium simultaneously.

NPR: Do we need to start doing something with the plutonium immediately? Does the technology exist?

Wolfgang Panofsky: It depends on what you mean by "doing something." If you mean disposing of it, the answer is no. If you mean better management, the answer is yes. There's no question that particularly in Russia, but also to some extent elsewhere, the management is unsatisfactory, and that remark pertains both to the civilian and military nuclear fuel cycles. I think that we should work immediately with the Russians to upgrade the many facets of the managment of existing plutonium, but we should also start designing a road map for disposition. Because there are so many disposition options, we can't pursue all of them. All of them involve a fair amount of money, so now we have to engage in a deliberate decision process to decide which option to pursue.

Thomas Cochran: The issue of declarations is fairly simple. Two years ago, people worked out essentially what type of data one should exchange--specifically, what could be exchanged without giving away secret design information. Also,

general agreement was reached within the technical community, among the people who were involved in this issue, that this should be done. Senior Soviet Foreign Ministry officials, senior officials from Minatom, and Soviet weapons labs agreed that the next logical step after the decision to dismantle thousands of warheads would be to implement the data exchange.

The Foreign Ministry officials went back and wrote a draft. Kozyrev, the Russian foreign minister, approved it. Then, Kozyrev gave a speech in which he called for a data exchange, not just between the United States and Russia, but among all of the nuclear powers. He took some heat for that, not because it was not the right thing to do, but because it hadn't been vetted thoroughly in the interministry process in Russia. But his proposal fell on deaf ears in the United States. The Bush administration did not respond, and the Clinton administration has not responded. Here we are 18 months later, and nothing has transpired, even though everybody recognizes that this is the first step that has to be taken. It's extremely frustrating to watch the U.S. government not take up this initiative or proposal. Russian Foreign Ministry officials tell us privately that they really cannot get out front in a public way on this--the initiative has to come from the United States--because of the internal political struggle between the hardliners and the current regime. But they told me, when I made inquiries (both 18 months ago and within the last month), that yes, they're still interested in this, and yes, they think they can get it through the system, if only the U.S. government would take the first step.

NPR: What is the U.S. motivation for not responding?

Thomas Cochran: In the Bush administration, there was a public argument and a private argument. The public argument was that there are more important things on the plate, and that this would bog down the process. The private argument was that we won the Cold War; we don't want Russians mucking around in our weapons policy and constraining our future policy. So, we don't want anything that might trigger restraints on our programs through some reciprocity. We will just get what we can and, in effect, buy it by building facilities, or helping to build facilities, in Russia. That's doomed to failure. In the Clinton administration, it's more a lack of leadership, and part of it is an outgrowth of the structure that was created in the previous administration for handling these issues between the United States and the Soviet Union, or the United States and Russia. The administration for a long time did nothing. Senators Nunn and Lugar stepped in and created this big fund, and that fund was essentially managed out of DOD [the Department of Defense]. People in DOD have their own pet issues, taking warheads off alert and so forth, which are laudable, but they don't have any particular interest in nuclear fuel cycle issues. So there is no leadership in the DOD to push things like a data exchange through, and this issue rightfully should be the primary program of the DOE. There's no leadership right now within the DOE to pick up the ball. So it's just languishing until the DOE puts somebody in charge who believes in this.

NPR: What are the problems involved in dealing with Russia on this issue?

Wolfgang Panofsky: One of the problems there is that Yeltsin right now doesn't have much control over Minatom. Minatom is almost a policy island in the Russian structure, and it is basically behaving like a free enterprise trying to make money. And again, this is all tied up with the election, and generally strengthening the Russian government. We will know presumably in the next month [December 1993] whether Yeltsin can stabilize the administration. Because right now when we negotiate with the Russian government we have no idea whether Yeltsin can deliver the ministries.

As part of our work on the National Academy of Sciences study, we went to Russia to talk about its policies on these things. The only way we could do that was to separately talk to Minatom, the Foreign Ministry, the Parliament, and the General Staff. We did all that, and to put it mildly, we didn't get agreement among those different parts. Now that problem exists in the United States too, but not to such an extent. A typical thing: their so-called Nuclear Regulatory Commission (NRC), Gosatomnadzor, is not being given any access by Minatom to any of the nuclear facilities. So Yeltsin says, "Thou shalt safeguard and regulate it," and Mr. Mikhailov says, "The hell you say." A lot of those things simply aren't working. So, if you do fact-finding there, you find it very difficult because there is no centralized control. Our knowledge about the level of security that they have, even within our government, is very poor. We get assurances, but not evidence.

Thomas Cochran: I'm not as concerned as Dr. Panofsky is about the lack of coordination. If you're a nongovernmental agency and try to go over to Russia and have discussions on what to do, you'll get different views from different departments. But you would get that in the United States. We have an interagency process for resolving all of that. I think their interagency or interministry process for that still works, if it were a formal, government to government program that was pushing it along. I think the logical response to their lack of organization is to get our proposal in order and take it to their Foreign Ministry. I don't think you would see any difficulty in their Foreign Ministry and Minatom and the Ministry of Defense coordinating on responding to it.

Wolfgang Panofsky: Russia's problem is that it would like to keep the plutonium as an asset for future use in fast breeders. But its fast breeder program is totally stalled. We believe its VVER-1000 reactors could be used for burning plutonium if there were the will to do that, which there isn't. The Russians are looking at building a High-Temperature Gas-Cooled Reactor (HTGR), but the question is, why do we build a new reactor for plutonium disposition if the net utility is zero? If the net utility is that you're ending up with spent fuel material, which still has plutonium in it (although the HTGR has less), it just joins the thousand of tons of civilian plutonium worldwide. So, why not use an existing reactor? There is simply no value added for the mission of disposing of weapons plutonium in building an HTGR or an advanced liquid metal breeder. If you want to go in that direction, you have to justify it not in terms of burning plutonium, but because the Russians do badly need safer reactors. But you can't let the plutonium tail wag the nuclear energy dog.

Oleg Bukharin: There is a tremendous inertia behind the plutonium cycle in Russia. There is still a civilian plutonium plant in Chelyabinsk. There is still a plan to complete construction at the second facility at Krasnoyarsk, and there are still plans to build fast reactors at Chelyabinsk and Beloyarsk. And although the industry is trying to reconcile these plans, the fact is that there is no money to spend. They are willing to accept that all of these plans will slip to the next century, but they still see this goal of closing the nuclear fuel cycle and developing a plutonium economy as a strategic goal of the industry.

NPR: Is there any way to change that?

Oleg Bukharin: Plutonium recycle is uneconomic. And now that Russia is moving towards a market economy, I would think that the idea of plutonium recycle is going to collapse under the weight of its poor economics uneconomic. It's more difficult in Western Europe and Japan, given the multibillion dollar investments they have made and all of the commitments they have.

NPR: Do you think the disposition issue is a priority for the Parliament and the government in general, or is it likely to be put on the back burner?

Oleg Bukharin: My hope is that the new Parliament will get down to the nuclear issue very soon. The first priority would be to pass the Atomic Law in general, which would be a legal basis for all nuclear activities. The Parliament must get involved through money appropriations and through revision of executive branch activities.

NPR: The United States and Russia are looking at storing plutonium for at least 20 years; is this just an attempt to defer the difficult decisions? Is there any reason other than politics to delay the decision?

Oleg Bukharin: I think that it's a logical decision. The option of burning plutonium in power reactors is more or less mature in terms of technology, but the technology is still expensive. Also, Russia just can't allow reactors to be built, although these plans do exist on paper, and they may move ahead. There are suggestions to incorporate plutonium into high-level waste and to vitrify it, but there is no technological experience of doing that. Development of this technology will be fairly costly, although much less costly then development of fast reactor technology.

Right now, there is simply no technological capability to process this material, and the only real objection to keeping it in storage for a long time is the cost of storage.

NPR: What are the technical issues involved in the disposition of plutonium and HEU?

Wolfgang Panofsky: The primary options for plutonium disposition are as follows:

One option is *once-through passage through existing reactors.* The vast majority of the world's reactors are light water reactors, and all of them can, in principle, burn a one-third fuel load of MOX [mixed-oxide fuel]. Some of them (four in the United States) can burn full fuel loads. In Europe, burning MOX has been amply demonstrated, so that is not a technical issue. However, it is an institutional issue, because no reactors in the United States are licensed to burn plutonium. But in addition to that, the vast majority of reactors are owned and operated by private utilities, and they have enough trouble, both in terms of actual technical problems and public relations, with running nuclear plants. They would have to be very heavily subsidized or otherwise persuaded to get into the plutonium business, because the additional complication of safeguarding plutonium is something they don't need. In addition to that, there is a political problem, in that the United States has a policy of not using plutonium in its civilian nuclear fuel cycle. So it would take a reversal of de facto policy to do that.

Another option is to *design and build new reactors specifically dedicated to burning plutonium.* The problem is that it's very hard to justify that, because if you use them on a once-through fuel cycle, some of the new designs have certain advantages, but they all leave some plutonium in spent fuel rods. Now in essence, if you burn military plutonium in civilian reactors, all you really do is burn some of it and convert the rest of it to spent fuel. However, there's now an inventory of something like 1,000 tons worldwide in spent fuel rods. So it doesn't make a lot of difference whether you're adding 20 tons or 5 tons to that or 50 tons to that. So therefore the efficiency of conversion in reactors doesn't really--paradoxically--make a difference to the usefulness in burning the material. Therefore, there is simply no incentive, economically or functionally, to build any new reactors for burning plutonium.

Another option is to *mix the plutonium into the high-level waste (HLW) stream from ordinary reactors for vitrification*. There are a few technical problems which come with that which haven't been fully worked out, so it will take a few years of research and development. For instance, it isn't known yet exactly how much plutonium you can put into vitrified glass. There are some problems in the long run if you store the glass logs in geological storage. If some of the materials leech out preferentially to some other ones, then there may be some criticality problems. So, there are some technical problems, but from the point of view of licensing it or doing it, that's probably the quickest option.

Then, one option is what we call *the substitution option*. You could in principle substitute the weapons plutonium for the reactor plutonium. The advantage of that is that technically the road for that is already smooth, because there exist contracts for burning it. The disadvantage is that there are a whole raft of contractual commitments for burning separated plutonium from the civilian cycle in Japanese and European reactors, so you'd have to negotiate with a very large number of political entities and private entities in order to do that. You would terminate quite a large number of reprocessing contracts, or you would reverse commitments to buy certain accumulated materials, and so forth. The negotiating path to doing that is not smooth. In addition, all indications are that the Russians would be opposed to having their plutonium leave their homeland. The Russians, in contrast to the Americans, attribute value to their plutonium. Their value essentially reflects thousands of man-years of labor. If you do straightforward economics, it's very hard to persuade yourself that it has value. But the Russians don't believe that.

There are also several *geophysical options*. One is the deep-bore hole. The Swedes and several others have developed a system where you drill holes about two to four kilometers underground and you take the bottom one to two kilometers and fill it up with layers of plutonium and then plug the hole up with clay. There are a lot of calculations but no data on how long it would take the plutonium to come to the surface. One can convince oneself that that looks quite safe. On the other hand, as far as America is concerned, it would be a brand-new disposal system and would have to go through all of the licensing and public acceptance hoops. So technically it looks quite good, but the acceptability hurdles are very large.

Another geophysical option is the ocean-bottom mud approach. It turns out that there are certain areas of the ocean that have a layer of mud that is the consistency of homogeneous chocolate, and if you let a capsule filled with either HLW or plutonium, you can design it so that it would penetrate into the mud and those things have been stable for hundreds of thousands of years. But again, the acceptance of that would be a very difficult problem. First, there's an ambiguity in the ocean-bottom dumping conventions, whether below the ocean bottom is the same as on the ocean bottom. So, those problems have to be solved. In addition to that, to convince the community at large that indeed the calculations

are good enough to show that the plutonium won't join the biosphere would be difficult. Those are basically the options.

The reactor once-through option will take the weapons plutonium and reduce it to what I like to call the spent fuel standard. That means that it's no worse and also no better than spent fuel. And the spent fuel standard cannot endure forever because of the radioactivity. It's now self-protecting through its radioactivity, but that decays. Right now if you're near a spent fuel bundle at a distance of five meters, you get a lethal dose in about half an hour. But if you're a proliferator, you're well-equipped, you operate behind shields, and you work fast, you can conceive of a scenario of swiping the stuff even now. As the radioactivity decays, that possibility becomes more and more feasible.

NPR: How much study has been done so far on the technical solutions?

Wolfgang Panofsky: A fair amount. The study of the vitrification is mainly at Hanford and Savannah River, but those studies have not focused on plutonium. All of the studies have focused on HLW disposal because plutonium disposition is a relatively recent problem. For instance, the ocean bottom studies have all focused on HLW. Now in some respects, plutonium and HLW pose very different problems. HLW generates much more heat than plutonium. So, the question in the ocean bottom of getting thermal convection up to the surface is a problem, where it's not a problem for plutonium. So, plutonium is in some respects easier, but in some respects it's harder than HLW. For HLW, nobody would want the stuff; whereas in the case of plutonium, retrievability is an issue. If you encapsulate material and put it in the ocean bottom, the stuff is very easy to retrieve. The material is so homogeneous that sonar can't pick up a buried underground capsule very easily. You want the capsule to dissolve rapidly in the case of plutonium, but not in the case of HLW. So there are quite a few differences.

Thomas Cochran: Which option one pursues will really be judged not so much on technical issues but on what will work politically. In the United States, my personal view is that vitrification disposal is the most likely process to succeed. In Russia, Minatom doesn't like that option, and therefore some option involving burning plutonium is most likely to succeed. So, we need to consider how we can move that process along without, in effect, subsidizing the creation of a plutonium economy, the closure of the fuel cycle in Russia, the development of breeder reactors, etc., which I think would exacerbate the problem rather than solve it. That has not been worked out in any detail. The institutional and political arrangements to do that are nonexistent.

NPR: If we chose one of these disposition routes, for example vitrification or bore hole, how long would it take to implement?

Wolfgang Panofsky: For both of those, getting the physical questions settled would take four to five years. Getting the bureaucratic questions settled is hard to predict, but I would say one could actually start the campaign in something like a decade. But that's true of all of them. Even the reactor disposition option with existing reactors, you couldn't actually start that, even being optimistic, for six to seven years, simply because of the formal approval process.

NPR: If we decided to burn the material in existing reactors, would the reactors be ready right now?

Wolfgang Panofsky: If you adopt the one-third or one-fourth fuel load, they're ready for that. But the thing that is not ready is the fuel fabrication. The United States has no MOX fuel fabrication facilities. They have some facilities in Hanford which are three-quarters complete. Work on these facilities was discontinued, so they would have to be completed at a cost of a few hundred million dollars. The Russians have several incomplete MOX fabrication facilities. There are several European MOX fabrication facilities, but they're all contracted for civilian fuel for the rest of the century. So, unless you cancel the commitments there, you have to build new plants. So MOX fabrication is the bottleneck on that one.

Oleg Bukharin: Siemens has a 90 percent complete 120 metric tons/year MOX facility in Hanau, but probably won't get the license to operate it. There is a lot of MOX utilization in Western Europe, but an undercapacity of MOX production in Europe and Japan. France will start up its large-

scale facility in two years, and Belgium is upgrading its facility. MOX presents its own problems, though; it is as big a security risk as plutonium. It takes only two weeks to fabricate plutonium from MOX.

NPR: What are the prospects for a resolution to this problem involving the International Atomic Energy Agency (IAEA) or some sort of an international storage or verification regime?

Oleg Bukharin: Practically, I am somewhat skeptical that it's going to happen. I think that what's going to happen is that there will be transparency on a bilateral basis, that the United States will get access to the Russian storage facility, and that Russia will get some reciprocal access. The United States will definitely be involved. I'm not sure how Russian involvement will evolve, but there will be no real role for the IAEA. On a personal level, I would welcome internationalization of this, but the political realities make it unlikely to happen, at least in the near-term future.

For other countries--France, the United Kingdom, China--it's not a problem. Their stockpiles are small and will not be transferred out of weapons complexes for a long time. It's basically a Russia-United States problem.

Thomas Cochran: I see a very long and protracted process of trying to put together any sort of international regime. Lots of meetings, lots of papers, no decisions. Basically I think the key is going to be what Russia and the United States are willing to do. So, I'm not opposed to doing those things on a bilateral basis and to getting the process agreed upon bilaterally before turning it over to the IAEA. It would be useful to have an IAEA regime safeguarding plutonium stocks, and HEU stocks, and that's one of the objectives, keeping your eye on the long-term objective of making this universal and nondiscriminatory. But there are so many things that one can do immediately, just to get started, that that's not an urgent matter.

NPR: So it's not a good idea for the IAEA or another international body to push this through?

Thomas Cochran: I'm in favor of the IAEA, and the people who are most interested in IAEA matters, moving ahead in trying to develop a regime. They've been through this process before. To some extent, it's a matter of taking out the old papers and dusting them off and seeing what changes ought to be made. The Clinton administration has agreed to putting excess fissile material under IAEA safeguards. That has some political benefits, but it doesn't have any real security benefits. From a political standpoint, one has to get there eventually, so one might as well start. To me, that just doesn't have the urgency of implementing the data exchange and beginning a process of bilateral verification.

Wolfgang Panofsky: I think there's an immediate urgency to put more pressure on the Russians to tighten up the management regime over the plutonium. And I think we should be able to offer a great deal of reciprocity in that respect. For instance, I think the disassembly process should be internationally monitored. Now the Russians, paradoxically, have an agreement with the Ukrainians that the weapons material from Ukraine will be monitored by Ukrainians at the Russian disassembly site. We should have a bilateral agreement with the Russians to monitor disassembly. The Russians disassemble in four different places, and we disassemble in Pantex, and it's technically quite possible to do that. Then, there should be an intermediate storage regime. Since all of the disposition schemes can't make a dent in the problem for a decade or more, we simply cannot have confidence internationally, with all the instabilities, that the Russians can certify to the security of their materials unless there's an international presence. In principle, there's some agreement on that, but it's a very slow process. It's part of the SSD talks. Providing them with storage facilities is high on the agenda, but that's stalled right now.

So we need bilateral inspections of safeguarding, and the sooner that can be turned over to the IAEA, the better. Probably one has to go in steps now, to go bilateral and then international. The IAEA doesn't have the manpower at this point, and to some extent the confidence, to play that role until there's some progress. It's a matter of putting it much higher on the national priority list of negotiations. Bilaterally, I think we can probably make some headway.

NPR: How will public perception of these issues, and public participation, affect the resolution of these issues?

Oleg Bukharin: Here in the United States, the nonproliferation community, which involves nongovernmental groups and the academic community, acts as a sort of watchdog against the DOE. In Russia, it's more of an internal Minatom

affair, but I understand there's a movement to bring in more independent expertise, public expertise. And certainly the Parliament in Russia and Congress here will have to be involved deeply in choosing the right disposal strategy.

NPR: You've said that the public's perception of "wasting" plutonium may be a problem when considering how to dispose of the material.

Wolfgang Panofsky: I don't believe that that's terribly important, but it is being perceived as very important by people in the reactor business. The issue is whether or not the weapons plutonium has value. If you translate everything into dollars and cents, and put in a reasonable discount rate for investment up front, you simply cannot persuade yourself that plutonium is competitive with LEU. That will change over time. Clearly in some period of time plutonium will become competitive with LEU, but that will be a long time from now.

Also, plutonium is a renewable resource. Even if now you throw it away, you can breed essentially hundreds of years worth of plutonium from depleted U-238. So the fact that you are throwing the weapons plutonium away need not signal the fact that you will never use plutonium in the civil reactor economy. Certainly, the time at which plutonium will have positive value relative to LEU is no sooner than 30, 40, or 50 years, and it may be a lot longer. There simply is no urgency to preserve this plutonium for the energy future of the world.

Oleg Bukharin: Plutonium has energy value, but fabrication of MOX today is about five times more expensive than fabrication of uranium fuel. Because plutonium is a very toxic substance, you need to take a lot of safety and health protection measures during fabrication. Therefore, it's more expensive, and because there's certainly no shortage in uranium now, it seems very uneconomic to fabricate plutonium into fuel. But this doesn't mean that the situation won't change in 20 to 30 years. So, plutonium is a liability. In 20 to 30 years, technology may advance to the point that the plutonium option may become more acceptable.

NPR: How is the future of nuclear power likely to affect or be affected by all of these problems?

Wolfgang Panofsky: I think it's a one-way business. The nuclear industry is trying to have the plutonium need be used as leverage to affect the future of nuclear power. This won't work, simply because the quantities involved are much too small. Even though the problem with weapons plutonium is a major security problem, the quantities involved are even today something like 20 percent of the other, and hopefully weapons plutonium won't be used anymore, while nuclear power is producing plutonium at a rate of about 70 tons per year. I believe that the linkage should go the other way around. The country and the world have to make decisions about the future of nuclear power, and they will require government subsidies. And I think the world needs it, particularly the less-developed world. Once it grows, then there's more opportunity for burning the plutonium, rather than the other way around. In my view, the pressure by the nuclear industry to use the plutonium problem to get support for a new generation of reactors is ill-advised and won't work in the long run because people just won't pay for it that way. It's not an honest argument.