PANEL: PHYSICAL PROTECTION ISSUES

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David Albright: If you could please take your seats, I would like to reconvene the conference and introduce our final panel.

This panel will address physical protection issues, post September 11. We are very pleased to welcome Dr. Frank von Hippel, from Princeton University, who will discuss a complementary third way for plutonium disposition that he and his colleagues have been assessing. Following Frank's talk, we will hear from Mr. Matthew Bunn, Assistant Director of the Science, Technology and Public Policy Program at Harvard University's Kennedy School of Government, who will address ways to reduce the threat of nuclear threat and sabotage.

Frank, you have the floor.

Frank von Hippel: Thank you David. I am pleased to be here.

As David mentioned, my talk is about what I am calling "storage MOX" as a third, complementary way for plutonium disposal. This is an idea that I have been working on with my colleagues Allison MacFarlane, Jungmin Kang, and Robert Nelson. We have published this idea in an article in the *Bulletin of the Atomic Scientists*,[1] and we will soon publish an article in *Science and Global Security*.

I'm going to talk about a possible third way for the disposal of excess plutonium, in part because the first two ways—using the material as nuclear reactor fuel, or immobilizing it with high-level waste—may not do the job. However, I want to emphasize that the third way is not in competition with the other two. Rather, it is a complementary strategy for those countries with plutonium for which one of the first two ways would not be available.

Figures 1a and 1b give the stockpiles of military and civil separated plutonium. These are figures that you have seen before. Figure 1a shows total military plutonium, including excess

Figure 1a: Military Plutonium Stockpiles (tonnes)

Country	Total	Excess	Orphan
Russia	100-165*	34	?
United States	85	38	?
Britain	7.6	0.3	0.3
France	3.5-6.5*		
China	2-6*		
Israel	0.5*		
India	0.5*		
Totals	**200-270**	**72**	**0.3**

*Estimates by Albright, Berkhout, & Walker, *Plutonium and Highly Enriched Uranium 1996* (SIPRI & OUP, 1997).

[1] Allison Macfarlane, Frank von Hippel, Jungmin Kang, and Robert Nelson, "Plutonium Disposal: theThird Way," *Bulletin of the Atomic Scientists*, May/June 2001 Vol. 57, No. 3, pp. 53-57.

Figure 1b: Separated Civil Plutonium Stockpiles (tonnes)

Civil (end 1999)	In-Country (Foreign-Owned)	Abroad	Orphan
Britain	72.5 (11.8)	0.9	60 +
France	81.2 (37.7)	0	
Russia	33.6	0	32
Germany	7.2	~17	
Japan	5.2	27.6	?
U.S.	14		
Other	4.5*	< 8.4	?
Totals	**~200 (~50)**	**~50**	

*Belgium, Italy, Netherlands, Sweden, Switzerland

military plutonium. Figure 1b shows total civil plutonium by ownership and location. In both figures, I have a category that I call "orphan," which is plutonium for which there is no obvious disposal path.

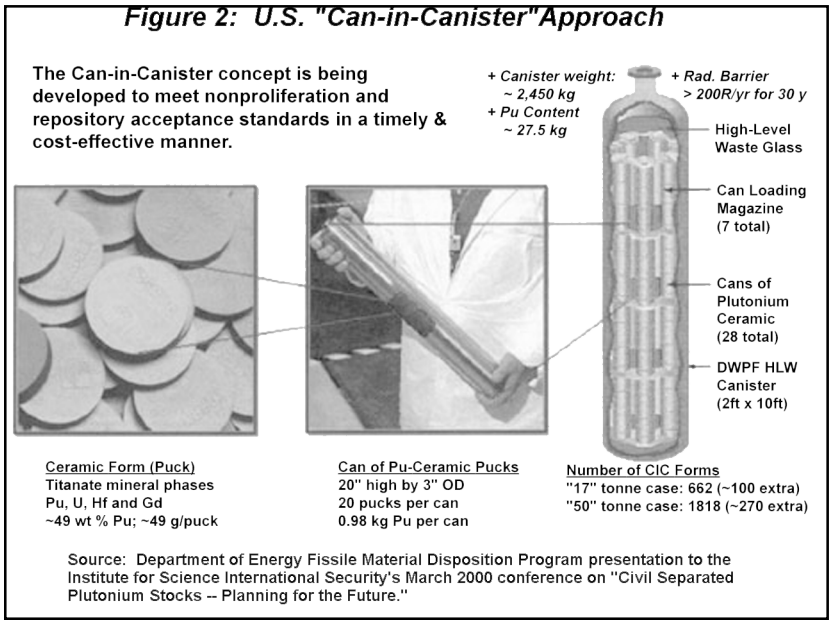
Certainly, Britain's and Russia's civilian plutonium are in the "orphan" category. It may also include the weapons plutonium that Russia has declared excess because its disposition requires the adaptation of the control systems of Russia's LWRs to use MOX. We don't know how that will play out in the licensing process. Certainly, if Russia declares more weapons-plutonium to be excess—as it could and should—then its LWR capacity will be totally inadequate—even if converted.

Now, with regard to the MOX route, the problem in Russia and in Britain is that they do not have sufficient LWRs, and as we have been hearing, the idea of using some of the world's excess LWR capacity to deal with these problems is a difficult one to sell.

The second approach that the United States has been pioneering is the disposition with high-level waste (figure 2). The United States has been exploring this option for about 12 tonnes of its excess plutonium. However, this approach requires an adequate supply of cesium 137—whose separation from organic contaminants has proven to be a problem in Savannah River. So this plutonium too may prove to be an orphan.

This form of immobilization would be quite workable in Russia and Britain in principle, but of course Russia and Britain are not interested in pursuing what could be called "anti-reprocessing"—basically putting the plutonium back together with the high-level waste from which it was separated—while they are still making money from reprocessing contracts.

Figure 2: U.S. "Can-in-Canister" Approach



Source: Department of Energy Fissile Material Disposition Program presentation to the Institute for Science International Security's March 2000 conference on "Civil Separated Plutonium Stocks -- Planning for the Future."

I don't expect reprocessing to continue too much longer in either Russia or Britain, and both countries are under pressure from their regulatory authorities to get rid of their high-level waste as quickly as possible. So this window of opportunity for the second option in Russia and Britain may not be there for too much longer.

That is why I and my collaborators looked at a "third option." Really, this was a proposal that was originally made by the Oeko Institute in Germany,[2] and it has also been looked at by two people in the UK for British plutonium.[3] My collaborators and I decided to look a little bit further at this idea.

The idea is basically to make what the German analysts first called "storage MOX"; that is, MOX that is a variation of the type that is made today in MOX fuel fabrication facilities, but it does not go into a reactor. Rather, it goes into a disposal cask with spent LEU fuel.

For specificity, we looked at doing this in a cask designed by one of the participants in this conference, Klaus Janberg—the so-called "Pollux cask," which is shown in figure 3. This would have the capacity to hold about five tonnes of spent fuel.

My co-authors and I carried out cost, criticality and nonproliferation analyses of this approach. First: How does the cost of this route compare to the cost of the fuel MOX route (figure 4, following page)? Well, storage MOX is advantaged by the fact that quality standards need not be as high as for MOX fuel, stainless steel can be used for cladding instead of zircaloy, and the MOX can contain a higher percentage of plutonium.

It is disadvantaged by having no fuel credit and requiring extra cask capacity because the greater number of total fuel rods. In our analysis, we took some relatively low cost numbers for making fuel MOX—about $1,800 per kilogram—and compared the cost of the fuel-MOX with the storage MOX on a per kilogram of plutonium basis. We assumed that one could put more plutonium into the storage MOX than one could put into the fuel MOX; we limited it to ten percent of fissile plutonium in the storage MOX. We also assumed that the price would actually increase per fuel rod as a result of increasing the amount of plutonium, even though one would not have to adhere to the same quality standards as for fuel MOX.

Because of the higher loading of plutonium, the cost per kilogram would be down. But the storage MOX would not have the benefit of the fuel credit savings. Also, one would have to have extra storage casks and emplacement costs, because you would be using more casks to get rid of the storage MOX. These factors affect the cost estimates.

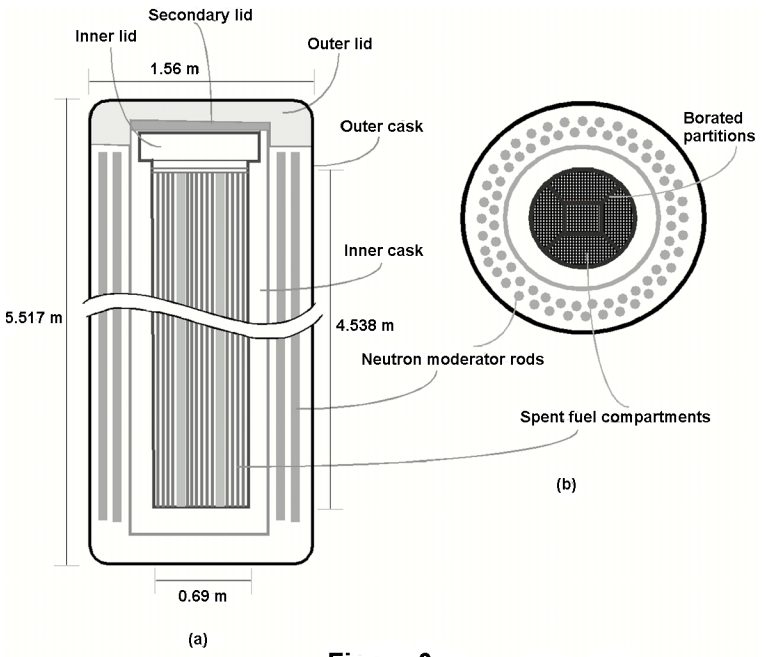


Figure 3
POLLUX cask design specifications, after Janberg (1998).

[2] C. Kueppers, W. Liebert, M. Sailer, Oeko Institute, 1999. For another treatment of this proposal, see also Mycle Schneider's presentation in Kevin O'Neill (ed.), *Civil Separated Plutonium Stocks—Planning for the Future*, Proceedings of the March 14-15, 2000 Conference (Washington: ISIS Press, 2001). < http://www.isis-online.org/publications/civil_pu_conference/index.html>

[3] Fred Barker and Mike Sadnicki, *The Dispostion of Civil Plutonium in the UK*, April 2001.

Figure 4: Cost Comparison* (per kg plutonium)

	Fuel MOX (53-43 MWd/kg)	Storage MOX (10 percent Pu_f)
Fabrication	$21,000 - $30,000	$12,000
Fuel Credit	($14,000 - $13,000)	
Additional Storage Cask and Emplacement Costs		$1,000
Net Costs	**$7,000 - $17,000**	**$13,000**
Cost of disposing of 26 tonnes of U.S. WGPu in fuel MOX**	$100,000	$74,000
Cost of disposing of 34 tonnes of Russian WGPu in fuel MOX***	$44,000	$27,000

* Only costs that differ between fuel and storage MOX are shown.

** *Report to Congress on the Projected Life-Cycle Costs of the U.S. and Russian Fissile Material Disposition Programs,* NNSA (Distribution Draft), March 30,2001.

*** *Cost Estimates for the Disposition of Weapon-grade Plutonium Withdrawn from Russia's Nuclear Military Program,* Joint U.S.-Russia Working Group, March 2001.

We found that, at high burnups under these assumptions—of course, there are great uncertainties here—the fuel MOX route is cheaper than the storage MOX when the burnup is at 53 megawatt-days per kilogram (MWd/kg). At burnups of 43 MWd, the storage MOX would be slightly less expensive. But the point is that the two costs are comparable. Indeed, relative to the costs of today's fuel MOX, the storage MOX would be a little bit cheaper based on these assumptions.

If you are talking about weapons-plutonium, the storage MOX costs are considerably cheaper. Our cost estimates are for the use of an existing European MOX fuel fabrication facility. But much higher fabrication cost estimates have been developed for the disposition of U.S. and Russian weapons plutonium in MOX. For such high fabrication costs, the cost savings associated with the fabrication of storage MOX could well win out over the cost benefits for fuel MOX associated with savings of LEU fuel.

So that is the cost comparison. Now, there is a question about the repository. A major factor in determining the repository capacity is not so much on the volume of the waste, but the heat output of the waste. In figure 5, (following page) we compare the heat output of the fuel MOX (solid line) over a few hundred years with the heat output from the LEU spent fuel plus the equivalent amount of plutonium in storage MOX that would have been in a tonne of fuel MOX (dotted line). You can see that the heat output, because of the large amount of americium 241 and plutonium 238 in the spent MOX fuel, is no greater if you go the storage MOX route.

Storage MOX could also be made into a better waste form than fuel MOX by, for example, replacing the uranium dioxide matrix by much more durable zirconium dioxide. It should be possible to fabricate zirconia-based storage forms in existing MOX fabrication facilities. We believe that the principal necessary change would be a higher-pressure pellet press.

The next question has to do with the assumption that storage MOX would contain a high percentage of fissile plutonium. Might criticality problems result? Now, for our criticality calculations we have assumed a mixture of up to one-third storage MOX—or "Kentucky Fried MOX," as Dr. Janberg likes to call it—with two-thirds spent LEU fuel.

At the first cut of this analysis, one makes a simple calculation that assumes that you have an infinite array of a mixture of LEU spent fuel and storage MOX (figure 6, following page). When we do this without any neutron poisons present, it turns out that a mixture of about one-third storage MOX and two-

thirds spent fuel is subcritical. It will be more subcritical when one goes away from the infinite array and takes into account the leakage of neutrons through the walls of the cask.

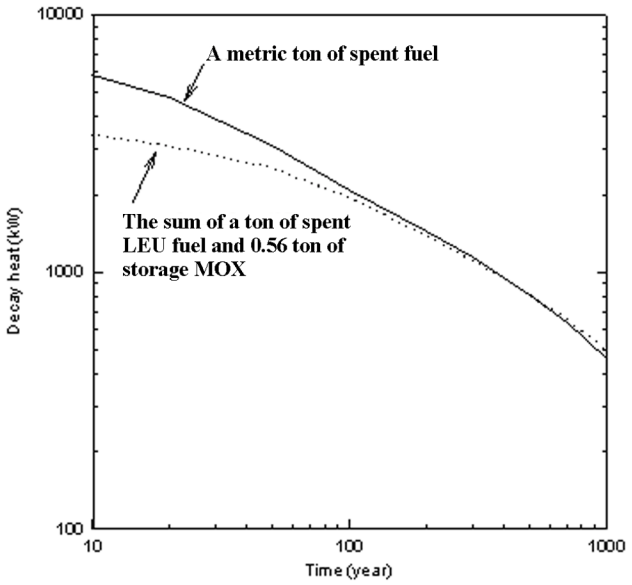


Figure 5: Comparison of decay heat from a ton of spent MOX fuel (53 MWd/kgHM) with that from a ton of spent LEU fuel (also 53 MWd/kgHM) plus a quantity of storage MOX containing the same amount of plutonium as the fresh MOX fuel.

But one could also put neutron poisons in the cask. This makes it a much more favorable situation than spent fuel, which cannot include neutron poisons. The cost of adding one atom of gadolinium and one atom of hafnium per fissile plutonium atom to the storage MOX would be about $1,000– $1,500 per kilogram of plutonium. That cost would be offset by savings at the fuel fabrication plant, because you would not have to worry about criticality problems during the fabrication process.

Finally, there is the question of proliferation resistance. Say that one has done all this, and we are at the point in the process where the Pollux cask is at some kind of storage facility but not yet in a geologic repository. How much would you have improved the situation with regard to making the plutonium inaccessible? What would be the challenge to a subnational group?

Here, the challenge would be to first open up the cask. Now, you could blow the top off of the cask—some explosives artists from Sandia convinced a National Academy of Sciences study group that you could do that in a matter of minutes. But then you would not only remove the top of the cask, you also would remove the radiation shielding. So, you would have a very lethal radiation dose coming up from the spent fuel.

Then, you would have to extract the rods. But if the rods all looked identical, you would have to take radiation measurements to figure out which were the storage MOX rods and which were the spent uranium fuel rods. That would be difficult, and you would still be with a rather poor material relative to pure plutonium oxide.

This separation process could be carried most easily in a large hot cell or under water in a spent-fuel storage pool. Final-disposal casks containing storage MOX and spent fuel would therefore have to be blocked from ready access to such facilities by distance or other barriers.

Recovery of the storage MOX could be made more time consuming if the final-disposal cask

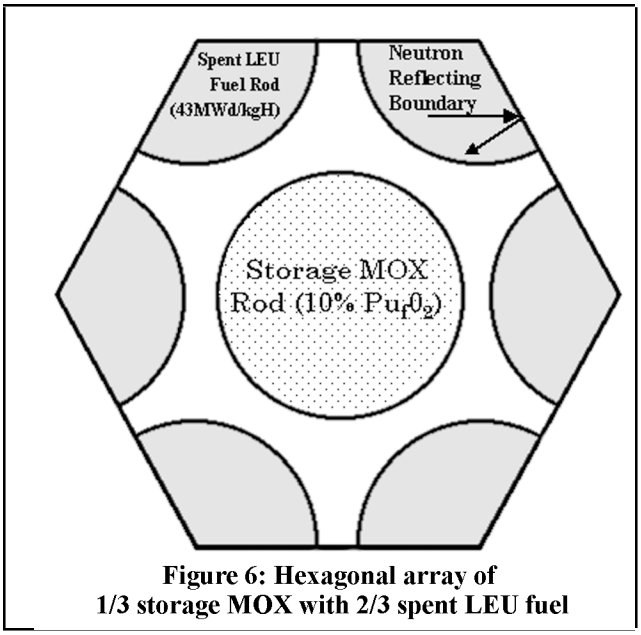


Figure 6: Hexagonal array of 1/3 storage MOX with 2/3 spent LEU fuel

Figure 7: Storage MOX Production Capacities of Existing and Planned MOX Fuel Fabrication Facilities

Facility (status)	Production Capacity (tonnes/year) HM in fuel	RgPu @ 15 %
OLD		
Belgium: Dessel (1973-?)	35	5
France: Caderache (1970-?)	40	6
NEW		
France: Melox (1995-)	115 (195?)	18 (29?)
UK: Sellafield (2002?-)	120	18
PLANNED		
U.S.: Savannah R. (2007?)	~ 50	7.5
Russia: MOX FFF (2007?)	~ 90	13
Japan: Rokkasho (2008?)	130	20

were filled with a low-melting-point material such as lead that would "glue" it to the spent fuel. This filler material—or a mesh imbedded in it—would have to grip the pins strongly enough to assure that their ends would break off before they could be withdrawn.I think that the situation would thus be significantly improved by this method. We can argue about whether it meets the spent fuel standard or not, but certainly with regard to our current concern about subnational threats, it would be a much improved situation than simply storage of separated weapons-usable plutonium.

Finally: Where could you make storage MOX? The obvious place is in existing MOX fuel fabrication facilities. Figure 7 lists the world's fuel fabrication facilities, and categorizes them into old facilities, which might shut down in the next decade or so, new facilities, for whom the reprocessing business may run out before their lifespan does, and planned facilities.

I think that the SMP facility in the UK might be the most interesting facility on this list. It is conceivable that reprocessing could go on in France forever, independent of the rest of the world. But I don't think it will go on much longer in the UK. At 15 percent total civil plutonium, the capacity of a Sellafield-type facility—with 120 tonnes per year of heavy metal capacity—would be quite large. You could push through about 20 tonnes of plutonium per year into storage MOX. The same would be true of Japan's MOX plant, if it is built.

The MOX plants that are being built to dispose of U.S. and Russian excess weapons plutonium are planned to have smaller capacities, but even so, Russia's facility, which is currently planned to have a four tonnes per year capacity for weapon plutonium, could have a ten tonne per year capacity for putting weapons plutonium into the form of storage MOX, and 15 tonnes per year for putting civilian plutonium into storage MOX.

In conclusion, there is no perfect solution for plutonium disposition—except perhaps in France. Our analysis indicates that the storage MOX is worth considering for countries for which the fuel MOX or immobilization options are inadequate.

Thank you.

Matthew Bunn: Unlike Frank, who had a very specific topic that he wanted to talk about, I am going to try to talk about everything under the sun. I am going to go through a lot of things very quickly. I also would refer you to a paper that my father, George Bunn, and I recently presented at the IAEA conference on terrorism earlier this fall.[4]

[4] Matthew Bunn and George Bunn. "Reducing the Threat of Nuclear Theft and Sabotage," Presented at the IAEA Safeguards Symposium, Vienna, Austria, October 30, 2001. <http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/pubs/nuclearttheft>

Basically, the point of this talk is that we are not doing a lot of things that we can and should be doing to prevent nuclear terrorism. The notion that the Bush administration has been putting forward that we are already spending exactly the right amount of money on exactly the right programs in this best-of-all-possible worlds is utter nonsense.[5]

In my view, after September 11 we have to nail down all the nuclear weapons and weapons-usable nuclear material worldwide, to stringent standards. We have to get rid of the most insecure and difficult-to-defend stockpiles that exist around the world, and reduce stockpiles worldwide. We have to protect nuclear facilities from sabotage—I am not going to say any more about that here, because we are really focused on plutonium at this conference. Also, we need to put into place effective controls on relevant technologies and expertise and interdict nuclear smuggling. I think that we need to spend a portion of the emergency budget arising from September 11 on these programs. I will say a little more about that later.

To provide some context, I'd note that the September 11 attacks increase our probability assessment that terrorists might actually try to get nuclear weapons, and therefore the urgency of trying to deal with this threat is greater. One thing that I think is relevant—I am actually more worried about the little stocks in various places around the world than I am about large stocks at large facilities. The larger stocks are often reasonably well guarded. We need to keep those little stocks in mind.

We also have some new opportunities. Given the newly forming global anti-terror coalition, with a sustained push from the highest levels, much could now be done—especially with Russia—that did not seem possible before.

First of all, we need to accelerate the process of securing nuclear material in Russia. There is a major program to do this, but after seven years of effort, less than 40 percent of the material is protected by what are called "rapid upgrades." We really need a drastic acceleration of that effort. I believe that if we took a real partnership approach with the Russians, in which Russian experts played leading roles in the design and implementation of the entire effort, rather than the attitude of "we've got the checks, so we'll call the tune," then we would be able to achieve the kind of acceleration that is needed. Maybe we could get all of the rapid upgrades done for essentially all the material in the next couple of years. To do that, however, it is going to take some very high-level leadership to overcome a wide range of obstacles on both the Russian side and the U.S. side. It will also take more money.

We have a similar situation on warhead security. Terrorists have carried out reconnaissance at Russian nuclear warhead sites twice in the past year, according to the commander of the force that protects those sites. The Department of Energy is working with the Russian navy, and is making good progress at securing almost 4,000 warheads. The Department of Defense is working with the Ministry of Defense on the remaining warheads; they have made some significant progress on what are called "quick fix" upgrades, but the comprehensive upgrades have been almost stymied over access issues—literally for years. We need a high-level political push to break that logjam, and it is going to cost more money.

I want to highlight the fact that this is not just a Russian problem. This is a global issue. There are 43 countries in the world with HEU at research reactors, for example. We need a major program to

[5] Shortly after this conference, Congress added more than $200 million in emergency spending to improve security and control over weapons of mass destruction and related materials and technologies, and the Bush administration shifted its position as well, coming out in strong support of these programs and proposing to expand many of their budgets.–M.B.

eliminate the plutonium and HEU from as many facilities as possible worldwide. That is, we need to seek the closure of facilities completely, or seek their conversion to LEU fuels.

Many of these facilities have absolutely no reason to exist. There are more than 270 operational research reactors around the world; my guess is that, if you took a serious look at the need for research and training, we only need about ten or 20 research reactors. It will require packages of incentives tailored to the needs of each of those facilities to convince them to give up that material. These programs include: the Reduced Enrichment for Research and Test Reactor (RERTR) program, getting the Russian RERTR and RERTR take-back of fuel that they have supplied, undertaking IAEA-coordinated and bilaterally coordinated efforts, and other programs—all of that needs to be done. It really has to be a new start. We are trying to do this a little bit in the Russian MPC&A program, but it would really have to be a new program outside Russia.

We should also be working to negotiate more stringent standards on security and accounting. I think that it would make sense to revise and strengthen the IAEA recommendations on physical protection contained in INFCIRC/225. There is already—more or less—a consensus that the Physical Protection Convention should be amended to cover domestic material as well as material in international transport, and to include basic principles of physical protection. But the experts have opposed a variety of important things, including developing actual standards for the levels of physical protection you should have, and including military materials. The experts have also opposed any kind of mechanism for reporting the kinds of practices you have, and they have opposed any kind of peer review. As we heard from our colleague in the audience earlier, the balance between transparency and physical protection is very difficult.

Towards this end, one important approach would be for the leading nuclear states to commit themselves to comply with IAEA recommendations, to report on their procedures, and to allow peer review —as a political commitment, without waiting for the broad international consensus required to include such amendments in the Physical Protection Convention. Over time, this would allow them to lean on all of the states they supply to do the same, so that the IAEA program that currently does peer reviews and helps states to upgrade the security of their material would become a more normal part of doing business in the nuclear world. Good physical protection would become part of the price of admission for getting good contracts. That is an important step to be taken.

At the same time, we need to deal with the problem of Russian nuclear experts. Today they are making on average about $150 per month. That's progress, in the sense that the salary was $60 per month a few years ago. Guards, as I understand it, make about $100 per month.

Overall, Russia and the United States still have nuclear weapons complexes that are much bigger than you could possibly need in the post-Cold War environment. So we need to be doing more and spending more to shrink these complexes down so that we are no longer talking about, for example, defending more than 400 buildings in Russia where plutonium or HEU is stored. We also need to focus on reemploying the nuclear experts who are no longer needed.

I'm not going to talk about plutonium disposition, because we have covered that a lot today. But I do want to talk about the HEU purchase agreement. First, we have to stabilize the existing deal at 30 tonnes per year. But beyond that, it would be useful to accelerate the agreement further. After all, that 30 tonne annual figure was set by what the commercial market could absorb. It has absolutely nothing to do with what would be desirable from a national security perspective in either Russia or the United States. After all, from Russia's perspective, it would be desirable not to have to keep protecting all of this HEU that isn't needed anymore. From the perspective of U.S. or international security, it would be desirable to get rid of it all tomorrow.

The Russian facilities can already blend down material about twice as fast as they are now. That, at least, is what U.S. experts believe, and some Russian officials have said more or less the same thing. And you could therefore decouple the security goal from the market constraints by simply paying Russia to blend down this material as a fee for service, and then to store it. As one example of how this might work, you could pay the cost now for Russia to use underemployed facilities to blend down this material to 19.9 percent, store it, and meter it on the market after the existing deal is finished in 2013. In this way, Russia would get two things: It would get immediate payment for its costs to blend the stuff down. Later, it would get access to U.S. markets at 30 tonnes per year extended beyond 2013 for a much longer period.

We also need to move forward on some kind of international monitoring and custody of excess HEU and plutonium stockpiles. Even if you do not think it will contribute to security, such a step is a key symbol that these materials will not be used for weapons. At the moment, the bilateral talks about transparency at Mayak are almost entirely stymied. Russia has resisted a number of U.S. proposals, and the United States has not offered any reciprocity, which has contributed to Russian resistance.[6]

The U.S.-Russia-IAEA Trilateral Initiative is still being discussed, and has been discussed for quite a long time. Russia is resisting some aspects, and the U.S. has been unwilling to offer any of its plutonium that is still in classified form for verification. The IAEA has been taking a rather inflexible approach on several aspects, and no one knows who is going to pay for it. I believe that such arrangements are likely to move forward only when there are strong incentives, and I don't think these incentives presently exist. Therefore, it will take a high-level push, more U.S. willingness to accept reciprocity, and the willingness to finance these arrangements to get things going.

Ultimately, with regard to monitoring fissile material, we need a much broader regime. The goal is to build confidence not only in the fact that a particular stock has been declared excess and is secure and accounted for, but also on how may nuclear weapons are left, how much military plutonium and HEU is left, and that it is all being reasonably well taken care of. That is going to be a difficult regime to create, because of security sensitivities.

Stopping the further production of HEU and separated plutonium is also part of this post September 11 agenda. Unfortunately, the effort to stop the production of weapons plutonium is on the verge of collapse. There is a bizarre opposition among Republicans in the House of Representatives that has carried over to the Defense Department to spending defense funds to replace the plutonium reactors in Russia with fossil plants. I think that if those people are not brought to heel by some adult supervision relatively soon, then that program will collapse entirely.[7]

There is also no program in place to confirm that there is no additional HEU being produced. I don't think that either Russia or the United States is producing any more HEU, but since we are paying the Russians a lot of money to blend down HEU to LEU—and we should be doing even more of this—it is going to be essential at some point to have some kind of transparency in place to confirm that we aren't just funding an endless cycle of enrichment and downblending.

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[6]After the ISIS conference, some significant progress was made on Mayak transparency talks, though as of early 2002, no final agreement had been reached. –M.B.

[7]After the ISIS conference, the Bush administration decided to shift this program to the Department of Energy and continue it with full funding. –M.B.

We have talked a lot about the nuclear fuel cycle, but I want to emphasize that there is an opportunity to return to the talks with Russia that were almost concluded during the Clinton administration about an idea that Vladimir Rybachenkov discussed—that is, providing more spent fuel storage in exchange for at least a temporary moratorium by Russia on reprocessing operations.

The recommendations that I've made will cost, in total, about $510 million more than is currently planned for fiscal year 2002 (figure 1).

Figure 1: Recommended FY02 Funding Increases

Initiative	*Recommended Increase from Existing FY02 Budget*
Accelerate nuclear material security upgrades	$150 million
Accelerate nuclear warhead security upgrades	[balances until FY03]
Close or secure non-Russian facilities	$50 million
Expand work to stabilize custorians and shrink complex	$40 million
Improve"loose nukes" intelligence	$50 million
Interdict nuclear smuggling	$30 million
HEU rapid blend-down	$90 million
Plutonium disposition	$60 million
Monitoring stockpiles	$30 million
Stopping production	$10 million
Total	**$510 million**

The Bush record, unfortunately, has not been a good one. On the campaign trail, the President said that these were very important problems, and that he would ask Congress for more assistance. The first thing he did, in fact, was cut $100 million, or about one-third, from DOE programs involved in preventing loose nukes. There was a lengthy review of these programs that effectively paralyzed policy for more than six months and came up with virtually nothing new. During that review, the NSC staff effectively attempted to kill both the Nuclear Cities Initiative and the MOX approach towards plutonium disposition. Immobilization options for plutonium disposition had been killed earlier, and the front-page skepticism on plutonium disposition undercut efforts to round up international financing for the program at a crucial moment, as Senator Domenici mentioned. Then, in the summer, there was a revision to the Defense Authorization bill that gave the administration the opportunity to correct what they claimed that they felt were mistakes. They did not take that opportunity, and instead cut another $40 million out of Nunn-Lugar programs.

A wide range of problems have been allowed to fester that are slowing the programs. There is still no decision on plutonium disposition. The plutonium production reactor shutdown program, as I mentioned, is stymied by the fact that the Pentagon is now telling Congress that it won't pay to do it even if Congress does allow them to. Out of the $40 billion of emergency funds, zero dollars were allocated to keeping

weapons of mass destruction out of the hands of terrorists, and basically nothing was done on the nuclear subject with Russian President Putin at the Crawford summit.

To be fair, subsequent to the summit, there have been some, I think, reasonably promising talks between Energy Secretary Abraham and Minister Rumyantsev, and between John Bolton at the State Department and his Russian counterpart. So, perhaps by the next summit, we can be getting somewhere. In order for that to happen, I think that Congress has to step in and begin applying some pressure.

In January 2001, the Baker-Cutler committee put forward a report that said that the threat of nuclear terrorism is the most urgent threat to the United States. To address this threat, you have to have a strategic plan to get the job done, you have to put someone in charge, and you have to make funds available. I think that it is incumbent on Congress to effectively legislate those steps. President Bush has said that keeping weapons of mass destruction out of the hands of terrorists is his top priority. Congress has to now step in and encourage the administration to take actions that match the rhetoric.

So, what does Congress have to do? It has to require the administration to work cooperatively with Russia to come up with a strategic plan to get this job done as rapidly as possible; require that the budgets submitted for fiscal year 2003 be consistent with implementing that plan; require the president to appoint a senior leader for these efforts, with the appropriate staff, power, and resources to pull all of this together—all of this is going on in completely different stove pipes, with literally no one in the government who is in charge of this overall set of activities—and Congress has to appropriate near-term funds, which is the biggest fight right now.

There is, in the $20 billion supplemental being debated in the Senate right now, $226 million for accelerating loose nuke programs and related efforts. While this is less than I am recommending, it could allow a substantial acceleration in a number of programs that would directly reduce the risk of nuclear terrorism. I think that it is very important that as that bill goes to conference with the House, which has zero funds for these programs in its version of the bill, that the people in this room help contact some of the conferees on both the Senate side and the House side to emphasize how important that this money be adopted.[8]

The fact that there are unspent balances does not mean that the programs do not need the money. The way that these programs work is to, first, assign money to a project. Afterwards, the relevant lab or firm negotiates a contract with the Russians—that takes awhile. Then the Russians have to do the work—that takes a while. Finally, the Russians get paid once the deliverable is provided. So you always have unspent money, otherwise you would just be handing out cash to Russians without getting any deliverables.

The fact that there is unspent money does not mean that they do not need money. In the MPC&A program, 99 percent of the money from fiscal year 2001 has been assigned to projects; it just has not been spent yet. So the notion that we can do a lot more with the money that we already have is not correct.

The next priority is a real strategic leader. It seems to me that, in essence, you don't get this job done unless you have two key ingredients—money and sustained leadership from the White House. I don't see how the sustained leadership from the White House really comes together unless you have a full-time

[8] All of this $226 million was preserved in conference. Additional funds were also provided for the Department of State's efforts to improve export controls in the former Soviet Union and provide new jobs for biological weapons experts. –M.B.

person with some seniority, who can keep it on the front burner day after day, doing this job. I think also, as Frank, Ken Luongo, and some others and I wrote to Presidents Bush and Putin, it would make sense to put together a joint expert commission that could get into more details, provide advice, and lay out specific ideas for overcoming some of the logjams that these programs face.

You can only really do this in partnership with Russia. These are very sensitive areas of cooperation. It takes major, heavy lifting on our side and on the Russian side to overcome the suspicions that slow down these kinds of initiatives. If you walk in there and say: "I'm the one with money, and this is the way that we are going to do it," then you will not get this agenda accomplished. The way to succeed is to really integrate the Russians into the design and implementation of the entire thing, so that there are Russian experts who have, in a sense, a feeling of ownership for what is being done, who understand why it is important, understand why it is structured the way it is structured, and are willing to lobby their own government to keep things moving forward. I can't emphasize enough that this can't be done without a partnership approach, and there is too little of that in most of these programs at the moment.

So, in short, we have to have a plan. We have to have someone in charge, we have to have the money, and we have to have sustained engagement at the White House. At the moment, none of that is in place. There is an enormous amount that we can and should be doing to address this risk. "Business as usual" is not good enough, and now is not the time to be pinching pennies.

Thank you.

David Albright: Thank you, Matt. Are there any comments or questions?

Question: I have one comment and one question. Matt, I thought that your presentation was excellent. I know that you and George Bunn have been—appropriately—giving a lot of emphasis to physical security, and I want to ask you to comment on one specific issue. There have been a lot of references to peer review of physical protection systems today, including in your talk. We keep hearing that there are national sensitivities about international involvement. The argument is that the inherent nature of physical protection requires secrecy, and keeping the adversary off balance. To me, that makes some sense. Yet, peer review continues to be enshrined as some sort of transcendental truth—that we won't be satisfied with a new regime unless we have more peer review.

If it is a peer review of countries that have small programs that don't matter, then how useful is it? Are we overplaying the importance or relevance of peer review? That is my question for you. For Frank: It is a very short question. How much interest have you engendered in your idea at the industrial level? How much interaction have you had?

Frank von Hippel: That's easy: Zero.

David Albright: Hal, didn't someone ask you that this morning? And you said the same thing.

Harold Bengelsdorf: Zero was a euphemism for us.

(laughter)

Matthew Bunn: On the peer review issue, it is an extremely sensitive subject. I would be the first to say that if we had an international consensus on a set of measures to strengthen physical protection that included everything else that seemed sensible, and didn't include peer review, then I would grab that. On the other

hand, without something like peer review, it is very difficult to figure out which countries do have good security and which countries do not.

We have the situation today where, if some country came to the table and said that it wanted to spend $20 million on the worst physical protection problems in the world, nobody would be able to identify the worst physical protection problems. Everybody would have a bunch of easy nominees, but nobody would know for sure that those were the worst. So, I think that the peer review issue is an important one to keep pursuing.

I don't think that it is going to make it into the Physical Protection Convention. But I think that there are opportunities for the major nuclear states to politically commit themselves to allow such kinds of reviews as part of encouraging the little countries that probably don't have very good security. Those are the countries that you really want to accept these kinds of reviews.

I think that it is very difficult, for example, for the United States to take a leading role in convincing other countries to follow the IAEA recommendations on physical protection, when the United States doesn't follow them. It is going to be very difficult for the United States to convince other countries to accept peer reviews if we don't accept them ourselves. I think that there are opportunities to use managed-access approaches and confidentially of information in ways to try to bridge what is a very real tension between maintaining secrecy in order to have good security, on the one hand, and giving the international community the information that it needs to have confidence that security is being handled adequately in different countries, on the other hand.

Question: Could I just add something? I think that it is important to define what we mean by peer review. One of the last things that I did before I left the U.S. government was to be involved in the proposals that we made to amend the Physical Protection Convention. It is important to understand that what the United States was proposing was a review of a country's physical protection *laws and regulations*. It did not involve sending IAEA inspectors out to see what the physical protection measures were at a given facility. The proposal to provide a peer review—just the laws and regulations—ran into an absolute stone wall. That gives you some idea of what the sensitivity is.

The United States has a very different philosophy on physical protection than does the rest of the world. Unlike the United States, the rest of the world sees secrecy as a very important component, and it is reflected in the stonewall response to the proposal that we made.

Now, one useful thing that the IAEA does is to go out and advise developing countries on the kinds of laws, regulations, and measures that they ought to put into effect. But I think that under the present circumstances, the notion of a peer review is a non-starter.

Matthew Bunn: I think that the higher priority for the moment is to make sure that those IAEA efforts that you described are well funded. There are a lot of countries that would be perfectly happy to upgrade the security at their facilities if they had the help to do so. At the moment, the entire IAEA effort in that area has less than $1 million per year. NTI just gave them $1.2 million over the course of three years, and DOE just matched that amount, so that will roughly triple the IAEA's effort. But it ought to be increased significantly beyond that.

Question: Matt, I have a question for you. You talked about changing the culture in Russia, closing down two of the four Russian weapons assembly facilities, and retraining and finding new jobs for the other scientists. In your most optimistic assessment, and if money were no object, how long would this process take? Is this a generational thing?

Matthew Bunn: Well, it depends on what you define as the end-state. Russia has already committed to closing two of the four weapons assembly/disassembly facilities. Vladimir can correct me if I am mistaken, but I believe that all assembly and disassembly at both of those plants is to be closed out by 2003. I do think that it will take a significant period of time to reemploy the scientists in any kind of gainful way.

I did a back-of-the-envelope calculation of what it would cost to pay every employee at one of the ten closed nuclear cities in Russia for the rest of their natural lives, and it is only a couple of billion dollars. Now, of course Russia would not just let the United States buy out its entire nuclear weapons program, but we are talking about a large but finite problem.

Frank von Hippel: Could I just add something back to the issue of peer review? Of course there is a lot of peer review already in the U.S.-Russian MPC&A program, so the principle has been established.

With regard to the industry's interest into the "third way" that I described, that is not our job. Rather, it is our job to produce ideas. We did the first paper on the first and second disposition methods—even before the National Academy study—and put these ideas out there. The question now is whether or not someone picks it up.

Question: One question that I've always had about these third way approaches, where you do not have the spent-fuel standard, is that it creates a new category of material. For instance, given a spent fuel storage facility that is now a category three facility with respect to physical protection, if you insert a substantial amount of plutonium at a relatively high concentration, how will that be treated with regard to these criteria? If you don't treat this like a plutonium storage facility, is the protection that is there already enough? And if you do treat it like a plutonium storage facility, have you gotten your money's worth in going through this procedure?

Frank von Hippel: I think that this approach is actually pretty much equivalent to immobilization, in terms of the amount of physical security that it provides the plutonium. The immobilization plan, at least in the United States, is the equivalent of this storage MOX, except that the plutonium is embedded separately in the high-level waste glass. The issue is how to separate the plutonium from the glass. In the third way, you have these MOX rods embedded with spent fuel, and the question is how to separate them.

I think that I mentioned in my talk that there are ways of making it more difficult to separate them. You could, in effect, "glue" them together, much in the same way that the high-level waste glass "glues" itself to the cans of immobilized plutonium.

Question: Ok. But you agree that without that kind of additional substance...

Frank von Hippel: I think that you are making a little bit of a legalistic point. The point of the idea is to make the plutonium a heck of a lot more secure than just leaving it in separated form. But one can devise ways to glue the spent fuel to the storage MOX.

Question: Frank, I don't understand the proposal well enough to see what benefits is offers over can-in-canister. It seems to be more expensive, and does not resolve any of the criticisms that the Russians have about easy access to can-in-canister plutonium from a breakout perspective.

Frank von Hippel: You're right. It is basically equivalent to the can-in-canister approach in terms of the result. Both are good in terms of making the plutonium inaccessible to subnational groups. With regard to

the Russian nightmare—I've been talking in terms of civilian plutonium, but if you applied it to weapons plutonium you would have the same Russian objection. But there is a lot of "orphan" civilian plutonium out there, too, for which there may not be high-level waste available when the time comes to dispose of it. At that point, you still will have spent fuel available to provide a radiation barrier. That is the fundamental point.

Matthew Bunn: The other thing that I would add on that subject—maybe Vladimir will disagree with me—is that I think the Russian argument about breakout is more ideological than real. If you are worried about the U.S. reversal of its arms reduction obligations, you have to be more worried about the thousands of warheads that the United States is maintaining in storage, and the additional thousands of pits that are being maintained in storage. The last thing that the United States is going to do is spend billions of dollars getting plutonium out of ceramic after we spent billions of dollars putting it into ceramic. It is just silly to think that that is the biggest U.S. strategic reversal problem that Russia faces.

Question: I have a question for you, Matt. Does Russia have any sort of design-basis threat process in either the military or civil sectors?

Matthew Bunn: The answer to your question is: Yes and No. They are still working to put into place as a regulatory matter a design-basis threat of the kind that we have at NRC. I believe that those regulations have been drafted, but are not yet issued. Nonetheless, certainly the 12th Main Directorate has an idea of the threat it is facing. The Russians hold exercises of mock attempts to break into nuclear weapons storage facilities, just as the United States does.

One of the proposals that I think makes a lot of sense would be for the United States to work with Russia to establish a firm that was basically manned by ex-Russian special forces personnel—just as there are firms in the United States manned by ex-special forces personnel—whose job would be to carry out tests and try to break into nuclear facilities. I think it would be a good thing if Russia had this kind of firm doing those kinds of tests on a regular basis. Similarly, the IAEA is very seriously considering expanding the service that it provides to help countries organize or carry out real tests of physical protection systems. That would be expensive, but would make sense for those countries that were willing to have others help them in this area. The IAEA is already helping countries with a workshop that they have put together in developing their own design-basis threats around which they can design their defense. One country that I would like to see get its design-basis threat regulations written and promulgated is Japan, which, so far, does not have a design-basis threat.

Question: I have a question for Frank. I assume that the radioactive spent fuel is part of the protection. My question is: What about those terrorists that are willing to die? How long would it take the radioactivity to kill them? Could they break open the casks and retrieve the plutonium before they die or become incapacitated?

Frank von Hippel: I think that they would have about an hour, at the most, to get a lethal dose. But it takes awhile to die. The radiation dose will depend a bit on the age of the spent fuel, but I think that the collectivity of the seven assemblies would give a dose of about 1,000 rad per hour.

David Albright: That is not necessarily going to incapacitate them.

Frank von Hippel: It is an interesting problem. This is a new thing to worry about, and it has not been integrated into the analysis for any of the disposition alternatives.

Matthew Bunn: One, more urgent, issue related to that is spent HEU from research reactors. This material is usually not very radioactive. We worry a lot about fresh HEU fuel, but a lot of programs are not

doing very much about "spent" HEU fuel. A lot of this stuff was irradiated a long time ago, and was not irradiated very much in the first place. If you are talking about terrorists that don't mind doubling their risk of getting cancer 20 years down the road, then this stuff poses essentially as big a proliferation hazard as fresh stuff.

Question: I'd just like to make a brief comment. I am struck by a couple of things at this meeting today. One is that we have been in this process for ten years, and we seem not to have made much progress on the disposition of excess military plutonium. We surely have made little progress in trying to reach a consensus that the overburden of civilian plutonium is something that needs to be dealt with. So I just want to comment that we should all ponder why there is no dynamic for doing anything here, except to come up with a lot of schemes that are quite interesting, but always cost money and require sensitive discussions.

Compare the present situation with the INF agreement; an agreement was put into place, a verification agreement was worked out, mutual destruction took place within an agreed time frame, and the job was done. So, I think we have to wonder why we are not making any progress at all in disposition.

The other thing that I want to mention is, in terms of immediate vulnerabilities and the value of a design-basis threat, I would ask you all to look no further than the 103 nuclear power reactors operating in the United States today. The fact is that force-on-force exercises demonstrate that half the plans failed to repel a much smaller adversary than was at work on September 11.

Look at the progress to-date to correct that problem, and I would simply say, go to the Nuclear Control Insitute's web site, take a look at the testimony that we just submitted to the Energy and Commerce Committee. The NRC is talking about a top-to-bottom review that eventually gets around to upgrading the design-basis threat as appropriate. The federal government is not considering any action to provide military protection for these plants, which in my view are vulnerable today.

You might also go to the POGO web site. Pete Stockton, a former staffer for Representative Dingell, has been looking at DOE facilities where there is a design-basis threat, and where the vulnerabilities are apparently quite large.

This leads me to conclude that it will take something catastrophic or near catastrophic to wake up the community. Short of that, little meaningful is being done, post September 11, with regard to the things that we know most about and presumably care most about.

Finally, Matt, I would like to ask you a question that is specific to your presentation. You said that you are more concerned about the smaller facilities than you are about the larger facilities. Are you satisfied that material accounting and control systems are adequate at Sellafield or La Hague? We know, from Marvin Miller's study that was done a few years ago, but still holds true today, that because of measurement uncertainties, undetected losses would have to approach about a quarter of a tonne before the IAEA would have a 95 percent confidence level and only a five percent chance of false alarm that any material is missing. You have to look at the question of the adequacy of the vetting of employees against insiders who know how to beat such a system. I question how you can express that degree of confidence that the larger facilities don't present the problem.

Matthew Bunn: I don't want to get into a long debate about the adequacy of IAEA safeguards, but I would just assert that if I were either an insider, or a group of outsiders wanting to go in with guns blazing, I would much rather do so at the HEU research reactor at Vinca in Yugoslavia than at either Sellafield or La

Hague. There are a lot of things that keep me up at night before I start worrying about plutonium stored at Sellafield and La Hague.

David Albright: Do any of the speakers want to make any last comments before we conclude this conference? Hal?

Harold Bengelsdorf: I just would hate to see the conference end up with such a fairly depressing statement that was just made. My own judgment is that a lot of progress has been made.

Matthew Bunn: I agree. I would point out, for example, that while not much plutonium has been disposed of, the reality is that hundreds of tonnes of nuclear material are much better protected today than they were a decade ago. Enough material for 5–10 thousand bombs has actually been destroyed in the HEU purchase agreement. Thousands of nuclear weapons have been dismantled over the past ten years. There are a lot of things going on today that would have been unimaginable ten years ago. We've made a lot of progress, it is just that we have to make a lot more if we want to solve the problem.

Harold Bengelsdorf: The other point is: Fred and I put out an idea this morning, and obviously we will welcome the reactions of each and every one of you to this proposal.

Thanks.

David Albright: Thank you very much for coming.

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