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table, and I have not been at the table. Trust me. The discussion is different when we are at the table: Meeting the needs of women as well as men in development; balancing the desire for cash crops and the concerns of subsistence, that is, the food we sell as well as the food that we eat; melding the advantages of local science and local knowledge systems.

In too many of our discussions, developing countries have been viewed only as problems, not as integral components of the complex ecology of Planet Earth. I think that we have to shift our view of developing countries from being only the targets of development to being the partners in development, recognizing that there is no such thing as "Your end of the boat is sinking."

We have to provide access to technology for sure, because quite frankly, I believe that information "haves" and the gap between information "haves" and "have-nots" is growing. We have to develop more scientists and engineers. I found Peter Raven's arguments quite compelling about the need for indigenous science capacity within the countries of the developing world.

This also means looking at our own institutions, to figure out if, what we provide in the way of advanced education to the rest of the world will meet the needs of these people when they return, if they return, to their own countries: To highly skilled people from the rest of the world, as we are not meeting our own needs for our own production of advanced people within this country. Finally, promoting science and technology literacy as though a world depended on it, because it does. Thank you.

Fourth Panel Discussion Questions and Answers

RITA COLWELL—*Questions*

For Dr. Rischard: Given the new directions that you have spelled out, how is the World Bank going to keep abreast of science and technology and tap all special expertise in technologies? Typically, the World Bank has financial expertise and increasingly, it has turned to the environment, but this is going to be a new direction, and along with that, what is the Global Information Infrastructure Commission? How can other organizations be involved?

JEAN FRANÇOIS RISCHARD—*Answers*

Technology is going to be one big, important solution to many problems that we are faced with in developing countries, particularly (actually, disproportionately) in favor of regions like Africa, which are very isolated and where one could really do marvelous things in leap-frogging basic education and women's education; I will come back to that later.

The big challenge for us in the Bank is to get our entire staff to think in these terms, to keep itself abreast of what is going on and be able to bring ideas to countries in the right way so that they can start planning for them and incorporating them into their development plans. That is a big job, and that is why I said that it is the sort of job which you have to do in partnership with others.

We started a partnership with the NRC. We now have a similar partnership planned with the European Union scientists through the Brussels Commission. The example of this Information Infrastructure Commission, which is actually an assembly of CEOs and leaders in telecommunications and those areas, with the express purpose of making sure that developing countries do not get left out and do not become information "have-nots" in this whole tremendously exciting development area. We have a lot of things to do.

We are actually not so much a financial institution as a developing service institution. We make loans, but we do spend a lot of time figuring out what is important or what are not priorities. We are studying what works best in education and in agriculture. One of our findings over the last 20 years is that the highest return you can achieve in a developing country is the education of women, particularly of girls at the basic education level. Indeed, it is not a new technology. It is an old, basic, obvious thing to do, yet it has not been done much in many countries. It does produce tremendous byproducts. It not only takes the brunt away from women, who are indeed going for the food and the fuel and water and handling the whole burden of the village generally, but it produces immediate improvements in the whole village productivity. It causes decrease in child mortality. It causes a quick decrease in fertility levels at the same time. The children tend to do much better. These are very important things. These are old technologies, but the new technologies will help a lot in moving these things ahead.

You remember I spoke about the idea of a community learning center, instead of a basic primary school. If you have an old PC and a cellular link, which is not expensive anymore, or is not going to be expensive anymore, you can use that community learning center for hygiene education or women's education after the school is over. You can use it for villager councils, so there are lots of things we can do in that area.

SHIRLEY MALCOM—*Answers*

I want to weigh in on this issue because I agree with you totally about the need for community education and about the potential for a community education center, but I also believe that center must be a part of the vision of the community.

I see too many things imposed—other people's visions imposed on these countries. In many places, including in the United States, education is a social activity, and the introduction and

imposition of technology, unless done very carefully, will in fact disrupt the social and cultural nature of education. It is a tool; it is not an end. I am afraid that unless we think our way through this, we are going to be mis-investing very seriously scarce resources, and I wonder whether we have really talked to the people that we are trying to assist.

RITA COLWELL—*Question*

The House of Representatives has proposed a $1.7 billion cut in education, which would all but eliminate Goals 2000 and with it the National Standards effort. Then there is the effort by Congress to send education's dollars back to the states. How is this going to affect science and technology?

SHIRLEY MALCOM—*Answer*

We have serious problems. Sending the problems to the states is not going to help. The states and locals were in charge before, and we had the problem. It is not clear to me that there is very much wisdom operating around these cuts. This is perhaps one of the least prudent things that we can do at this particular time, given all of the challenges that we have to face in this country.

RITA COLWELL—*Question and Answer*

A question was brought forward about the spread of disease organisms in fish populations. I did not make it clear that in the biotechnology that I was describing a totally closed system, not the open ranging that is done in the harbors and bays, and that is a major advantage.

RITA COLWELL—*Question*

To Jean François: You painted a very rosy picture of the future concerning the impact of increasing communication technology. Are there any downsides?

JEAN FRANÇOIS RISCHARD—*Answer*

Yes. The downsides are those Shirley alluded to. I was at an event around the G-7 summit in Brussels about a month ago on information technology. The Europeans were exceedingly worried about everything. In their speeches they were worried about the erosion of their culture through an invasion of soap operas from the United States. They were worried about security of data. They were worried about privacy, and they were worried about mis-investments. They were worried about everything.

Then came the Deputy Executive Vice President of South Africa, Mr. Mbeke, who is a

fabulous speaker. Mr. Mbeke spoke very calmly and said he welcomed everything that was coming down the pike. He could see so many things that would help turn South Africa around and make it into a great success. He was not going to be afraid of cultural erosion: He was going to export the South African culture elsewhere. I was very impressed by that speech, because between the recoiling and threat-based reaction that I heard from the Europeans and the opportunities-seeking reaction from Mr. Mbeke, I could tell who the long-run winners were going to be, as well as the long-run losers. So I made a rosy picture.

SHIRLEY MALCOM—*Answer*

Let me say that those of you who know me understand that I am an informed, hopeless optimist—and I do not believe that we are without hope. Sometimes when things are darkest, we in fact rise to our greatest moment. I think we have an opportunity here to rise. In many of the countries as well as our own, there are tens of thousands of people engaged in communities in local effort, people from non-governmental organizations, people from aid groups and what have you, groups like the Y and the church groups who are there on the ground, in the villages, with the people that we are talking of trying to assist.

What we must do is work in partnership with them so that they can take this education message and mission, and the science and technology component of it, with them as they go into these kinds of areas. I think that is the possibility that holds out some hope for being able to really rise above the current kinds of situations which can so mire us in despair.

RITA COLWELL—*Summary*

Let us thank the panelists. We obviously could go on for another hour; but we are not allowed to, so thank you very much, both of you.

Plenary Address

JANE WALES—*Introduction*

I have the pleasure of introducing Daniel Goldin, who has been NASA Administrator since 1992 and is well known for his leadership of that agency. I think all of us know him as a dynamic and tireless leader. If you have never traveled with him, let me tell you—he is tireless. I think that the average American knows him probably most recently for his redesign of the space station and his successful efforts to draw Russia into that space station partnership. This is only one example of international collaboration in space that is of interest to Dan Goldin and has been championed by him.

Before joining NASA, Dan was Vice President and General Manager of TRW's Space and Technology Group. Dan Goldin is a true friend of international science and technology, and I am proud to say a true friend of mine.

DANIEL S. GOLDIN
Administrator, National Aeronautics and Space Administration

Good afternoon. As I was preparing to get my remarks together for tonight, I thought about how different the world is. I made a little list of things that are happening, and I said, "These are not supposed to be a space program."

Just a few weeks ago we had a ballet in space between the American shuttle and the Russian MIR station. We had two countries that were just a few years ago pointing missiles at each other across the oceans, and here the day after the launch the Russians expressed concern about the leaky thrusters that we had on our shuttle and said, "We are afraid that it might come in and damage our MIR space station." As I sat in my house on Sunday and listened to the news reports I thought, "should I pick up the phone, and shall I activate the senior-level managers, or should I let the process work its way out?" I opted for the latter.

For the last year and a half, under the leadership of our President and Vice President, and President Yeltsin and Prime Minister Shenevyev, we have literally had hundreds and thousands of engineers on both sides talking to each other, so we said, "Let's see if trust has been built because this is not just about technology, it is about trust."

We were supposed to rendezvous at 2:30 on Monday, and at 10:30 in the morning on Monday, Jack Daly, who is a Deputy at NASA, walked into my office. He said, "This is a great day! The Russians trust us. Our engineers worked with their engineers, and they are no longer afraid we will damage their space station."

I just had to pinch myself and say, "Is this reality?" Here is Dan Goldin, at TRW, in the

defense and weapons business, and here is Yuri Khopshev, the head of the Russian Space Agency, a few years ago at the Bureau of Machine Building, doing similar things to what I was doing. In fact, he went out to TRW just recently and before he went, he said, "I know what you are doing." I said, "I cannot acknowledge anything." Boy, was he accurate!

Another thing that struck me was we had a delegation that just got back from the Ukraine, and they were talking about flying the Ukranian space welding machine on board the space shuttle. This again is unbelievable.

I was in Nepakatrask; I spent my life looking at Nepakatrask. I was looking through the weapons laboratory there, and this was just a year and a half ago. Here we are today talking about the possibility of flying in the Ukrainian cosmonaut to test out the most advanced space welding machine ever conceived by humankind.

The sands of the Sahara blow and a funny thing happens, and we only found this out from space through international cooperation: Those sands come up into the upper atmosphere, they go across the Atlantic Ocean, and they land on the Brazilian rain forests. That sand has nutrients that nourish the plants in the rain forests so the biomass can grow, so carbon dioxide can be converted into oxygen, and so the world can breath.

This is something that we just did not realize until a few years ago, and the only reason we found it out is that we have satellites that sit above the earth, that holistically look down, and international scientists look at the data and collaborate and understand this is important.

A number of discoveries have been made relative to chlorofluorocarbons (CFCs). Someone can have a spray can in Kazakhstan and do the same kind of damage to the ozone layer as someone in the United States, or France, or South Africa for that matter. We did not understand it, because when some of these CFCs were invented—when we invented Freon years ago—it was going to be pure and clean and nontoxic. Oh, sure it was. Except we did not know that the CFCs rose into the upper atmosphere and had weird chemical reactions with ultraviolet radiation. It took international collaboration to understand that.

So up is down, and down is up, and left is right, and right is left. I think back to the Cold War era and the Fifties, Sixties, and Seventies, and a word that comes to my mind is "territorialism." I looked in the Collier's Encyclopedia, and let me tell you how they define "territorialism." "Territorial neighbors are often hostile, but rarely kill a neighbor."

If you think back to the Cold War era, we were dominated by a time of territorialism when we had weapons of such mass destruction that we could not go kill each other directly. We had to stand on both sides of the ocean and flex our muscles. Those of you who are old enough to remember, remember the Charles Atlas ads? You know, "Throw the sand in your face, I will go do push-ups and sit-ups and I will stand like this."

Think of the behavior that we had in our world, and that behavior caused us to do a number of things that caused a number of alliances to occur. We had the Eastern and Western blocs, and leadership was very clearly defined: Washington and Moscow. From an economic standpoint, we did not have multinationals and global competition. America had its own domestic market, and that consumed the lion's share of our economic output. We sold overseas, but at the time (it was after World War II) the infrastructure of the rest of the world was down and our products could dominate. We did not need cooperation because we had the marketplace—and we dominated the world marketplace.

We did not understand the environment. We were environmentally illiterate at the time. We had a variety of different forces that caused us to behave differently. Territorialism manifested itself in many ways, and the space program was no different.

We all remember President Kennedy announcing, "We are going to the moon," and we look back on it fondly. In fact, I have talked to many people and we think it was a great scientific achievement. If you go back into history, you ask: Why did President Kennedy do it? It had nothing to do with science. It had nothing to do with goodness and virtue. It had to do with the fact that the Russians had launched the first robotic satellite, and then they launched the first human into space. It was the act of launching Yuri Gagarin that caused fear in this country.

How could America lead the Western Bloc if we were not technologically superior—if we did not flex our muscles and project our power? How could we be technologically superior if we did not demonstrate to the world that we could lift larger masses into space, thereby implying that we could lift bigger weapons into space? How could we lead the Western Bloc if we did not have all the key ingredients to push back the Soviet Union?

The Soviet Union did the same thing. So we rushed to Mars, and we rushed to Venus, and we asked: Who is going to soft-land on the moon first? "Who is going to have the first human on the moon?" That absolutely drove what we were doing, and clearly it justified the enormous investment in the space program: 4.5 percent of the total Federal budget. By reference, we are now at .8 percent and dropping like a rock.

People now say, "We want that spirit from Apollo." Well, sure. It was a bipolar world. Leadership was already defined, and all we had to do was supply the money. The world is a lot different today, and it causes us to have these strange reactions.

The Berlin Wall came down, and we had a completely different environment: Multinationals and a huge global marketplace. America has a balance of trade in excess of negative $100 billion a year. If Boeing wants to sell a plane in China, if Boeing wants to sell a plane in Europe, they have got to involve the companies in those countries. The only reason Boeing could sell that plane is it is the best technology in the world; and it has some cooperative

aspect to it. It does not happen by magic. It is crucial.

America has got to deal with the former CIS states to get them to behave in a pattern that we believe is right. We cannot tell them not to proliferate weapons of mass destructions. We cannot demand disarmament. We have got to work with them and convince them that it is in their national interest to do that, and it is in the international interest of this world.

So just sitting on our side of the ocean and flexing our muscles is not going to get our world to the place that we want it to be. We are going to have to have true leadership, and that leadership has to have a number of qualities to it.

First, if we want to lead the world, we will have to earn it. If our products are going to sell in other places, if we are going to have good relations with other countries, then we have got to have superior technology, and that technology must be agile and ready for the marketplace faster than anyone else.

We have to have a reputation—not only for performance, but a reputation for commitment. Do we do what we say we are going to do? Or do we build a supercollider and then we cancel it because we "have budget problems in America"—because we have a consumptive society, not an investment society.

People will not want to do business with America if we are going to be flaky about our world commitments. They will not do business with us if we do not perform.

What is the boldness of what we are doing, and are we really on the cutting edge? Do we have the ability to be inclusive? Or are we going to stand there flexing our muscles, saying, "We deserve it!" Or will we earn it?

These issues are very crucial. We came across these issues in our first major activity in trying to work with the former CIS states, first with the Russians.

The Russian Government—just like the American Government, the Japanese Government, and European governments—are having tremendous financial stress. The Russians have more severe stress than the rest of us because they tried to go from a totalitarian society to a democracy and from a controlled economy into a capitalist economy overnight. That is one long puff to make happen, so they have some problems.

Are we going to convince them to work with us in a world that is quite volatile and dangerous by hooting and hollering and shouting and flexing our muscles? Or are we going to try to entice them to do things that will be in their national interest? You start by asking: What is important to Russia, and what is important to the United States? Do we have an intersection point that is meaningful to our people? It became very clear, after President

Clinton's first summit with President Yeltsin in Vancouver, that there was a point of major intersection between the United States and Russia.

We no longer had to have a space program that demonstrated national macho. I mean, if that was the reason for the space program, we might as well cancel it, but it became very clear that space was crucial to the future economic vitality of our country and Russia. It was crucial to the inspiration of the people. It is crucial for intellectual nourishment, to understand the creation of the universe. It was also clear that neither country had the resources to do all the things we wanted to do. So the Russians said, "This is a good point of intersection. The space program is so important to us that we want to work with America. We cannot afford to have our own human space flight program, so we would like to merge our program with the United States with a U.S.-led international space station." That is leadership; that is not direction.

Many very positive things happened as a result. In my mind, one of the most significant things ever to happen in space was when Jack Daly walked into my office and said, "Dan, the Russians trust us. Our engineers talked to their engineers." You have to understand the Russian mentality and psychology to understand what a significant event that is, because it takes time to earn that respect and trust, and we did it in only a year and a half. I am so proud of this team that we have.

Now we are working toward a basic understanding between our peoples. The United States Ambassador to Russia and the Russian Ambassador to the United States both told me that the space station is probably the strongest program connecting the United States and Russia today, with all else that is going on. In a world with all these very difficult situations, we have one shining light that brings us together. In my mind, even though the technology is wonderful, the fact that we have this cultural connection is crucial. Not only is the United States involved, but ten European countries are involved, [Canada and France and hopefully more countries to join us]?!

When we talked to our other partners that were already with us from the Western Bloc and said, "The Russians are coming in," they not only said "Yes," but "What a great idea!" They too wanted to participate in this cooperation.

That is one area. There is another area that I think is just as important. We live on a planet that has limited resources, and that is very clear if you take a look at some of the pictures from space. I have one in my office, where from space you can look down on earth and see this little blue fringe around the surface of the planet. That is our atmosphere. Look at the Earth back-lit from the sun, and then you say to yourself, "Here is this lonely planet, sitting against the black sky, and we have this very limited atmosphere. It knows no boundaries. No country could put up a wall and say "This is my atmosphere." We all share the same air.

If someone pollutes it, we cannot say "Well, that is not my problem." It is everybody's problem.

It is not just a problem for the developed countries. It is a problem for the developing countries. If the United States were to have its own scientific program to understand our environment and the naturally-induced and human-induced effects on that environment—to separate them out so you could make policy decisions relative to global warming, and a whole variety of issues, who would trust us? It would look like an economic wedge. Developing countries would not have that sense of trust.

If we are truly to get policy decision—making at a rational—not an emotional—level, it is essential that every country in this world participate in the collection of the data, in the processing of the data, and in its dissemination, and make the data openly available to everyone: There will be people who come from every direction but will have truly a worldwide, world-class peer review.

So when the policy makers and the United States Congress and the Russian Duma and the Parliaments in Europe have to make decisions, they will not be based upon passionate speeches that lack knowledge or feeling, but speeches with good hard data that everybody sees and everybody understands. In that sense it is essential, in the United States' national interest and national security.

If we have a disaster in the Pacific Rim countries, and we do not have an early warning of that, it will affect our economic and national security. It is in our interest that we understand it at the same time that the people in the Pacific Rim understand it. That is another reason why it is in the national interest.

And, by the way, we did not get together with Russia to have a "feeling good." It was in the United States national interest to work with the Russians in space. This helped Russia get to understand us and we got to understand Russia. When they started to participate in nonproliferation arrangements—which they did—the world became a safer place. It is in our national interest. We do not do it out of "feeling good." We have a less expensive space station with twice the power, twice the pressurized volume, much better science and much safer because we have a backup to the shuttle in the Proton and the Soyuz and the progress launch vehicles. It is a safer, robust, more scientific program, but it also builds bridges.

In the same way it is in the United States' national interest to share remote sensing environmental data, because it gives us more economic and national security. When we go to negotiate these treaties, people do it based on understanding, not on emotion and passion.

There is a third area that is very crucial, and I will put it under the term "economics." I will give you two examples of that.

United States long-haul jet transports generate something on the order of $30 billion a year positive balance of trade, it is the highest level of manufactured product that we trade—the largest positive balance of trade. In the last 25 years we have lost one percent of market share per year in this area. There is a $1 trillion market, so, in the future, each point of market share is worth $10 billion. If the United States were to put up a wall around ourselves and forget that we have a global economy, and say "we will just sell domestically," we would be out of business.

If we are going to be in the international marketplace we had better learn how to participate with other countries. We cannot force our products on them. The only way we can sell those products is if they are technologically superior. We must be able to productize faster than anyone else in the world can do it. You must be able to have the most economical product in the world. We have to build bridges to other countries.

There are two aspects of this. The technological development we are very cautiously holding to ourselves, because that is the magic key. Once we have demonstrated that leadership, it is crucial that we have a more inclusive system, and that is the only way Boeing and McDonnell Douglas are going to sell planes worldwide. Without that manufacturing capability, we will lose unbelievable skills in high temperature materials, ceramics, combustion, you name it, and this is an area that is very, very important.

We also need cooperation in environmental monitoring, which is what we are doing. The world must become ecologically and technically literate, and the only way to achieve this goal is by sharing. On the other hand, there is a potential $10 billion-a-year market in selling goods and services for remote sensing, so in that respect it is in the United States' national interest to very jealously guard the technologies we have and transfer them to our commercial industry while sharing the scientific results.

We do things in the national interest, and at the same time in the new world we make our planet a safer place to live. We make wonderful economic conditions for our children and children in other countries, and instead of slicing up a smaller pie and pushing it around, we want to lift all boats. Thank you very much.

Plenary Address Questions and Answers

JANE WALES—*Questions*

How large a reduction in our space research center infrastructure inventory do you envision? How many centers do you suspect will have to be closed?

DANIEL S. GOLDIN—*Answers*

Well, life is not fair—but let me say this. We have a space program that has done wonderful things for the people of this country and has inspired the people of the world. This infrastructure was set up to compete with the Russians. Price was not an object. What was crucial was how fast we could get things in orbit, and how big and complicated we could make it.

We now live in a new world, and we have got to get NASA to become a leading-edge research and development agency and get out of the operations business. We have formed a whole constituency during the Cold War, not just with the people in the industry but also with the people in the universities. They became accustomed to a program that dealt mainly in the advancement of science, but it was quite isolated from the American public and no one really recognized that the American public is the ultimate customer.

The scientific community looked a little too inward, and the American public has given us a very loud, resounding message: We love science, but you had better do it for less money. We love science, but you better make it relevant to us. We understood when we had to have national defense and the security of the United States was at stake and survival was at stake. We did not mind having these enormous increases in the United States budget for the science and investment account.

It is a new age. Stand up and recognize that this new age is here. You cannot dip your hook into the water and go to the Congress every time you want to start something new to get a new program. You have to decide what is your lowest priority and cancel it to make room for something new, because the United States government budget is not going up.

I have other arguments that say, "Well, maybe you should increase the investment account," but in reality, for the next few years, that is not going to happen, and to go argue for that will be terrible because we have real problems. We have talked about education, and the education budget is getting cut. So we at NASA were asked by the President of the United States to cut our budget another $5 billion—that is on top of the prior $30 billion we cut.

Up until now, we were able to cancel irrelevant programs that did not make a major contribution and restructure others. Now the hard part comes. We have an infrastructure that was designed for a budget at the end of the decade of $20-plus billion. Our budget is going to be $13 billion. So toward that end, we had better get with it and downsize the infrastructure. We are not about jobs in 1995; we are about jobs for the class of 2015. I do not want to sound harsh and cruel, but we have to get an infrastructure that has a modern system, it is rid of all the overlaps.

Each of our NASA Centers had marketing departments to get new work for them, and there

are marketing departments in a variety of other organizations that support us. That is not what we are about. We are about cutting-edge science, and we have got to get rid of the overlaps; we have got to get rid of the antiquated systems; we have got to have a peer review system that is more inclusive.

Our peer review system is not inclusive with a broad cross-section of America. So we are going to restructure the agency and get rid of the overlaps. We are going to find areas where the agency should not be doing things; we are going to cut it out, and we are going to strengthen and make sure everything we do is world-class. If a university has a better capability than that, we will transfer that function to the university or to an industry.

It is going to be very, very painful, and there will be loss of jobs, but the United States Congress, the American people, and the President have spoken. NASA is not just doing a budget exercise. We are preparing ourselves for the 21st century. As hard as it is to believe, we have computers that operate thousands of times faster in our scientific calculations than computers elsewhere. The computers that operate our administrative system are nonexistent.

When NASA was formed in 1957; we did not have modern, wide-band, digital, multimedia communications systems that were distributed, so each center became an independent city-state and unfortunately became more and more insulated and isolated with time. We are going to have a distributed, interactive mobile system. People and ideas are going to move electronically, and in a few years when we get done, NASA will be recognized not only as the center of excellence and technology—but we will also be recognized as the center of excellence in management. We will treat our people humanely and with the dignity that they deserve, but we are going to downsize.

JANE WALES—*Questions*

Will you estimate the savings effect of cooperation with the Russians on the space station? Do you see a role for international cooperation in a follow-on to the space shuttle?

DANIEL S. GOLDIN—*Answers*

With regard to the former, in just pure dollars and cents, we will save $2 billion if the station goes up 15 months earlier. I would say that is a wonderful savings. We have doubled the power we have, roughly 100 kilowatts instead of 50. If you want to build a scientific laboratory, power is absolutely essential for the science. We have roughly 40,000 cubic feet of pressurized volume instead of 20,000 cubic feet of pressurized volume. Again, that is crucial to science.

I cannot put a dollar value on it, but let me tell you, from a scientific standpoint I have gone from a condition of thinking the space station is good to one that it is outstanding. Then I

think about the opportunity for collaboration. Our Russian friends do things differently than we do; they have a richness in their system that really amplifies the things that we do, so I think the science is going to be much more robust.

I think the opportunity that we are going to create in working with the Russians when their economy recovers (just in pure economic terms)—because we were with them when they needed us, I think will create unbelievable opportunities for business with Russia. There are no guarantees—there are risks. Who knows what is going to happen in Russian elections? Who knows what is going to happen in Russia? We cannot afford not to do it.

With regard to a launch system to replace the shuttle, I now get back to issues of national interest. The United States has not developed a new rocket engine in 15 years, yet we contend to be a space-faring nation. We have not developed a major new launch system in 25 years, and we contend to be a space-faring nation. Our commercial launch has lost 40 to 50 percent market share and is on the verge of losing almost all of it. So this is an issue when I talk about national leadership. What we are going to do now is leap-frog technology. We are not going to have "me too" technology with multibillion dollar programs. We are going to have focused, small programs, working with industry to prepare the industry with pre-competitive technologies.
After we meet that first criterion and show that we can productize it, then it is time to do with a launch vehicle business what we do with aircraft, and that is the approach we need: Technological leadership. It is in the national interest right now to focus on technology in America.

JANE WALES—*Summary*

Please join me in thanking Administrator Goldin. I invite you all to join us for a reception at which Deputy Secretary Deutch and Secretary of the Air Force Sheila Widnall will be making some brief remarks; but first, enjoy the Air Force's String Quartet.

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RECEPTION

SHEILA E. WIDNALL
Secretary of the United States Air Force

Good evening, and thank you for that warm welcome. It is a pleasure to be included this evening in such an important forum. I am particularly interested in the subject, since it represents the intersection of my main interests these days: Science and technology, national security, and economic policies.

You have asked me this evening to discuss the relationship between science and technology and the Air Force, and the resulting impact on national security. I would like to broaden that issue somewhat to discuss this relationship as an example of the more general partnership between the federal government and the scientific and technical community.

Like all enduring relationships, that between the federal government and the scientific community is constantly evolving. Federal spending on research at universities and in industry is an investment in the future. It provides basic research results upon which industry builds robust applications, and it grooms the future generations of scientists and engineers who function as our engine of economic growth.

The benefits of this relationship extend well beyond generating research results and producing scientists. Faculties at universities and their industrial counterparts play an invaluable but perhaps less visible role providing independent scientific advice to federal agencies as individuals or members of advisory committees. At a time when some may question the value of this partnership, it is useful to reflect on past benefits that set the stage for future rewards.

For the past five decades there has been just such a relationship between the Air Force and the scientific community. This past November, here at the Academy, the United States Air Force celebrated the 50th Anniversary of the Scientific Advisory Board (SAB). Since its founding, the SAB assembled this nation's premier scientists from universities and industry to provide independent scientific advice to the Air Force. It was the first scientific board established by a branch of the military services and one of the oldest in our government. The charter of the SAB is to seek out science and technology on and over the horizon which might change the character of war and help defend this nation. Members of the SAB also provide input to meeting today's challenges. Their advice is invaluable! They are our corporate memory!

Fifty year ago, in the closing months of World War II, General Henry "Hap" Arnold challenged Dr. Theodore von Karman to search the world for the most advanced scientific

ideas and to project them into the future. Von Karman brought together a team of our foremost scientists, the inaugural SAB, who responded with what became one of the world's premier technological forecasts: *Toward New Horizons*. With remarkable foresight, von Karman's team predicted supersonic aircraft, pilotless aircraft, all-weather flying, perfected navigation and communication, the Global Positioning System, the B-1 and B-2 bombers, radar, composites, television, and weather prediction. And remember—this was 1945!

Of more importance, von Karman also reminded us: "Only a constant inquisitive attitude toward science and a ceaseless and swift adaptation to new developments can maintain the security of this nation."

Back in 1944, in the shadow of World War II, it was perhaps easy to focus on the importance of staying on top of advanced weapons. Likewise in the Cold War years which followed, it was easy to focus on the missile race, the bomber race, the space race, and the nuclear standoff.

Today we face different problems: Globalization, international competition, proliferation of weapons of mass destruction, and doing more with less. We see more intersections between commercial and defense technology as we transfer defense research and development into commercial products, buy more equipment off-the-shelf, convert some defense facilities and technologies into commercial opportunities, and consider economic strength in "military" decisions.

One thing is certain: There has never been a period in the history of our country when a "swift adaptation to new developments" has been more important and in which the security of our nation depends on a "constant inquisitive attitude."

As a first step in renewing the enduring relationship between the Air Force and the scientific community, I have challenged the Air Force Scientific Advisory Board to initiate a forecast using the theme of *New World Vistas*, envisioned as a truly independent, futuristic technological forecast of how the exponential rate of technological change will shape the 21st century Air Force.

Our goals are to identify fields of rapidly changing technology, predict the impact of these technological changes on the capabilities and affordability of Air Force weapons systems and operations, and predict science and technology areas where we can minimize Air Force investment and turn to the commercial world for technology development. *New World Vistas* is only the first step. We will continue to depend on the unique scientific and engineering talents of the nation's universities and industries as we extend our relationship with the scientific community for the next 50 years. It is important that we reach out to involve members of the scientific community that are not part of the formerly defense-dedicated sector.

I am pleased to say that the new members of the SAB reflect deep involvement and substantial accomplishments in the commercial world—in computers and information, aircraft, civilian applications of GPS, materials, etc., even to the point of my having to spell "Air Force" in my initial conversations with them. Although our research budget has decreased in recent years, our commitment to research remains strong.

The Air Force has always been at the cutting edge of science and technology. What is new is that we are constrained now by a much-reduced defense budget. We can no longer design, develop, and buy weapon systems at cold war rates. The overall defense procurement budget is down in real terms by almost 50 percent from its peak in the mid-'80s.

These budgetary constraints are turning the Department of Defense into a customer instead of the technology driver it used to be. We are moving toward a single national technology and industrial base to serve military as well as commercial needs in a new partnership with industry for technology development. It will be good for us and good for America.

Air Force technology advances ensure the qualitative edge we need to deter wars when we can and to win wars when we have to fight. Precision and stealth are good examples. One F-117 stealth fighter with one pilot dropping one precision-guided bomb can reliably destroy a target that would have needed, during World War II, 108 B-17s, with 1080 aircrew members, and 648 bombs. Today the F-117 fighter can fly alone, expecting invulnerability. In World War II, our bombers required hundreds of escort fighters, and often took staggering losses.

Tomorrow our F-22 fighter will guarantee air superiority in future conflicts. The resulting freedom of maneuver has allowed our forces to win quickly and decisively. As we have learned, with air superiority everything is possible; without it, nothing is possible. The F-22 will dominate the skies of the future in the face of global proliferation of radar, missile, and aircraft technologies. When the F-22 enters the fleet in significant numbers, our current air superiority aircraft, the F-15, will be over 30 years old.

In the space arena, we are working on a cheaper, more reliable booster. This program could be the springboard to restore world market share in our commercial launch industry. With DOD's worldwide commitments, space forces provide the needed global situation awareness; they are an integral part of our defense policy.

This search for new air and space technologies is vital to the security of this nation and crucial to our economic strength. Our aerospace industrial base is a mainstay of the American economy. It not only contributes significantly to both the nation's gross domestic product and exports, it also represents the foundation upon which our future progress will be based, developing products and technologies for the nation as well as skills and expertise in the people they employ.

We are entering into a new era in defense. While we have always been high-tech, we will now see more of these advances coming directly from the commercial sector. This is to the benefit of this nation and its defense as these industries provide a solid technical and commercial base for a healthy economy, a capable military, and substantial exports. Fortunately for all of us, American science and technology continues to be a source of national strength and renewal.

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SESSION THREE

Using Science and Technology to Meet New Defense and Arms Control Needs

Plenary Address

JANE WALES—*Introduction*

Good morning, and welcome to the second day of our forum. I am still Jane Wales from the White House and want to again thank you very much for donating your time over this two-day period. This conference just to remind has been sponsored by the Council on Foreign Relations and the American Association for the Advancement of Science, as well as the White House.

Yesterday President Clinton charged this gathering with the task of drafting a strategy for putting science and technology to the service of national security. The way we have organized ourselves to carry out that task is to establish drafting groups that have been meeting. They met twice yesterday. They will meet twice today. They are revising and refining the white papers that are in your notebooks to try to capture and reflect the comments that you are making and the questions that you are raising during plenary and break-out sessions.

I remind you of this process in order to encourage you to use those questions and comments cards that are in your folder. Even if the session chair does not get to your question, that question or comment will not be lost, because the cards are being gathered by a member of the staff who will be in the aisles, and they will be given to the drafting group to be taken into account in the final product.

We have a long day ahead of us, beginning with the Director of Arms Control and Disarmament Agency, John Holum, and ending with the Vice President at 4:30 this afternoon—at which time he will give us his vision of science and security.

The focus of this morning's session is the role of science and technology and defense and arms control issues. John Holum has been kind enough to join us to give us the policy context in which we develop policies of prevention of conflict.

JOHN D. HOLUM
Director, Arms Control and Disarmament Agency

Thank you very much, Jane. It is a pleasure to be here. I want to thank you and congratulate

you and Jack Gibbons and the other organizers of this conference for significant contributions to our knowledge and also to our national security.

The nuclear age began 50 years ago at Los Alamos, New Mexico. The Trinity Explosion made glass of the desert sand and moved J. Robert Oppenheimer, the head scientist of the Manhattan Project, to utter the now famous words from Sanskrit poetry, "I am become death, the destroyer of worlds." Science and technology have often been cast as the villains in arms control and nonproliferation—sometimes by scientists themselves. It is widely believed that if we could just place a lock on the technologies of mass destruction in the laboratory and certainly in international commerce, then we would hold the key to a safer world.

Technology denial is one important method of arms control, but I want to emphasize this morning the contributions of technology development to the same cause. Adlai Stevenson said there is no evil in the atom, only in men's souls. From my seat at the National Security table, science and technology are not the enemy. Instead, one of their main effects is to empower us by enabling us to make arms control effective and broaden its scope.

Partly as a result—and speaking unmistakably to some of those who think this work is a Cold War relic—President Clinton, in his March 1, 1995 address to the Nixon Center, affirmed that in 1995 the United States will pursue the most ambitious agenda since the atom was split to dismantle and fight the spread of weapons of mass destruction. I would like to illuminate the role of science and technology and arms control and nonproliferation by focusing on several leading elements of the immense agenda the President described.

Last week's tragic events in Tokyo underscored the need for all nations to make chemical weapons harder to make and easier to trace. The United States has the opportunity to lead this year in bringing the Chemical Weapons Convention (CWC) into force. No one step obviously can guarantee a world without terror. As President Clinton said in his speech, nonproliferation has no silver bullet, but the CWC is a huge step forward. Without it, stockpiling chemical weapons is legal. Under it, all chemical weapons will be outlawed and their ingredients more widely and rigorously controlled.

The CWC actually resulted from a confluence of scientific wherewithal and political will. The use of chemical weapons was banned in 1925, but the Geneva Protocol that year was quickly rendered toothless, in part because the technology of chemical weapons had far outpaced the development of any tools to detect them. The problem was compounded by the fact that chemical weapons are often made from ordinary chemical precursors with legitimate uses.

New technology—for example, a portable combination gas chromatograph mass spectrometer—which I will henceforth refer to as GCMS, makes it feasible to detect specific compounds in small concentrations. If pared with sophisticated software, GCMS can sniff the

molecules specific to chemical weapons production and degradation while not reporting other chemicals involved in legitimate proprietary processes. The CWC's extensive verification regime harnesses advances already achieved and by design leaves room for others to come—an explicit assignment for scientific communities represented here today.

We have in some respects an even greater challenge in the realm of biological arms. Where chemical weapon compounds are relatively distinct and unambiguous, biological weapons agents may be fragile and, with the relatively common carbon-based composition, even hard to detect. While chemical weapons usually become less lethal as diluted, biological organisms and the right host environment will multiply and spread.

These challenges magnify the role of science as we wrestle this year with ways to strengthen and improve compliance with the biological weapons convention. For detection purposes we need to pinpoint the exact genetic composition of biological agents. Already we have instruments that can find some organisms with concentrations of one in one billion. We need even better capability to deduce the range of bugs and work reliably under even dirty and mobile conditions.

There is an even cheaper and equally indiscriminate weapon that as yet has not received much scientific attention—anti-personnel land mines which the Clinton Administration is taking major steps to bring under control. Today some 100 million such land mines are buried and still active. At least ten new ones are in place for every old one cleared. Leftover land mines kill and maim people every day, most often children at play and farmers returning to their fields.

We are unlikely any time soon to achieve a global consensus against military uses of land mines. If all mines included self-destruct devices, then after some reasonably short period the mines could deactivate and cease being a threat to anyone. We urgently need to develop cheap self-destructing and self-deactivating components costing, say, $3 versus about $25 for those now standard in United State mines. Closing this gap will boost our efforts to rid the world of long-lived mines.

Finding mines is also no easy trick. Most de-mining today is done with 40-year old technology. Modern neutron probes and earth-penetrating radars could do better. One experimental infrared technique has even been directly adapted from instruments used to measure the temperature of a nuclear denotations fireball. Although all of these ideas work, none is as at yet fully practical. Whoever makes these breakthroughs will have achieved a human good of heroic proportions.

1995 is a momentous year for nuclear arms control and nonproliferation. Starting next month the fate of the nuclear non-proliferation treaty (NPT) will be determined at its 25th year review and extension conference in New York. President Clinton has made it clear that

nothing is more important to prevent the spread of nuclear weapons than extending the treaty indefinitely and unconditionally. The NPT, now with 174 members, is increasingly valuable because the International Atomic Energy Agency (IAEA) is increasingly effective. The IAEA has strengthened its safeguards regime in recent years, thanks to improved measurement devices, integrative systems for surveillance and measurement, robust tamper-indicative devices, reliable communications, and other advances.

The New York conference will also focus on the NPT as an engine for scientific cooperation and commerce and the peaceful uses of nuclear energy. Under effective international safeguards, the United States has vigorously promoted and practiced such cooperation—according preference, of course, to NPT member countries or members of equivalent regional arrangements. An uncertain future for the NPT would put at risk most peaceful nuclear cooperation and its many fruits enjoyed throughout the world, in fields ranging from agriculture to power generation to medicine.

Paranoia and selfishness cripple scientific progress. The United States is committed to keeping them out of the laboratory. The NPT's role in support of peaceful nuclear cooperation is yet another strong reason to make it last forever.

1995 is a decisive year for the Comprehensive Test Ban Treaty as well. The test ban's time has come to ensure that there will not be another qualitative arms race and also to restrain proliferation by denying aspiring proliferators the ability to advance beyond primitive, cumbersome devices. President Clinton has revised the United States negotiating position to speed conclusion of the treaty. He has further extended the United States moratorium on nuclear tests to overlap with the expected completion of the test ban.

The meaning of this is profound. If the Conference on Disarmament does its job, we are prepared for the conclusion that the United States had already conducted its last nuclear test. For decades the chief barrier to a comprehensive test ban has not been its desirability as a matter of policy, but its feasibility as a matter of science—both as to verification and to confidence in maintaining a safe and reliable stockpile. For verification, we can now build more sensitive monitoring stations to help locate and identify clandestine testing. Hydroacoustic monitoring—a global network of radioactivity measuring equipment and remote studies of likely test sites—all will also contribute to our confidence that the ban is being respected.

One likely component of a global monitoring system is made possible by the remarkable growth in the power and cost-effectiveness of high speed data communication links and digital computers. A proposed international data center will routinely and continuously process gigabytes of raw data, boiling it down to a form at least 10,000 times more compact, thus making it useful to treaty parties. Because nuclear deterrents remains vital to United States National Security, we will also maintain a science-based stockpile stewardship

program—including sustained research and a viable base of scientific expertise and nuclear weapons design and manufacturing.

For example, the Las Alamos Nuclear Physics Facility, a proton linear accelerator where physicists may recently have measured the mass of the neutrino for the first time, is being adapted to become a powerful source of neutrons that will allow us to peer deeply and nondestructively into the pits of nuclear weapons so that changes can be detected before the safety or reliability of the weapon comes into question.

New fast-cycling charge-coupled devices (CCD) may make possible hydrodynamic testing. Facilities could produce x-ray movies of the implosion of nuclear warhead replicas. These movies could confirm that even as they grow old, our existing weapons will perform correctly, but would not provide information for the confident design of new weapons.

The National Ignition Facility (NIF) could conduct experiments of great scientific value in fields closely enough related to the physics of weapons design to maintain the skills of a cadre of nuclear experts. The NIF is neither intended to generate new weapons designs nor to risk spreading nuclear weapons technology.

Another leading negotiating priority in 1995 is global cutoff in the production of fissile material for nuclear explosives. It is our best hope of putting a cap on the potential nuclear programs of the so-called nuclear threshold states—India, Pakistan, and Israel—that are outside the NPT. For detecting undeclared activities, perhaps the most dramatic scientific developments relate to extremely sensitive environmental monitoring. No matter how careful a violator may be in conducting clandestine nuclear activities, some particles will escape. Even minute concentrations can now be detected through sampling and particle analysis. Of course, we seek further advances in this area.

1995 is also a decisive year for strategic arms control and particularly for implementation of the Strategic Arms Reduction Treaty (START) and ratification of START II. Signing ceremonies are nice, but the promise of arms control is not fulfilled until the agreed reductions are made and verified, for verification has always been the sine qua non of sound arms control.

Even today when on-site inspections are routine, national technical means are ways to look but not touch are decisive. For example, the COBRA DANE Phase II ray radar in Alaska and the COBRA JUDY ship radar combined—with the COBRA BALL aircraft radar—allowed the United States to monitor every re-entry vehicle flown from Russian test ranges. So we know the capabilities of each Russian missile, new or old. This is a remarkable capability at the intersection of policy, geopolitics, and science.

Looking to the future, strategic stability will be even better served once we and the Russians

find ways to prove to one another that not only launchers and delivery vehicles, but bombs and warheads themselves, have been eliminated. This calls for creative diplomacy and science, transparency agreements, and instruments that can, for example, measure the fissile materials and weapons without revealing design information.

That may seem like a tall order, but there is a precedent. The cargo scan x-ray machines used to verify the Intermediate Range Nuclear Forces Treaty allows United States observers to learn just enough about a Russian missile to be sure that it is not one of those forbidden—but without divulging the secrets of those missiles that are still allowed.

These are just a few examples of how science advances today's rich arms control agenda. They also broadly illustrate some of the priorities of the government's new working group to coordinate research and development in arms controls and nonproliferation which ACDA co-chairs, as well as some of the needs identified by the National Science and Technology Councils Committee on National Security.

Some of these priorities also highlight how science can be a promissory note as well as a delivered product. The prospects for development of the portable gas chromatograph mask spectrometer I mentioned were carefully considered in the lengthy negotiations culminating in the chemical weapons contention. We have learned to look to science for capabilities that do not yet exist and to expect them in the reasonable future, even if at first blush our requirements seem anything but reasonable.

We in the policy community need to keep the science and technology community aware of what we would like to do, and you, in turn, should keep us informed of your new ideas, techniques, and developments which, given the nature of science, may find valuable uses even in unattended or unexpected ways. At least, as Farraday said to the Cabinet Minister interested in his electricity experiments, "Someone here in Washington will find a way to tax them."

President Kennedy established ACDA to drain the danger from the Cold War's chill. He set his course by a star of a less heavily armed world and sent the United States out as he did to the moon on a ship powered by possibilities. Today scientific advances are helping us decide not just how to formulate and verify arms control agreements, but whether to do so in certain areas. They give us a richer array of policy choices. They allow us realistically to pursue forms of arms control which even just recently were beyond reach. It has been said that arms control is often rocket science. In fact, I have said it more than once recently in defending an independent expert agency for arms control. This morning has been a return for me to the central nexus in my field between policy, law, negotiation, and science. As its "rocket science," arms control is also national security and using Secretary Perry's apt phrase, "defense by other means." It is a source of national strength fortified by science.

This room is and will be filled today with men and women of tremendous intellect and good will. It is exciting to think that this forum may well spur some to apply science and technology to arms control in ways that protect peace, prevent suffering, and make our lives at once more civilized and more secure. The technology of destruction marches ever onward. Human nature almost guarantees that. Our task is to contain and counter that trend with a greater one. No less than their colleagues who find the cure for AIDS or cancer, the scientist and engineers who help the tools of peace prevail over the instruments of war will be heroes.

That science and technology should and can help us should come as no surprise. The products of science and technology—computers, their networks, CNN, and fax machines—are already paving the way to a world of more open markets, open societies, open possibilities. Arms control is part of this overarching trend of engagement. As the President and his National Security Team have emphasized, this work serves not to isolate us, but fulfill and deepen our engagement in the world. Aided by science, arms control can help us build the kind of a world that is in our deepest interests—a world where nations are valued not so much for the arms they keep, but for the commitments they keep to other nations and to their own people. Thank you very much.

Fifth Panel Discussion

Cooperative Threat Reduction: An Experiment in Cooperation

JOHN M. DEUTCH, ***Chair***
Deputy Secretary, United States Department of Defense

John, thank you very much for a stimulating start to the day. I understand we will not have time to take questions for John this morning. Perhaps you can catch him at the break. I did speculate during the course of your very stimulating talk the fact that President Reagan used to "talk about trust, but verify," and it seems to me, if there is a slight twist on that, that what President Clinton and you and others are doing is building trust through transparency, cooperation, and verification. It is that building of trust that has been going on through transparency and cooperation that really makes the whole system sing. Ultimately, that whole process moves forward on the sure foundation of technical verification. That is the enabling force that technology can provide. We very much appreciate your talk this morning, and we will catch up with you as time goes on.

I have been waiting for this opportunity all my life—and certainly for the last two years—to moderate and regulate this distinguished group. I am going to thoroughly savor every moment of this session. I plan to run it with an iron fist and want to tell you about the way we propose to use the next 90 minutes.

What we have here is an absolutely remarkable case in America diplomatic history, where two

legislators some years ago, actually during the prior Administration, I believe—saw there was a different way to think about our security relationship with our old adversary, the Soviet Union, as well as the importance at growing down on weapons of mass destruction in that region of the world, and took a far-reaching and bipartisan approach to that problem. It has been remarkably important in my judgment in terms of the history of this country—a different approach. To bring us to realization required a young man from California to come in and help implement it as quickly and rapidly as possible. It is the story of this program that is our subject this morning.

Our plan is to hear from our three speakers, and after that time to open the session to discussions, to address the issue about where this program goes from here, some of its difficulties, and some ways of making it stronger. I hope that all of you will participate and address your questions to our distinguished panelists. I would like to begin with Senator Lugar, the great senator from Indiana who is going to speak to us about this program. Thank you, sir.

RICHARD G. LUGAR
United States Senator

Thank you very much, John. I appreciate the opportunity and your invitation to try to put the John Lugar situation into a larger context of foreign and security policy. I will commence by paying tribute to my colleague, Sam Nunn, who brought together a bipartisan group of senators at an important time. I pay tribute to Ash Carter, who met with us at breakfast on a fateful morning with an excellent report he had prepared while at Harvard. We are all indebted to Secretary Perry both for taking a trip with Sam Nunn and with me and with Ash, David Hamburg to Russia at a critical moment in which the previous Administration was trying to think through seriously how to implement the beginnings of the Nunn-Lugar business. Bill Perry and John Deutch, each in their own way, offering strong leadership in this endeavor which we share and in which we are honored to be a part.

The critical post-Cold War challenge for the United States is to prevent the re-emergence of the nuclear danger that characterized the world throughout the Cold War. The nuclear threat to the United States is today greatly reduced and of a different form. Cooperative efforts to reduce and eliminate nuclear weaponry in the former Soviet Union have contributed significantly to our security.

These developments are neither complete nor irreversible. The Russian arsenal remains the only force capable of threatening United States national survival. Furthermore, the spread of nuclear and other weapons of mass destruction now poses a larger and growing threat to

United States and global security. The former Soviet Union is a potential source of nuclear material for states eager to develop their own nuclear capabilities. The task before the United States is to avoid a return to the large arsenals of the Cold War and to prevent proliferation of such weapons.

The United States is continuing the process of reducing strategic arms and stabilizing their structures as represented by the START II Treaty. Nunn-Lugar assistance helped encourage Ukraine to sign the nuclear proliferation treaty (NPT) and as a result the START I treaty was finally entered into force. In effect, Nunn-Lugar helped to break the START I logjam.

For both Russia and the United States, Nunn-Lugar helps to carry out nuclear arms reduction agreements. Indeed, as an important emphasis of the Nunn-Lugar proposal is the coming period will be to assist Russia in meeting the costs of START II dismantlement requirements and to accelerate progress even prior to START II coming into effect.

The START I Treaty and the Lisbon Protocol were a critical beginning to the process, but as Senator Nunn and I recognized in creating the program, the actions required to carry out the pledges and the commitments under these agreements presented a challenge of Herculean proportions for the states of the former Soviet Union, which were then and are still in the midst of domestic political and economic revolutions.

Nunn-Lugar technical assistance makes the nuclear dismantlement process in these countries both more certain and certainly much more rapid. In addition, the Nunn-Lugar program has helped to sustain the commitment of the states of the former USSR to dismantle their weapons of mass destruction as well as put them on a practical path to do so. The Nunn-Lugar program has given us a voice at the table as these nations make decisions about the disposition of their weapons, their military forces, and defense production capabilities.

Above all, the Nunn-Lugar program has focused the attention of the leaders of these states on the nuclear issue as an urgent priority in the midst of all sorts of other priorities, when they might otherwise have been preoccupied exclusively with their political and economic problems, which are severe. The prospect of Nunn-Lugar assistance has eased somewhat the political and economic costs for them in making tough decisions to dismantle the weapons located on their territories. At the same time, our assistance motivates these states to add their own significant resources to the dismantling effort.

I chaired the final Foreign Relations committee hearing on the START II Treaty in the Senate yesterday. The Committee will seek to mark up the treaty after the April recess, and we will look to potential floor action during the middle of the month of May. It is a good treaty, but it is one thing to have reached agreements and understandings; it is another to have them fully implemented.

To reach the START II limits by the year 2000 or 2003 will require enormous effort and cost, particularly on the Russian side. This would be difficult in the best of times, but it is particularly challenging given the political and economic revolution engulfing Russia today.

This political and economic turbulence means that there is inevitably some uncertainty associated with the process of implementation within Russia of the START II Treaty and other agreements regarding the reduction of nuclear weapons. One does not respond to this uncertainty by scrapping the START II Treaty. Rather, support for the Treaty must be accompanied by a number of steps which can help reduce the risk associated with the current turbulent state of affairs in Russia.

First, the United States needs to continue its efforts to assist Russia financially and technically in implementing agreed reductions and to do what we can to speed implementation of these reductions on the Russian side so we can speed implementation on our own. Both sides should expend their efforts to deactivate, disable, and disassemble nuclear delivery systems slated for destruction even though their actual destruction may not come until a later point.

Second, the United States should push ahead with efforts to encourage the Russians to undertake the steps to improve command and control over their nuclear forces and their safety and security of those forces. This should help the risk of unauthorized or accidental launch of nuclear weapons as a result of political turmoil should it spread to the military forces who are custodians of those weapons.

Third, the United States should assist Russia in ensuring that the technical know-how, trained personnel, special nuclear materials, and even nuclear weapons themselves do not move outside its borders and fall into unfriendly hands. We should cooperate with Russia to ensure the security and safe storage and disposition of nuclear warheads and special nuclear materials. We must work for transparency and full accountability of these very important nuclear materials.

We are doing some of these things now, and we need to do more of them. This is the Nunn-Lugar program. Ratification of the START II treaty must be accompanied by a commitment by both the Administration and the Congress to continue such steps and to do so steadily throughout the years. This will require both political courage and stability and financial support at a time of budgetary austerity and electoral politics in this country. Such a program is an essential complement to minimizing the potential risks of instability in Russia associated with the on-going political and economic turmoil. It is an essential component, as well, to the full implementation of the START treaties and attendant efforts to prevent the reemergence of the nuclear dangers that characterized the Cold War.

SAM NUNN
United States Senator

I want to say to John, before the beginning my remarks, it is great that you are going to bring a sense of humor to the CIA; they need it now.

I want to thank Jane Wales and the White House Council on Foreign Relations, the American Association for Advancement of Science, and others who have participated in putting this program together.

I endorse everything Dick Lugar has said. We have seen this eye-to-eye from the very beginning, and I think that is the reason this program has had the kind of support it has had on Capitol Hill.

The subject today is of immense importance and there are very few jokes that go with it, but there is a true story that I guess I can tell to this audience about a Republican senator. I will not name him, but he was elected a few years ago. He had a press conference the morning after his election, and the news media asked him what his top priority was. He said after thinking a little bit, that somehow he was not prepared for the question. He was a little flustered. He said, "I have thought about it a lot during this campaign and decided my top priority is to prevent my beloved state from becoming a nuclear suppository."

We do not want this wonderful world to become a nuclear suppository either, and that is what we are all about here today. I have been asked to give you a brief summary of the history of this program, and I can do so by telling you a little bit about why I came to the conclusion something like this was needed.

My own experience started in 1975. I went to Germany and toured some of our tactical nuclear weapon facilities there at the request of Senator Stennis, who was chairman of the Armed Services Committee. I came back after a very revealing—I would say almost shocking—experience. As I was getting the normal tour that generals give in the Department of Defense, I was told that these nuclear facilities were perfectly safe and everything was wonderful. A guard handed me a note and said, "Senator Nunn, there is a lot that you need to know. Please come by my barracks so I can tell you, anytime after five o'clock." Well, I thought about it, and then I decided to do it. I went by the barracks and I had an eye-opener, because everything was wrong with nuclear security at those tactical nuclear bases.

First of all, we had a demoralized military coming out of Vietnam: A lot of alcohol and tremendous drug problems. A number of the people who were guarding those weapons were on drugs, I was told. I went back and I looked at the physical security, too. That was a big problem.

When I came back, I did not go home when I got off the plane at about four o'clock in the afternoon. I went directly to see then-Secretary of Defense, Jim Schlesinger, and gave him a full report, because I felt that something had to be done very quickly. We were very vulnerable to having just a few terrorists, well-organized, come in and actually take over a facility guarding nuclear weapons in those crucial countries in Europe at a time when it would been have devastating to our national security and probably to our nuclear deterrent. That was my first eye-opener.

We had a number of hearings in 1982 and 1983, but we had them all during the 70s, also. I slowly but surely was coming to the conclusion that perhaps the greatest danger that confronted us was not an all-out first strike by the Soviet Union, but rather some kind of accidental nuclear launch or some kind of third country launching a missile or a submarine missile that would start a war between the two super powers.

I asked Dick Ellis, who was then General Dick Ellis with was then the Strategic Air Command, to give me a summary of the United States' ability to detect the origin of a nuclear strike. I do not mean by that an all-out strike. That would have been obvious. But one or two weapons—even some being delivered by submarines whether we would know where the strike came from and what the origin was. He gave me a somewhat ambiguous answer: He said he did not have a real study on that. So I asked him to go back and look at what the United States could do to detect the origin of nuclear strike and what the Soviet Union could do.

He took it very seriously and spent about six months. He put some of his best staff people on it. I went to a classified briefing—some of it was later declassified; some of it is still classified. The bottom line was we were fair in our ability to detect the origin of a nuclear strike. The Soviet Union was much worse. That was not comforting.

I came to the conclusion out of that, as did General Ellis and all the staff working on it, that we had a real stake in their ability to detect the origin of a nuclear strike. It was no comfort that their intelligence was not as good as ours and that their means of ascertaining the origin of the strike was not as good as ours. In fact, it was more concerning than if it had otherwise been the case. Because, if they thought that a strike—let us say from a Chinese submarine—against the Soviet Union came from the United States, then we can all imagine what might have happened in the 1980s.

Out of that I came to the conclusion that this whole nuclear business was not a zero-sum game and that we had better stop treating it as such.

The next event that had a real impact on my thinking was in the then Soviet Union, I was there about four or five days after Gorbachev returned from the coup attempt. I had a long meeting with him, and during that meeting I kept coming back to the question of nuclear

control during his captivity or his semi-imprisonment. He kept giving me somewhat glib and not very thorough answers. It was obvious to me he was very uncomfortable about the whole subject.

About that time I concluded that we had to start doing something. It was apparent that the Soviet Union was coming apart and that we had better start doing something and working with them to be able to help them control their own weapons. We had a vital national security interest in doing that.

To make a long story short, about the time I was concluding that, Les Aspin was concluding that we needed to help them at that stage with some emergency food shipments. We had passed the House bill on Armed Services. We had passed the Senate bill, and we were in conference. Les proposed that we do something on emergency food shipments. I proposed that we do something on the overall question of helping them control their own nuclear, chemical, and biological weapons.

We came up with a conference report that included a provision and money for both purposes. It was not well received—there was tremendous opposition. There was legitimate opposition, because it had been in neither bill—not a good habit. I felt it was an emergency and it was justified. Nevertheless there was substantive opposition because people felt that we were helping the Soviet Union. We had all sorts of people come out against it on the floor. The bottom line, Les and I decided in prudence that we needed to go back in conference and take it out; we did. This was in late September.

We came back, and Ash Carter gave his report which I understand was financed by Carnegie. The topic of your conference is how science and technology can assist in making the world more stable. This was a science and technology project done by Ash Carter at Harvard and financed by Carnegie.

That report had an astounding effect. Dick Lugar and I got together. I knew that Dick had tremendous influence on the Republican side, tremendous influence in the Senate, and in the country. We really formed a partnership. Ash Carter presented his report to us. We then brought in other senators, and within about three to four weeks we had built a consensus.

A proposal, in an earlier stage received overwhelming opposition on both the House and Senate side, became one that was widely accepted. It became known as the Nunn-Lugar proposal. We passed it about six or eight weeks after it had been overwhelmingly not voted on, but rejected in terms of voices on the floor on the House and Senate. It became known as the Nunn-Lugar program, and that was the beginning of what we are here to discuss today.

There has been a lot of talk in the media about how slowly implementation has occurred, but it has been very effective—even when the money was not being spent. It created a

psychology that focused the Russians and others on their own problems. It calls them to be much more attentive, as Dick Lugar has already said, to their own problems—to make them a priority because they knew that we thought it was important and they knew there was some money, at least in pipeline.

Why was it slow? First of all, this was not an executive branch initiative. Whether Republican administration or Democratic administration, things that do not originate in the executive branch are not always treated as high priorities. We have noticed that over the years. The Bush Administration was rather cool to the idea at first. They were not opposed to it; they were simply cool to it.

The second reason was because of the stage of the proceedings and because we were trying to get the money any way we could. We had to authorize transfer of money from other DOD programs into this program. We did not give them what we would call "fresh money." It was transfer authority, and that meant they had to cut something else. So they had to find the money somewhere else in order to transfer it, and that is always a problem in terms of Congressional initiative.

The third, and maybe the most important reason, was the breakup of the Soviet Union left those countries in a situation where they did not have the kind of coherence or the kind of governance that would allow them to make tough decisions in these areas was not always their top priority. The Nunn-Lugar program did start off slowly, but it has been a very solid success and an example of how we are going to have to use innovative ways to deal with these unprecedented problems.

This is the first time in history that an empire has broken up that had in its possession over 30,000 nuclear weapons, over 40,000 tons of chemical weapons (that is very conservative estimate), and an undetermined number of biological weapons.

It is also the first time in history that we have had an empire break up where there were thousands of scientists that knew how to make these weapons of mass destruction, conventional weapons that have tremendous implications, weapons that could get into the hands of terrorists, and missile technology. It is the first time we have had thousands of scientists running around part of the world not knowing where their next paycheck was coming from, also knowing that their services would be in great demand in a number of rogue nations in the world and certainly with a number of terrorist groups.

One of the first contests in the period after World War II was regarding which side was going to get access to the German scientists. We got more of them than they did. We are in that period right now, but we have not focused on it as much as we should. Bill Perry will go into more details about what has been done.

If we could develop a weapon that would basically cause three nuclear states to give up their nuclear weapons, how much would we pay for it? The Nunn-Lugar program has done that. Belarus, Kazakhstan, and Ukraine have given up (or are in the process of giving up) their weapons.

If we could develop a weapon that would get rid of 2,500 strategic nuclear warheads which have been removed from the launches, how much would we pay for it? If we could have a weapon that would get rid of four regiments of SS-19s that were aimed at the United States, how much would be pay for it? If we could developed a weapon that would get rid of 600 launches physically, how much would we pay for it? If we could develop a program that would employ in a gainful way some 5,000 former Soviet weapons specialists, what would it be worth? A great deal, I think many, many times more than we have spent of the Nunn-Lugar program. Thank you.

WILLIAM J. PERRY
United States Secretary of Defense

Harry Truman once said that progress occurs when courageous, skillful leaders seize the opportunity to change things for the better. In 1947 the opportunity presented itself to rebuild Europe after a terrible war, and George Marshall seized that opportunity. The result was the Marshall Plan, and it changed things for the better—to make an important understatement.

In 1991, the opportunity presented itself to unbuild the Soviet Cold War nuclear weapon arsenal to prevent its dispersal and to forge cooperative ties with former enemies. Senator Sam Nunn and Senator Richard Lugar seized this opportunity, and the result was the Nunn-Lugar program and it is changing things for the better.

So far the Nunn-Lugar program has helped us to remove 2,600 warheads previously aimed at the United States. It has destroyed almost 600 launchers and bombers. Along the way, these projects have built a channel of trust and cooperation with the former Soviet Republics and in my mind (without any doubt) was the critical factor in leading the three of these nations—Ukraine, Belarus, and Kazakhstan to agree to become non-nuclear states.

I have seen what Nunn-Lugar can do with my own eyes. Last year I went to what was one of the largest, most modern ICBM sites in the world at Provomaysk which is in Ukraine. Today I have a picture on the wall in my office that shows me peering into that Soviet ICBM silo at Provomaysk. I could see the SS 24 inside the silo, but the business end was gone. The warheads had been removed the week before and sent to the factory for dismantlement, courtesy of the Nunn-Lugar program.

This was an ICBM whose ten warheads had been aimed at targets in the United States just weeks before. This is why we call the Nunn-Lugar program defense by other means.

Last fall a secret mission was completed called Project Sapphire. This also illustrates the potential threats that the Nunn-Lugar program can eliminate. We had been working on Nunn -Lugar projects with the government of Kazakhstan, and they approached us and asked us to do a favor: Could we take about 600 kilograms of highly enriched uranium off their hands? This was enough uranium to make about 30 nuclear bombs, and the Kazaks were concerned (as were we) that it would somehow end up in Iran jumpstarting an Iranian nuclear weapons program.

In my job I face decisions every day which are hard to make. This was not one of them. Today all 600 kilograms of that material are now under guard at the Oak Ridge facility in Tennessee, where it is safe forever from terrorists and black marketeers and nuclear warheads.

This was historic in nonproliferation, and once again it was the Nunn-Lugar program in action. These stories about weapon dismantlement and the safeguarding of nuclear materials are compelling reasons why the Nunn-Lugar program is a very good investment of defense funds. By spending millions to eliminate nuclear weapons that can threaten us, we save billions in defending against them. These stories also pay tribute to the courageous and skillful leadership of Senator Nunn and Senator Lugar, and I am honored to be on the program with them today. How many people can say that they are personally and directly responsible for reducing the potential risk of nuclear annihilation?

Ironically, however, this program has run into some problems with Congress. Few question the wisdom of spending defense dollars to dismantle Soviet nuclear missiles. It is harder to make clear that dismantling missiles is not enough, and you have got to also deal with the massive infrastructure of launch facilities, missile offices, defense factories, skilled workers and nuclear scientists.

If you leave the people and facilities in place, you run the risk down the road that they could regenerate and reproduce the new weapons for a hostile regime abroad or for a regime at home if reform were to fail in Russia. A small portion of our Nunn-Lugar appropriations—about 20 percent—have gone toward reorienting nuclear scientists to nonmilitary research, to converting weapons plants to commercial production, and to decommissioning the former strategic Soviet rocket forces.

The government is not doing these things alone. The private sector, sensing an investment opportunity, is also playing a key role in this activity. A small amount of these Nunn-Lugar monies helped set up joint business ventures between American companies and former defense enterprises in the former Soviet Republics, and they are helping to reduce and reorient the Soviet nuclear weapons infrastructure. For example, we have just allocated $10 million in Nunn-Lugar funds to set up an American-Ukrainian business partnership to make

prefabricated housing in Ukraine. The first rounds of production from this will help to provide housing for the former strategic rocket officers who manned and controlled the missiles in Ukraine.

I told you about my visit to Provomaysk. After I witnessed the silo and control facility there, I was hosted for a lunch by the Ukrainians defense minister and by the military leader of these strategic rocket forces. At that lunch they told me that the biggest impediment . . .**[End of Tape]**

. . . the day after tomorrow, Saturday, I will be back at Provomaysk. We will be meeting again with the Ukrainian Minister of Defense and with the head of the Strategic Rocket Force. This time we will be conducting the ground-breaking ceremony for the new housing complex that is going in there. I will be going from there to the factory which used to build Soviet warships, and which is now making the prefabricated housing which is going into this project.

When that project is completed, this factory will go on to build prefabricated housing and to sell it commercially in Ukraine and Russia. This is a joint business partnership between an American company and an Ukrainian company.

The Nunn-Lugar funds are also being used to facilitate the formation of joint business ventures to convert excess weapons factories to commercial production in Russia and Ukraine—somewhat along the model of this prefabrication partnership which I have just described to you. Getting these factories out of the weapons-making business does protect American security. Critics in the United States have charged that these conversion programs will have the effect of sustaining the Russian defense industry.

We not only have critics in the United States, but we have critics in Russia. The critics in Russia have charged that these programs are designed to cripple the Russian defense industry. On the one hand, critics are claiming that it is sustaining the defense industry; and on the other hand, they are claiming it is crippling.

Both sets of critics cannot be right; and indeed, neither of them is right. These projects exploit neither the United States nor Russia. On the contrary, they benefit both nations. They help to privatize the Russian economy, they reduce the potential for weapons to hostile regimes, and they help open new markets for American companies. This is a win-win program in the best sense of the word.

As you can tell, I believe in the Nunn-Lugar program. I am committed to it, and I will continue to fight for it.

I want to close with a quote from Augustus Hehrer, who wrote, "Half of the failures of this world arise from pulling in your horse as you are leaping." Over the past year the Nunn-

Lugar program has taken off. It has leaped. We must not reign it in, in midleap. Thank you.

Fifth Panel Discussion Questions and Answers

JOHN M. DEUTCH—*Questions*

The Nunn-Lugar effort addresses an issue of broad international interest. To what degree have our allies taken actions of substance in this area, including commitment of resources? If the answer is none, why not? What is our position on pushing this issue with our allies?

WILLIAM J. PERRY—*Answers*

The one area where we have had substantial support from allies has been in a program we have not described to you this morning, but it is an important and integral part of what we are doing here. This is setting up a science center in Moscow and Kiev to provide employment in nonweapons areas to nuclear scientists and technicians who were employed in the former Soviet nuclear program.

The objective of this program is to keep these scientists from wandering out of Russia into Libya, Iraq, and Iran by giving them alternative means of employment. We know for a fact that there is intensive recruiting going on in Russia to try to hire these scientists. This program was set up for that purpose and, it has substantial support from two of our allies. More of the half of the total support for it comes from allies.

SAM NUNN—*Answers*

If I could add to that, I think we need to push that part of it. The Nunn-Lugar program focuses mainly on chemical, biological, and nuclear weapons and scientists who are dealing in those areas, as well as missile technology. I think we need a much broader look at the Soviet scientific community. I mean by Soviet the former states, not just Russia.

At the national level we need to really encourage every university and scientific group in this country during this crucial period. So many of these scientists are really without means to sustain themselves and their families. We need to get them over here and have our people over there. We need a maximum exchange program. I would like to see every university that is involved in research in the United States have—at least—former Soviet state scientists on board for the next year or two, maybe on a rotating basis. We need to have a national initiative in this regard. It will be a colossal failure of initiative if we let these scientists end up dispersed all over the globe doing all sorts of things that may not contribute to world stability.

JOHN M. DEUTCH—*Questions*

Why has United States funding for United States/Russian scientist-to-scientist cooperative research been so meager and so slow in coming? Can and will this change? It seems that there is an ambiguity in Congress about their willingness to see Nunn-Lugar program resources used for scientists-to-scientists programs. Is that correct, Senator Nunn?

SAM NUNN—*Answers*

We had to draw that program in a narrow way so that it would be aimed primarily at weapons of mass destruction. The further away you get from that, the more you jeopardize that program. This program is not sufficient. It is a very good start, but we either need to broaden some of its own applications, or we need to create other funds that would go beyond the weapons of mass destructions and scientists involved in that. That is what I was just alluding to. We need a major program, because there are all sorts of conventional weapons that can be used almost like weapons of mass destruction, and there are all sorts of scientists over there that know how to make conventional weapons or soon could. They have tremendous scientific talent in those former Soviet Union countries.

RICHARD G. LUGAR—*Answers*

Saying that it was narrowly drawn certainly describes the situation politically. A good number of senators on both sides of the aisle were hostile. We drew up a program that targeted weapons of mass destruction, and it was a chaotic situation. We could not sell it.

From that point onward, we all learned much more about the conversion situation and about the science situation. We visited with a lot of these people. This was sort of a hands-on, on-the-ground type of operation, not legislation from afar. We have been working with our colleagues ever since to try to think through and understand what all is involved in this. That is why we come to you today with an appeal to help us. There has to be a much broader American understanding of our security interests. It clearly affects these scientists as well as transparency and accountability. I often see in my mind a large vat with all the highly enriched uranium which we know is there. You can count it and see it in both the United States and in Russia, and then we put pressures on others for accountability, working from the strength of that relationship with the Russians—which is considerable amidst of all the headlines about turmoil and pragmatic politics and the end of the honeymoon. We have our work cut out for us. It is always missionary work, both here and abroad.

SAM NUNN—*Answer*

We have got a situation right now that will come up in the next week sometime. The logic will be that if Russia goes forward with the sale of reactors to Iran (which the Administration

properly opposes and I think we need to vigorously oppose that,) that we ought to cut off Nunn-Lugar and all other funding. I suppose the logic is if we are going to see Russia sell weapons to Iran, we also want to keep Russian weapons pointing at us. That is the only logic I can see to cutting the Nunn-Lugar program as a retaliation. It would be an act of destruction in terms of our national security, but that is the logic we are in right now.

I think we have amendments on the floor of the House and Senate to cut off every single bit of aid to Russia based on this Iranian sale of reactors probably within two months. So we are really going to need the scientific community. I see this as similar to the time after World War II, from 1945 to about 1950. We are in a very formative period in terms of the next 20 to 30 years, and what we do in the next couple of years is going to determine a great deal about the future of our children and grandchildren.

We have never had a crisis like this in terms of the challenge, and we probably never had less public understanding about the nature of this challenge. It is a proliferation challenge of tremendous magnitude, but it is not commonly understood. I have never yet had an audience that I spoke to that did not understand it when I got through explaining it. It is something that is not hard to explain. It is awfully hard to have access to the media to get the mass information out there, and I think we are really going to need the scientific community to help explain the context of where we are in this point of history.

JOHN M. DEUTCH—*Question*

Senator, I would ask you not to answer the questions until I have read them! Should the Russian deal with the nuclear reactor deal with Iran, assuming it goes through, be allowed to derail the CTR program?

WILLIAM J. PERRY—*Answer*

I would like to add just one additional comment on the broader problem with the broader set of Russian scientists and engineers, besides those narrowly tied to the nuclear weapon program. These have been described rightly as a potential problem for United States security, but I want to also emphasize that there are opportunities there as well as problems. I have met many of these scientists and engineers. I have been to many of their research facilities and laboratories. This is an amazingly competent, diverse, broad group of talented technical people. The opportunity to use them in an effective way for the good not only of their country, but of our country as well, is very real. Indeed they pose a problem, but there is an opportunity there to be seized as well.

JOHN M. DEUTCH—*Questions*

Do you believe that the cooperative threat reduction program will prosper under the new plan to parcel out key components to the Departments of Energy, Commerce, State, and other agencies? Will this Balkanization process make it more difficult for the President to use the cooperative threat reduction effort in pursuit of broad United States foreign policy objectives? Will it also become more difficult for the different government agencies to secure funding for these programs if they are no longer within the DOD budget?

WILLIAM J. PERRY—*Answers*

I am not terribly concerned about the Balkanization as described in the question. It would probably surprise many in the audience to know that the different government agencies working in this problem in Defense, State, National Security, and Energy actually are working very closely together and have a clear and common vision about what it is we are trying to do. I described one of my trips to the Russian Ukraine. I have made actually two or three trips in the last year and a half and I am making another one this weekend. With me on this trip will be senior representatives from those other agencies. We are working together with a very clear vision and a common purpose for what we are trying to accomplish. For that reason, I am not concerned about what you are describing.

JOHN M. DEUTCH—*Question*

Here is a different question. It appears that the Nunn-Lugar funds are being used to prop up Russia's nuclear weapons program. I have heard the statement that 20 percent of the Russian nuclear weapons laboratory budget is now being paid for by the United States. Can this be in our interest?

WILLIAM J. PERRY—*Answer*

I had intended to answer that question with my talk. The brief opening comments that I made noted that what we are doing with those funds is forming joint alliances between American companies and segments of Russian defense enterprises, the purpose of which is commercial production. The funds do not—I repeat, do not—go to the Russian enterprise. They go to the American company who then uses them specifically develop this commercial production. The American company also is required in the proposal they make to us to provide their own funds, as well—typically on a 50-50 matching basis—sometimes as much as two or three to one matching.

The reason for that requirement is not only to get more for the government dollars we are spending, but most importantly so that the criteria about what is being done will be basically a judgment made by the American company. If they were simply applying for grant money,

they could think all of sorts of reasons for doing this program, but if they are spending their own money as well, then they have to be persuaded that there is business merit to the proposal.

The business merit revolves around the commercial product that is being manufactured. No, this is not in any sense propping up components of the Russian defense industry. It is converting them. It is causing both the people and the facilities to be diverted over into other enterprises which result in development and production of commercial products.

JOHN M. DEUTCH—*Questions*

In these days of budgetary authority and deficit reduction efforts in Congress, is Congress willing to provide the funds needed to make the Nunn-Lugar successful? What steps can be taken to improve the program presentation to Congress in this regard?

RICHARD G. LUGAR—*Answers*

One of the purposes of our panel today is to try to gain a larger forum. As Senator Nunn said, we need a mass understanding of the criteria and priorities of this. I think the budget situation will be a very difficult battle. We are bound to have an ongoing debate throughout the entire end of the year. We may revisit it again and again, but I think we are of a mind that this is vital to our national security, and therefore it needs to remain at least at the current level of funding. That certainly will be our quest in a bipartisan way.

JOHN M. DEUTCH—*Questions*

How about the balance between the chemical and biological efforts and nuclear efforts in Nunn-Lugar, Senator? Is there a sense of what you think that balance should be?

SAM NUNN—*Answers*

I think that it is not as balanced as I would like to see it. More focus has been on the nuclear side—mainly because the Russian nuclear side has been more willing to work with us and as have the Kazakhstan, Belarus, and Ukraine nuclear side. The chemical side has been more difficult because of the personalities of some of the people we are dealing with.

To me, the chemical side is the area where the whole world has much at stake. The Tokyo subway tragedy was a good example of what I am afraid may be the terrorist choice of weapons in the future. I think the chemical side deserves a great deal of attention, not just in the program but worldwide to determine how we are going to try to deal with this situation. Biological is much more difficult, because the Russians basically do not acknowledge some of the things that we suspect have happened in the biological area. We are not quite sure how

much some leaders really know about that, but Bill could probably take it from there.

WILLIAM J. PERRY—*Answers*

The situation is as Senator Nunn describes it. In the last four to five months we have made some real progress in the chemical area, particularly in assisting the destruction and demilitarization of chemical weapons. I see that as a potential major breakthrough in the chemical area.

There is very great potential for conversion in the biological area. We have not made progress there, because we have not been able to get a full and open discussion of what the biological program is (or was) or how it could be dismembered. I am by no means pessimistic on that. I have continued to work that program, and I continue to believe we will have success there. In sum, most of the progress has been in nuclear. Just in the last few months we have started a major program in chemical demilitarization. The biological program is important, but there is no progress to date. We must still continue to try.

JOHN M. DEUTCH—*Question*

Slowness in initial implementation of the Nunn-Lugar program resulted in a negative psychological effect in states of the former Soviet Union, since their hopes were first elevated and then dashed. What is the impact of the slow implementation on expectations in the states of the former Soviet Union?

WILLIAM J. PERRY—*Answer*

That is a very good point. Expectations were not only higher than we have achieved, but probably higher than we ever had any possibility of achieving. In just the six months, there have been substantial projects started in this area. One of the purposes of my visit over there is to highlight them to the Russian and Ukrainian public so they can see the progress that is being made in this area.

We have joint ventures now underway that are actually manufacturing dental equipment, manufacturing air traffic control equipment, bottling soft drinks, and conducting scientific research in areas of interest in the medical field. All of these programs are now underway. We see tangible progress coming out of it, so I think that highlighting these programs will be a substantial help.

In terms of expectations, we are talking about a relatively small amount of resources to deal with a very large problem. The 20 percent or so of the Nunn-Lugar funds amounts to about

$80 million a year dealing with a defense industry which is substantially larger than the United States defense industry—it spent tens of billions of dollars a year for defense programs.

From the beginning we have taken the position—and have tried to explain to the Russians—that the Nunn-Lugar program cannot convert this defense industry. We do not have enough resources to do that. We can only serve as a model for how the conversion should take place and as a magnet for attracting other funds.

The real test will be whether these small model programs we started, the pilot programs, are successful in attracting large sources of private funds. I am taking with me on this trip, ten CEOs of major United States companies who either have investments in Russia or in Ukraine or are contemplating making major investments focused on defense conversion. I am also taking Ruth Harkins with me, who is president of OPIC, the Overseas Private Investment Corporation. She has set a fund of $500 million specifically for investments in defense conversion in those countries.

This provides the amplifying funds necessary to follow up on what I would call first-round seed capital investments being made with Nunn-Lugar. From a venture capitalist point of view, the venture capitalist makes the seed capital investments, but then some large source of funds is needed to come in for the second and third rounds of investments. That is what we see coming from private industry and OPIC. The purpose of bringing the CEOs and OPIC along on this trip is to let them see with their own eyes the early stages of what we are doing with Nunn-Lugar so that when the second round of investments—much larger sources of funds—become necessary next year, they will be there and they will be ready.

The expectation problem has two aspects to it. First of all, we were slow getting off the block, for the reasons that have already been discussed, but we are now functioning. Secondly, and more importantly, we are only a small part of what needs to be done. The second and third round of financing is still ahead of us, and we are trying to accelerate the date. We hope to pass the baton quickly and efficiently from what we are now doing on Nunn-Lugar to private and OPIC-type investments, which will make the second and third round.

JOHN M. DEUTCH—*Question*

There is a widespread impression that the Defense Department is not very interested in conversion of the defense industry in the former Soviet Union to civilian purposes. How broad do you make this Nunn-Lugar effort in the Defense Department?

SAM NUNN—*Answer*

If I had my way, I would make it very broad. I think we are in a crucial period of time. The more we can give them the incentive to convert their own defense industry, the better off the world is going to be—whatever regime may emerge two, three, or four years from now.

Looking at the reality on Capitol Hill, to enlarge the purposes of the Nunn-Lugar program or to move much further down the line on defense conversion than we have already gone would jeopardize the whole program. I do not want to jeopardize the whole program. I think we have got to keep the core program focused and narrowed toward weapons of mass destruction. I think we have to make sure that everyone understands it is not a perpetual program—that we are going to have it expire around the turn of the century. If we do not, the whole program could be shot down in the atmosphere we are in at the moment.

Yes, we ought to have a much broader focus. We have a tremendous stake in the kind of world that our children and grandchildren are going to face. The years to come are going to be determined by what Russia ends up being, in terms of a democracy and a market economy if they make it. History tells us that it is going to be difficult. Some people take the fatalistic view that historical reading indicates that it is hopeless. I do not view that. That is self-fulfilling prophecy, and history will judge us harshly if we do not do what we can on the margins—and I admit it is on the margins—to give them assistance where assistance can help.

The main thing, though, is private development. What Bill Perry is doing in terms of taking CEOs over there is the key. Government funding is going to do only a limited amount here. The main thing in terms of the overall economy is going to be the question of private investment. That requires a whole set of things they have to do in terms of rule of law and getting control of some of their crime problems which are very serious and overlap into this proliferation area.

The ultimate horror is a combination of proliferation, broke scientists, disgruntled miliary, and organized criminal elements operating not just in Russia, but all over the world. That is the ultimate kind of danger we face. There is a law enforcement issue here. The FBI has a big role to play. I have talked to Louis Freeh about it a number of times. He has made a trip over there. We are only on the margins there, but it is imperative that we help them develop a better law enforcement system.

WILLIAM J. PERRY—*Answer*

This question of economic development in Russia and other related nations is very important. The answer to that problem is not expanding Nunn-Lugar. The program for dealing with that (to the extent that we are making an important contribution to the United States government) is a different vehicle called the Gore-Chernomyrdin Commission. This is a joint United

States-Russian Commission chaired by Vice President Gore on the United States side and Prime Minister Chernomyrdin on the Russian side. It is specifically directed to promote cooperation leading toward economic development in Russia. This has been a very active and very productive Commission.

The defense conversion which is being done in Nunn-Lugar is just one of the committees of the Commission and works in cooperation with the other committees. It involves an activity in the Department of Energy which is focused toward cooperation in developing the vast energy resources in Russia.

There is a committee chaired by Ron Brown of the Commerce Department which is developing the sort of things we are doing in defense conversion but not related to defense as specifically. It has an area of cooperation in science and technology that is chaired by Jack Gibbons and Jane Wales, and it has the involvement of Ruth Harkins of OPIC. That is how we first got together and got Ruth to agree to support the work we are doing in defense conversion with OPIC funds. This is the vehicle for making broader advances in the economy in Russia and having the United States and Russia cooperate. It has been a very successful activity, and I have high hopes it will continue to be successful.

JOHN M. DEUTCH—*Question*

Is it possible that NATO expansion would undo Nunn-Lugar from the Russian side?

WILLIAM J. PERRY—*Answer*

There are a whole host of geopolitical issues and controversies that are going to be a problem between the United States and Russia in the months and years ahead. Our Administration's position is that we cannot let them derail us from doing things which are in our best security interest. Sam has already given an example of how we can seize on any given issue (in this case the example he gave was the sale of a reactor to Iran) and let it derail the things which are in our best interest to do. It would be foolish on our part.

Certainly that is going to be one of the issues I will be discussing with officials in the Russian government on this trip. It is an issue which will be discussed with the President at the summit meeting in a month or two. It has been discussed at the meeting of the Gore-Chernomyrdin Commission. I do not believe we should let other issues derail us in doing the cooperative ventures which are in our mutual, best interest.

JOHN M. DEUTCH—*Summary*

We have a whole array of very interesting questions we have not been able to address here this morning, reflecting a lot of interest and a lot of incisive views. I am sorry that we have

not addressed them all. I think the main point of the morning is the importance of the Nunn-Lugar program and how new, different, and important it is for stability in Russia and for moving Russia away from nuclear, chemical, and biological weapons.

First Bill, and then Sam, please share any final points you have about the overall purpose of the Nunn-Lugar program.

WILLIAM J. PERRY—*Summary*

The Nunn-Lugar program is focused on how to deal with the problem posed by the scientific and technological capabilities in the former Soviet Union. It has been quite successful and will continue to be quite successful in doing that. Besides associated problems, there are potentially great opportunities in the scientific and technological capability in the former Soviet Union. What I would urge the scientific community to do is to seize on what we can do in the United States to take better advantage through cooperative programs of the science and technological capability in Russia and Ukraine today. That would be an enormous benefit which would supplement the sort of things we are doing on the Nunn-Lugar program.

SAM NUNN—*Summary*

Universities and research institutes throughout the country need to have an affiliation with Russian scientists in some fashion: Some exchange program would be enormously helpful for the next 10 years. I know resources are a problem. I do not see the governmental resources to do that beyond what is already out there, but I do think it is very much in our national interest.

It would be enormously helpful for those of you who believe this program has merit to get as familiar with it as you can. I know Ash Carter and others are available to brief the scientific community on what is happening in terms of details. Constructive criticism is not only welcome, but very helpful. Capitol Hill also needs a lot of support. We need letters to the editor. Most letters to the editor now or most op ed pieces are critical. People who are defending a program that seems to be going along pretty well usually do not speak up. If that continues to be the pattern, we will have a very difficult time sustaining this program. I thank you all for your interest and invite your continued assistance and constructive help.
[End of Tape]

Sixth Panel Discussion

Nonproliferation of Weapons of Mass Destruction

KENNETH L. ADELMAN, ***Chair***
Vice President, Institute for Contemporary Studies

Good morning. Let me start off by thanking everybody for coming and Jane Wales especially for putting together this conference. It is wonderful to see that the Executive Office of the President, the White House, has assembled a group like this on a topic like this. It is critical that we look at international affairs and national security affairs and how science and technology can really contribute.

When you look at weapons of mass destruction and what science and technology and diplomacy and intelligence have done over the years, it is by and large made the spread of weapons of mass destruction far less than what we had expected. When I was Deputy to Jeane Kirpatrick at the United Nations, I used to tell of this favorite comic strip that I had from Peanuts, that had Charlie Brown missing 15 free throws or striking out 18 times in a row, and Lucy coming up to him and saying, "Oh, Charlie, do not feel so bad. You win some and you lose some." He looked at her and said, "Gee, that would be nice!"

At the United Nations we never seemed to get into the situation where we won some and we lost some. I am thinking some day that would be nice. Looking at nuclear proliferation, I think it is fair to say that the Nonproliferation Treaty and the whole regime of stopping the spread of nuclear weapons has been one where we not only won some and lost some, but we have won a lot more than we ever lost.

When you look at the strategic literature of the 1950s and even early 1960s, you see the books filled with predictions that the world was going to become one of many, many states with nuclear weapons all around the world. In fact, President John F. Kennedy in 1963 predicted that by 1975 there would be 15 to 20 nuclear weapons states in the world. That was 20 years ago. There are not 15 to 20 nuclear weapon states. When he made the prediction, there were four. Now there are six or seven. There was one the next year after he made that, in 1964, with China.

Since that time there have been very few additions. This has been an area where because of a lot of singles and very few home runs over the years, the world has done far better than predicted. Whether that will remain the case in the foreseeable or distant future is the subject of our panel this morning.

To start us off, we have Secretary Charles Curtis. Charles Curtis is Under Secretary of Energy. He comes with a very nice portfolio that is perfect for our panel discussion. He is

in charge of science and technology, national security, environmental clean-up, and a whole host of other responsibilities for the Department of Energy. He was an attorney in private practice before coming to the Clinton Administration. In the Carter Administration he was chairman both of the Federal Energy Regulatory Commission and the Federal Power Commission. Before that time he had positions with the Office Comptroller of the Currency, the Treasury Department, and the Securities and Exchange Commission.
Secretary Curtis, if you could start us off, we would appreciate it.

CHARLES B. CURTIS
Under Secretary of Energy, United States Department of Energy

It is a daunting task for someone schooled in the law to talk to an audience of such renowned technical leaders, but I am comforted by Niels Bohr's observation that an expert is but an individual who has made all the mistakes which can be made in a very narrow field. I have found as Under Secretary that I have a daily opportunity to make all the mistakes that can be made in many fields, and so I can lay claim to broad expertise on these and other matters.

Our fundamental objective in nonproliferation is to stop the potential for growth in the number of fingers on the nuclear trigger around the world. The Department of Energy's role in this effort arises from our stewardship of the nation's nuclear stockpile. While that responsibility requires our continued and serious attention, in the last two years we have also created the Office of Nonproliferation and National Security to better focus those aspects of the Department's programs and assets that addressed post-Cold War threats.

DOE's technical expertise, particularly the outstanding talent of the national laboratories, many of whom are with you today, represents a global resource with a critical part to play in stopping nuclear proliferation. Let me offer a few examples of the fundamental role this unique expertise plays in stemming proliferation.

DOE experts are providing the technologies today that will be needed to verify the comprehensive ban on the testing of nuclear weapons, as they have in the past provided the expertise to verify the Arms Control Agreements that have been negotiated in past Administrations. In another decade-long effort, DOE experts have developed most of the technology for the International Atomic Energy Agency used to implement nuclear safeguards throughout the world. Indeed, it is a fundamental cornerstone of the entire nonproliferation regime.

Consider Iraq: When it came time to dismantle Iraq's nuclear weapons program, uncover its supplier network, and design the monitoring system needed to make sure Iraq never rebuilds its nuclear effort, DOE experts were on call to get that job done—and they did.

Or consider North Korea: When the corrosion of North Korea's spent fuel appeared to offer

Pyongyang a potential excuse to restart reprocessing, DOE experts working with colleagues from around the world provided technical solutions that if given the opportunity will allow us to manage this fuel safely—and, we hope, forestall the crisis that would certainly follow if Pyongyang had begun separating bomb material from this fuel.

Our efforts focus not only on prevention but on response as well, known as "counter-proliferation." John Deutch, my good friend who was on the earlier panel, and I last year executed a Memorandum of Understanding that in a more focused and systematic (and we hope budgeted and supported) way, will bring the expertise of our national laboratories more directly to bear on counter-proliferation threats of weapons of mass destruction beyond nuclear.

These are essential capabilities, and hopefully will be excused as an unabashed pitch to say it is not in the nation's best interest to dismantle this remarkable reservoir of expertise at this time. I usually make my arguments against dismantlement of the Department by pointing out that we are dysfunctional, armed, and dangerous. I think there is more substance that can be brought to bear on that issue.

Let me now focus on our cooperation with the former Soviet Union. There is no issue on the national agenda today more important than stabilization of the former Soviet States. What we do now can make the difference between peace and instability for generations to come. These, the Cold War legacies, pose very difficult challenges for the United States. In Russia, those challenges must be met in the midst of a wrenching transition, and with a budget crisis that makes our own budget difficult choices easy by comparison.

Working closely with the States of the former Soviet Union, our Administration has developed a comprehensive four-part plan to manage the nuclear material legacy of the Cold War: Securing nuclear materials; building confidence through openness; halting further accumulation; and carrying out their ultimate disposition, transforming these materials into forms that pose far less security risk.

Most urgent is the task of securing nuclear materials, as any newspaper reader of the last six months can attest. A critical part of this task has been assigned to an innovative, laboratory-to-laboratory partnership between DOE laboratories and their Russian counterparts. This has been a wonderful melding of scientific capability, initiative in the laboratories, and the wisdom in Washington to recognize the great potential capacity that this partnership has for securing these nuclear materials.

We do not take credit for the initiative. We take credit for coordinating what the laboratories brought to the table. Together we have developed a three-part approach: Improving the facilities, demonstrating and deploying technology, and instituting national standards.

The remarkable work done at Kurchatov Institute in Moscow, which made the press this last February in Russia, is an example of the kind of success we hope that we will repeat elsewhere. It is an unprecedented joint effort between Kurchatov, Sandia, and Los Alamos that has brought a very dramatically improved security system to two critically important sites in Kurchatov.

Kurchatov is but one of an ever-expanding list of efforts. Also in the laboratory-to-laboratory program a new modular material control and accounting system has been set up at Arzamas–16 to demonstrate technologies that could be deployed throughout Russia's nuclear complex. The key to this strategy that we are developing is a cooperative program: We emphasize mutuality of effort over and over again between their institutes and our laboratories to use those institutes, as the implementing agents in Russia to distribute technologies and knowledge throughout the very large number of civilian facilities in Russia that have possession of direct weapons-usable materials.

Through this year, much of this work has been funded by the Department of Defense, through the Nunn–Lugar program, which was the subject of our earlier panel. In fiscal year 1996 the laboratory-to-laboratory and government-to-government programs on material protection, control, and accountability are both included in the Department of Energy's budget request, totalling $70 million dollars. I believe we have a compelling case to make to Congress and that this program will receive strong bipartisan support. Indeed, it would be hard to think of a better investment in our nation's security.

Related to this effort is the industrial partnering program which represents an equally innovative security investment. Created in fiscal year 1994, this program is based on a clear vision that trade and investment, not government aid, is the long-term answer to peace and stability in the New Independent States. The industrial partnering program brings together United States national laboratories, private industry, and laboratories and institutes in the NIS in cost-share partnerships designed to commercialize new technologies.

This is a win-win-win approach: It redirects weapons scientists to profitable civilian scientific work; it increases United States industry investment in the New Independent States; and it provides assistance in program management and business education to scientists in those states who need the skills to adapt their technical talents to the commercial marketplace.

Already hundreds of contracts employing hundreds of weapons scientists have been signed, designed to bring a broad range of technologies to market. I am very happy to say that United States industry has been an enthusiastic partner with the United States and the former Soviet laboratories—if you will, a market-test validation of the worth and merit of this program.

The first eloquence, Lloyd George remarked, "is that which gets things done." These

programs describe briefly but speak eloquently for themselves in the face of urgent opportunity. They represent the best tradition of the science community's long-standing contribution to world security, and I am proud to be associated with them. Thank you.

KENNETH L. ADELMAN—***Introduction***

Thank you very much, Secretary Curtis. You may be armed, but you do not seem very dangerous.

Thank you, Josh Lederberg, for being here. Professor Lederberg is at Rockefeller University, where he was President for a number of years. He received at the age of 33 the Nobel Prize in Physiology of Medicine for his work. He is Professor of Genetics, and he has been involved in government science boards for a good number of years, including the Defense Science Board, the CNO Executive Panel, the Commission on Integrated Long-Range Strategy, and he has a particular concern for biological and chemical weapon proliferation. Thank you.

JOSHUA LEDERBERG
Professor, Rockefeller University

Thank you, Ken. We turn to chemical and biological weapons under the general heading of Weapons of Mass Destruction. I would like to point out some distinctions between those and the nuclear that have appropriately been given so much attention.

Chemical and biological weapons potentially can be almost, if not just about, as devastating as nuclear weapons, if applied on a large scale as with respect to attack on undefended civilian populations. They are accessible to a much wider range of hostile individuals. They do not require a large industrial plant. They require, one might argue, rather less sophistication on the engineering and the technical sides, the sort of thing almost anybody can do.

In that sense we are dealing with problems not just about the behavior of states but of individuals and subnational groups to a degree that overlaps those issues on the nuclear problem but is, in fact, very much more pervasive.

The one saving grace, if you will think of that, in our reaction to chemical and biological weapons, is that while they are very difficult to prevent—we do not know how to prevent an attack any more than we know how to prevent attack with a nuclear weapon once the weapon is in the hands of an adversary—there is much more than can be done post-attack, if we only have the appropriate preparedness measures. Once a nuclear weapon has blown up, there are not too many pieces left to be coping with.

With biological and chemical weapons, the toxicity may be early, but there could be a large

proportion of individuals whose lives are still in the balance with questions of appropriate care, and remediation can make all the difference in their outcome. There are also protective measures that individuals can take, ranging from gas masks that will be used by the military or the sealed rooms that were unfortunately the necessary habitat of many people in Tel Aviv during the Gulf War. This is to illustrate that there are different elements in the balance when we consider those weapons. Above all, they are very widely accessible and more can be done about preparedness.

Now, whatever skepticism there might have been that there are crazies in this world who would contemplate attacks on a scale that you have to call them "warfare," not just terrorist demonstrations, was dispelled about 12 days ago in Tokyo with the tragedy that was involved there. There may be some hope that there is a wake-up lesson about the kinds of things that loom in our future if we do not take at least some steps by way of anticipation.

In the past I have been very reluctant to discuss these details in a public forum. I did not want to help put ideas in people's heads. The Tokyo incident brushes that aside as a consideration for discussion, but I will still draw only on very widely available public reports in what I have to say.

A report from the Office of Technology Assessment on proliferation of weapons of mass destruction indicates the potential lethality of an attack with chemical weapons and what might be done under different climatic conditions with a biological agent. I do not want to specify what it is. You do your own research if you feel you have to go into it more deeply. The shading on the right is the lethal zone of a line source, 100 kilograms of biological agents, such as might be spread by a crop duster flying in the traverse from the south to north across the Washington area. A very large part of the population of this city would be at risk under those circumstances. It is not an exaggeration to say that the casualties, if undefended and untreated, could be in the range of millions of people.

That capacity for destructiveness is in the hands of individuals no more sophisticated, no more intent, and no more crazy than we have seen happen in Japan in just recent weeks.

Just a little bit more detail: Because this is a scientific colloquium you will want to hear something about the microbiology.

(Slide) This is not a list of known or authenticated biological weapons (BW) agents. Such lists have been published. I do not want to give you recipes. These are taken from the NIH Bio-Safety Manual. They list the bacterial species which are regarded as being sufficiently hazardous in handling that special precautions have to be taken. Some of them plainly would not be appropriate for BW purposes, and some might be. It is not important that you memorize the names of these linean binomials; it is significant that there are so many of them. While a few stand out as being of more particular interest, it is not a question of there

being a single target. The development of one vaccine is not going to take care of those issues once and for all.

If we go beyond the bacteria (I put those first because they are more readily accessible), they are easier to grow in larger quantities and they can be handled more safely, but we have a number of other deadly agents as well.

(Slide) The Bio Safety Level 3 agents, and the world have many more than these, but these are the ones that have already been authenticated. Where they are allocated to Biological Containment Level 3 for their use, bunny suits are really the order of the day in coping with them. The important point is how many there are.

(Slide) There is a small handful of BL Level 4. There are only two facilities in the United States that are equipped to cope with these particular agents, whose contagiousness and lethality and our inability to treat and to cope with is of such dimensions that they require very high security facilities. Those, the CDC at Atlanta and the Army Research Institute for Infectious Diseases at Fort Detrick, are really the only two places in the United States that can cope with the handling of these agents. These places are where occasionally individuals who have succumbed to these diseases during travels abroad are brought for their care and therapy.

(Slide) That will just give you some notion of the threat. Now, there is one element of solace in what I have told you. Most people playing with these instruments of destruction are going to kill themselves in the process. They are not easy to deal with, and it does not take much sophistication to grow them. However, it takes a lot of sophistication to grow them and still be alive at the end of the process. Hopefully that does remain a deterrent with respect to one of you having your own ideas about what you are going to do this weekend in this regard.

It is not a wholly reliable deterrent. There are people who are going to transgress those bounds, and there are precautions that malefactors can take if they have the wit. There are feasible kinds of things for them to do.

Okay; what do we do about it? I just wanted to express some of the patterns of response. I have starred the situations where high technology is called for, and where a good bit is in the offing. We need more appropriate means of detection, assessment, diagnosis, and a basis for reassurance.

Suppose there had been a biological agent in the Tokyo subway. How would you know when it was safe to re-enter those tunnels? Imagine the Metropolitan System, the Metro in this city, and the assiduousness with which that would have to be combed in order to be able to reassure the safety of the public facility after that kind of an attack. Our current technology is sort of barely up to it; it does need to be improved; and it needs to be available and deployed, if it is actually to be of any benefit.

Dr. Young, who will succeed me in the presentation, will have much more to say about some of these issues.

We need to know how to decontaminate, and to do it in ways that do not destroy the facilities and the equipment that are there. We need the technical basis for containment, for preventing further spread of epidemic disease from the individuals who are the first victims of attack, and making sure it does not go still further. We have the criminalistic, law enforcement aspects of protecting the evidence so we can go after the culprits and respond appropriately.

I will be glad to deal in more detail with some of these matters in further discussion. Thank you very much.

KENNETH L. ADELMAN—*Introduction*

Thank you very much. As Dr. Lederberg pointed out, we have a wonderful addition for our panel this morning—that Jane thought was important. We all thought it was important to add Dr. Frank Young.

When I saw a book called *Hot Zone* on the Best Seller list the other day I thought it was another steamy sex novel, but it was a steamier topic of what happens if there is an outbreak of chemical weapons. Apparently there is a movie that is storming right now starring Dustin Hoffman, called "Outbreak." There are other current books called *The Coming Plague* and Hot Zone, making this the topic of the hour, at least after the dumbing of America. Here to talk about it is Frank Young, who is the Director of the National Disaster Medical System. He is responsible for knowing what to do after the kind of attack that Josh Lederberg mentioned, that we all have feared for many years, and that Japan is dealing with right now.

Dr. Young was former Dean of the Medical Department at the University of Rochester, and former Commissioner of FDA. Thank you very much, Dr. Young, for joining us. It is a pleasure to have you.

FRANK E. YOUNG
Director of Office of Emergency Preparedness and National Disaster Medical System, United States Department of Health and Human Services

Thank you very much. As your token "walk-on," I will try to be brief and give you an overview of how the federal government is organized to respond to the types of nightmares that Josh raised and that we saw in Japan.

There is a lot of good news in what has happened in this Administration. First, the President, through the appointment of James Lee Witt, has revitalized Federal Emergency Management Agency (FEMA), and FEMA has responsibility for an all-hazards approach to both natural and man-made catastrophic disasters.

As FEMA is a management coordinating agency, there are 12 action agencies beneath it that are responsible for various programs. Our Secretary, Donna Shalala, is responsible for the health, medical, and health-related social services program from an executive agency standpoint. Dr. Philip Lee, our Assistant Secretary for Health, is the senior official that would be responding in this type of a crisis.

The way the Federal Response Plan is developed is that there are 12 departments and agencies that support the Department of Health and Human Services, enabling one to bring to bear all of the federal assets for health and medicine to respond to a local or state catastrophe.

There are three elements that are important to focus on in this brief discussion. First is the concept of prevention. There are two modes. First, the intelligence that can be gathered throughout the world and domestically in dealing with the type of threats the United States may face. They can come in essentially three different formats: A threat with a warning, a threat with no warning (that is really an action), or a threat with no action accompanying it. The case in Japan was an action without a known previous threat.

As one moves in to respond to the third, that category of an action with no threat, these are the things that you need to know: First, the crisis is managed in the Federal plans through the Federal Bureau of Investigations. They are the crisis managers. The consequence manager is the organization, FEMA, through its Federal Response Plan. The lead for any health and medical would be the Department of Health and Human Services.

Immediately upon receipt of this type of information, one would go into the Federal Response Plan, and the focus would be on the detection of whatever agent was involved, diagnosis of the agent, recommended therapy, mitigation, removal of the contaminating material, and public information that would be involved.

I think we saw in the case of the Japanese episode a scene from Dante's *Inferno* that would deal with the massive type of action that Josh referred to. It is important to note that no amount of planning, no matter how well done, would prevent the deaths and morbidity at a Ground Zero attack area. This is something that is necessary for all of us to know.

On the other hand, the good news is that there is a great deal of work in the practice of medicine that would enable us to respond expeditiously. The key is in the local community. There is excellent planning through the Federal Response Plan for an all-hazards plan that deals with both man-made and natural hazards.

We have been exercised in responding to many things in the last three years: The response to Hurricane Andrew, the Midwest floods, the Southeast floods, the North Ridge earthquake, and the California floods. We all know each other, and we are not exchanging business cards at the time that we are there. The massive terrorist response is really no different, conceptually, than the response to a massive earthquake. Both of those occur without warning and with loss of life. Both of them need a very rapid deployment of individuals, and I am pleased to inform you that this Administration, through its action to revitalize FEMA and the Federal Response Plan, has stitched these types of events.

This is not to say that these are not difficult and that we must focus on rapid detection. As a microbiologist and pathologist, 24 to 48 hours is not the answer. There needs to be good research to focus on that.

On diagnosis and information, I would not want to call for the hands of the people that are hypochondriac within their own, but all of you know the extent to which people respond with imagined threats and the need to get out good information and with the plans in place, I believe that we can respond, because these weapons, unlike the nuclear ones, do have good forms of therapy. Remember, the first eight to ten hours are extraordinarily difficult.

Thank you very much for your attention.

Sixth Panel Discussion Questions and Answers

KENNETH L. ADELMAN—*Question*

It seems that detection is one area where science and technology could contribute but has not very well; we are still kind of in the Dark Ages. Is that a fair assessment?

CHARLES B. CURTIS—*Answer*

My reaction is that we have got to be vigilant, hard-working, and lucky. Technology can help us, both in safeguards and in discovering threats, but we are far short of having a fail-safe system.

KENNETH L. ADELMAN—*Questions*

What would you suggest to improve it? I will give you one example: Years ago skyjacking was a big problem. Now we have metal detectors in airports, and it is a nonexistent problem. Is there anything like this in our business coming up?

CHARLES B. CURTIS—*Answers*

I think your example is a good one, because it is a testament to the advantage of a technological solution to a threat and its inadequacy, because clearly those detection systems have been defeated. There have been some examples in which the threat has materialized into some outright harm and tragedy.

We are trying to bring scientific capability into our laboratories to bear on this problem in a more focused and budget-supported way. That is what I mentioned in the Memorandum of Understanding on Nonproliferation. We are also attempting to invest more in our laboratories' capabilities to transfer those technologies into the former Soviet Union states. This is not something for which technology or investment alone is going to provide a solution.

Essentially, the fundamental solution lies in the hearts of men and women and in their intentions. What we hope for as a people is success for our diplomatic efforts and for the progress of human nature, for which history does not give us a lot of confidence, or trust. It is obviously a combination of all things. What we can do is address those things that we can address. In the Department of Energy, that is making a more focused and coordinated investment in bringing our technological assets to bear on what we refer to as the "urgent opportunity."

JOSHUA LEDERBERG—*Answers*

Well, for the most part, it is not detection and prevention but deterrence which is the keystone of our security in the nuclear area. As long as we are dealing with other states it more or less works: Even if a state goes nuclear, it does not mean that they are going to automatically be in a condition to use those weapons, and specifically not likely against ourselves.

That breaks down when you have a kamikaze—when you have people willing to commit suicide as part of the game. Deterrence is not a feature there. When we are talking about capabilities of individuals and smaller groups, it is a totally new ball game. For some of them, nuclear weapons figures in that. Others have the industrial capacity, and that is a pretty formidable threshold. When you have the breakdown of the Russian economy, we are seeing all kinds of possibilities and the likelihood of leakage of materials. We can potentially see nuclear weapons in the hands of terrorist groups, too.

In the nuclear field there is some room for detection. There are devices that can spot weapons or weapons material in transport. It is much more difficult in the chemical and biological area—it is next to impossible. I think what happened in Japan illustrates that.

Here we have a private religious fanatical group, and the scale of it is so impressive. They had tens if not hundreds of tons of material sequestered away, and in ordinary civilian life. So I just do not see much possibility for detection.

KENNETH L. ADELMAN—*Question*

In summary, in chemical and biological concerns it is almost hopeless; wherein in nuclear, it is better. In Iraq it was not better in nuclear; it was disastrous, was it not?.

JOSHUA LEDERBERG—*Answer*

I think we had deterrence to back us up. That is, even if Iraq were to have a nuclear weapon, they would not be about to use it the next day.

CHARLES B. CURTIS—*Answer*

I would like to state the obvious, but it is an important obvious to call attention to. The nuclear danger has grown very differently and very significantly. It is not deterrent-treatable, when we are talking about a nuclear danger associated with nuclear materials insecurity that can dribble out and get into the hands of subnational and terrorist groups that are not subject to deterrence in such matters.

Russia claims to have over 1,200 metric tons of highly enriched uranium, distributed among almost 100 facilities in the Russian Federation. The Russian Federation has relied on a security system of guards, guns, and gates, but largely made up of the Communist Party surveillance mechanisms as well as restriction of movement in that society.

With the happy breakdown of the Communist Party, however, we estimate as much as a 50 percent loss of the security system on nuclear materials in the Soviet Union, as restrictions of movement and the Communist Party breakdown have occurred. This is a very serious equation when it takes only 15 kilograms of highly enriched uranium—this is against a 1,200-metric ton universe of material—to make a bomb the size of Nagasaki.

KENNETH L. ADELMAN—*Question*

So are you saying, Secretary Curtis, that you think there is a lot of nuclear material out there unaccounted for?

CHARLES B. CURTIS—*Answer*

One of the interesting aspects of the Soviet system is that because they had such a disciplined and rigorous control of movement and people, as well as guards, guns, and gates, they did not

rely (as we do) on inventory controls and technological tools such as perimeter monitoring. The reality is that the Russian Federation really cannot account for its nuclear materials security, because it has never done the type of inventory work that has been characteristic of our security system. The answer is yes. It is not accounted for in the sense that we use that term. I think it should be very worrisome to us all.

KENNETH L. ADELMAN—*Questions*

Where are the Russians' biological weapons scientists, and what are they doing now? Where are their weapons? What do we know about how their program is being dismantled?

CHARLES B. CURTIS—*Answers*

Those are intelligence questions that would have to be dealt with at different levels of confidentiality. I will quote the public statements that have been made on this matter. The Russian biological weapon program was very extensive. It continued for many years in abject violation of the Soviet Union's commitments under the Biological Disarmament Convention. President Yeltsin has acknowledged as much. It seems very likely that he is not in control of, or fully aware of, the residuals of these programs that now exist.

The estimates that I have seen would say that it is not an active production program and that it has been mostly disassembled, but we cannot be sure of that. We do not know where the stockpiles are. There is still an infrastructure. The individuals who were in charge of those activities are still on the payroll, and they are still doing something. There has been less than avid cooperation in sharing information, either about past history or current events in that residual within the military. I have talked to many of their biological scientists, people at the institutes, and people who used to work for the military in these programs. They are very open about what they had done and what they are not doing at the present time. They will also say that what is going on inside the Ministry of Defense is still a closed book to everybody, and it is to us. I think that is where we are right now.

KENNETH L. ADELMAN—*Questions*

If we had to divide the threats from the former Soviet Union into nuclear weapons, unauthorized attack; nuclear material, unaccounted for; and biological and chemical weapons, either unauthorized attack or unaccounted for; how would you stack those up? Which do you worry about most, and which do you worry about least?

CHARLES B. CURTIS—*Answers*

I would rank them in reverse order. I would worry less about loose nukes. I think the

weapons of the former Soviet Union are by and large under good protection and security, including the dismantling product of that. I would worry more about nuclear material, and I would worry most about what sometimes we refer to as "cheap nukes," or the biological and chemical weapons of mass destruction. Chemical weapons would be the number-one worry. In terms of seeing a world that is threatened more by terrorism and subnational groups than by strategic confrontation among nations.

KENNETH L. ADELMAN—*Question*

If the Tokyo attack had happened here, what would have happened?

FRANK E. YOUNG—*Answer*

I think you saw what would occur here, just the same as you saw in Japan. Japan has an excellent medical system and an excellent response. That type of action would be very similar. You would see the first few hours of chaos followed with death and morbidity and the attempt to move in and to mitigate that as rapidly as possible. You would mobilize individuals to the perimeter, as they did—to bring individuals to the hospital, to stabilize them, and to focus on doing no harm until you know what is going on. That was essentially what they did.

KENNETH L. ADELMAN—*Question*

Can we expect more and more of these as the years go on?

FRANK E. YOUNG—*Answer*

I can give you some data. Following the death in 1986 of Diane Elsroth from cyanide poisoning, there were a large number of copycats, so one always wonders and worries about copycats. The tendency to see one event followed by others is high. Having said that, I think the good news is that there is always a lot more focus on deterrence and prevention.

JOSHUA LEDERBERG—*Answer*

Deterrence is the threat of retribution, and I think we are seeing some of that right now. I think the very efficient way in which the Japanese federal police are getting after those people is setting an object lesson: This is not something that any person or group can do and expect to get off free. When you have a suicidal bent and such fanaticism, that may only carry you so far. I do not want to underestimate that aspect as well. No, there is no way to prevent such an attack. You are not going to be able to search everybody coming onto the subway system during the very crowded commuter hours.

If they are prepared—there were only six fatalities; there were only 500-odd casualties that had to be taken to the hospital. On that scale, that is within the zone of capability of a municipal health system and local resources and the police.

You have to envision the possibility (and I shudder to have to say this) of a thousand times larger level; I will not even mention a million times larger.

Suppose it had been 6,000 dead, 100,000 people in perilous condition. Your local authorities cannot begin to cope with events of that kind. That is where Frank comes in.

FRANK E. YOUNG—*Answer*

That is absolutely correct. When we look at this, our focus is exactly on the catastrophic focus—on injury—so when we play our earthquake scenarios, we are looking at those exact type of numbers that Josh deals with, because we have to be prepared to meet the local needs and to organize and mobilize the federal response.

KENNETH L. ADELMAN—*Questions*

Looking out into the future, do you see any possibility that there will be detection of dangerous chemicals? Or are there just too many? Are we ever going to get a situation where we know where they are?

JOSHUA LEDERBERG—*Answers*

Would you now spend several hundred million dollars to equip all the transit systems in the country with mass spectrometers or similar devices that could have picked up the sarin leaking from the lunch boxes in Japan? Then knowing that you have done that—well, a few years later on, there would be counter-technology, different chemicals, some other way to get past it. And, yes, one could then refine further devices, but at what cost?

So I say, what are the kinds of things that would not cost as much in turmoil, confusion, and development of anxiety, and could they have other purposes? There are things that can be done at quite modest expense: We can equip our medical facilities to have the right antidotes available, to have the knowledge there, to have a mobilizable team like the NEST teams available in this area—this could go a very long way, and for a tiny fraction of the cost mentioned. We could at least see enough damage mitigation, that we could say,"Well, at least we did that part of it."

FRANK E. YOUNG—*Answers*

To pick up upon what Josh said, that is the basics of the National Disaster Medical System.

which is a partnership between the Departments of Health and Human Services, Defense, the Department of Veterans Affairs, and FEMA. We have 4,200 private sector physicians, nurses, and support individuals that can be called into federal service in about six hours of call-up time. They are strategically located around the nation and can be moved anywhere. There are VA and DOD assets. Consequence management is where we have focused at this time. I would concur with Josh that detection, while it can be done, is at this point very expensive. As technology goes on, detection may become more cost-effective. At least for now I would focus on preparedness and consequence management.

CHARLES B. CURTIS—*Answers*

We really do not know what our technical capabilities usefully applied can produce; it depends on the applications that you would apply those technologies to. For example, portal screening type of devices are very interesting technologies under development that are molecule identification sniffers that could contribute to our security in certain applications. It would not have protected against something like happened in Japan. This strikes me that there is no fail-safe system here and you could make progress only at the margin. Experience is that people are careless, and subnational terrorist groups have been particularly careless. If you can marry up technology, hard work, intelligence, and luck, you may actually get something out of this. Certainly it is worth the effort.

JOSHUA LEDERBERG—*Answers*

It is the operational aspects of deployment, of say, screening technology rather than the technology itself. Just try to visualize how you go about doing it, the kind of delay and interference with quick movement and so on that it would impose— that is the issue more than whether you could have technology.

If you had a system where everybody entering the subway system had to stand in line, one at a time, and go through the equivalent of a metal detector, yes, there are sniffer technologies that could pick up most of the chemical agents. They would not pick up any of the biological ones, unfortunately, and we would have to foresee yet another technological device. The net result in interference with our daily lives is what I had in mind as much as the cost of the technologies per se. If these events became endemic, then, yes, that is what we would come to.

KENNETH L. ADELMAN—*Question*

I thought your point was not only the cost and the inconvenience to daily life, but also the low probability of detection of a lot of these chemicals, anyway. Am I right?

JOSHUA LEDERBERG—*Answer*

That just says there is another technical challenge, and if you were really intent—you know, made a major priority about going after them, yes, I agree with Mr. Curtis.

CHARLES B. CURTIS—*Answer*

You can put a lot of focus on this type of technology. The technologies are moving very rapidly, but there is an inconvenience in life; you balance off the risk-benefit analysis. At the present time the focus is more on the ability to respond than on the ability to detect—not diminishing the importance of detection, but looking at what the issues are when you are faced with a vulnerability and a very low risk at this moment. When you look at all the things facing us, this is still a relatively low risk per 100,000 population.

KENNETH L. ADELMAN—*Question*

Let me ask one question to Secretary Curtis. Are you putting any money into this kind of detection right now?

CHARLES B. CURTIS—*Answer*

Yes.

KENNETH L. ADELMAN—*Question*

What is the most promising area?

CHARLES B. CURTIS—*Answer*

I think this differs, and there is a combination of mass spectrographic work. I do not know how much of this is in the public domain and how much of it is not, but that is the area of promise that we are investing in.

KENNETH L. ADELMAN—*Questions*

Thank you. I would ask each member of the panel to give your final thoughts on this area: What is the role of science and technology in precluding these kind of disasters we have talked about? What words of advice would you leave us with?

JOSHUA LEDERBERG—*Answers*

I am still going to focus on remediation, because I think these are technologies which are equally important in coping with natural outbreaks of disease and those which are initiated by malicious action. We have still got a long way to go in coping with viral disease. There are possibilities of intervention; there is a considerable amount of very basic research going on that gives very exciting prospects and possibilities.

We may have to make some changes in center structures to have appropriate industrial involvement. Last year, zero new antibacterial agents were approved by the FDA. It is not been a popular arena for private investment in the pharmaceutical industry, at a time when we are seeing a resurgence of organisms which are becoming ever more drug-resistant.

The level of pharmaceutical investment has gone way down in that area. So those are the general kinds of issues of technology I would put the first emphasis on. We do need them.

There are many other elements to it, as Secretary Curtis very correctly points to what the sniffers can do. I want to be sure that we have sniffer technology in mobile platforms capable of coming quickly to a scene of disaster—within a couple of hours—and tell us at least what the agents were.

Dr. Young has talked appropriately about some very reassuring plans that are in the offing, but they still have quite a ways to go for their full materialization.

CHARLES B. CURTIS—*Answers*

I think that science and technology can contribute to security in this area, but it cannot provide it. It is an element of a multifaced effort. I want to emphasize again the component of human intelligence to this process. That has been a very important part of our ability to deal with subnational terrorism. There is a lot of very dangerous conventional stuff out there that does not have any of the exotic characteristics of what we have been talking about. It can make a big mess, and so this is just a part of a much larger picture. I think science and technology can make a very significant contribution to it.

FRANK E. YOUNG—*Answers*

Catastrophic disasters with terrorism of chemicals and biological agents is no different (other than compressed and in highest magnitude) than what goes on in nature. Josh focused on the variety of different infectious agents that have come out: We have seen antibiotic-resistant tuberculosis, the emergence of AIDS, and other infectious diseases. The platform of fundamental research to respond to those activities is there.

Ten thousand or more chemical disasters occur in the nation per year. What we are looking at in this type of a disaster is the ability to prevent by appropriate detection with the intelligence community, but then the need to respond expeditiously and with a measured response to what the local needs are and to then come in, detect what you have on the scene, devise appropriate therapies, get public information out, and clean it up afterwards. It is a fundamental discipline.

Going back to the early years of recombinant DNA, the question was: Does what we see in the laboratory occur in nature? The fundamental issue is that there are harmful chemicals and organisms around us. Those same measures of response, natural and manmade, need to be able to swiftly move in at the time of an outbreak of disease.

KENNETH L. ADELMAN—*Summary*

Thank you very much. Let me on behalf of the audience and Jane Wales and others, thank very much Professor Lederberg, Secretary Curtis, and Dr. Young for coming. It was a wonderful, wonderful discussion, and your opening remarks were short and crisp. I thought the discussion was very good. Let me on behalf of the panel thank everybody here in the audience. The questions were outstanding; looking over the list of participants, it is a real honor for all of us to speak to such a wonderful audience. Thank you very much.

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SESSION FOUR

Technology Leadership to Strengthen Economic and National Security

Seventh Panel Discussion

W. BOWMAN CUTTER, ***Chair***
Deputy Assistant to the President for Economic Policy

Since Vannevar Bush wrote *Science: The Endless Frontier,* we have had a science and technology policy that focused on basic research and on mission-oriented technology. The policy worked well for over 40 years. We had a well-integrated science, technology, and innovation system that was related to how our economy worked and to our place in the world.

We had a dominant corporate position in virtually every sector of the United States economy—a dominant global position. Our defense establishment had a dominant role in terms of United States research and development. Diffusion of ideas around the world were slow. We had major corporation and public laboratories with clear missions, and particularly with respect to corporate laboratories, a sufficient economic margin to make different kinds of bets and to make long-term bets.

There was a clear system, and it worked. The public sector had a clear, major role, and made a substantial impact. If you take computing as an example, government-sponsored research and development played important roles in time-sharing, graphics, networking, work stations, risk computing, and parallel computing.

Now the system, the model, the paradigm has changed. Global industries are all now vastly more competitive. Defense is not as dominant a factor. There is as least as much spin-in of important ideas as there is spin-out, or there ought to be. Diffusion is vastly more rapid.

This *not* a bad picture. There is in this economy—and particularly in one as competitive and as open as the United States economy—enormous pressure to innovate for productivity. We have created whole new institutions like the venture capital industry. The United States system that we all can dimly see today will probably enable us to innovate more, mobilize more investment, and achieve faster and higher returns that the previous system did.

This is going to be a different model. The commercial sector is going to cater to national security and dual use in the Technology Reinvestment Program (TRP). Long-term, applied

research and development is going to matter. Joint ventures across an industry's value change are going to matter and, hence, the way in which both the TRP and the Advanced Technology Program (ATP) function.

We think the Clinton technology policy is an effort to think systemically about the system of innovation for the United States, the system that is right for the economy of the next 40 years for a turbo-charged, information-rich global economy. It is necessarily a work in progress, and it will evolve. We look forward to the debate, but we ask that our critics try to think as systemically as we have tried to.

I would now like to turn to Paul to ask him to start the panel.

PAUL G. KAMINSKI
Under Secretary for Acquisition and Technology, United States Department of Defense

Thank you, Bow. I am pleased to be with you all today to share with you some of my perspectives on technology development and utilization by the Department of Defense. Our predictions about where we are going remind me about the story of the late Supreme Court justice, Oliver Wendell Holmes, who once found himself on a train, but he could not locate his ticket. The conductor watched, smiling at the 88-year old justice while he searched through all of his pockets without success. Well, of course, the conductor recognized the distinguished justice, so he said, Mr. Holmes, do not worry. You do not need your ticket. You will probably find it when you get off the train, and then you can mail it back to the Pennsylvania Railroad. Well, the justice looked up at the conductor with some frustration and said, "Dear man, that is not the problem at all. The problem is not where my ticket is. The problem is where am I going?"

Our frame of reference in the Department of Defense is changing dramatically, and like Justice Holmes, it is sometimes difficult to know where one is going in such a period of great change. The DOD's technology strategy is really shaped by three dramatic changes that are occurring in today's environment—changes which I am looking at as fundamentally driving how we are going about technology development and utilization in the Department of Defense.

The first of these changes deals with change in post-Cold War needs. There is a transition in why we buy what we are buying for our major programs today. This environment can be characterized sort of in simple mathematical terms for me. If we look at the mean value of the greatest threat that the United States is facing today, the mean value of that single, monolithic, pre-Cold War threat has been reduced dramatically. And as a result, we are taking down our forces in response to that, taking them down by about a third. The irony for us in this situation is that the variance of the threat that we are facing in the external environment is not down. It is actually up considerably in this environment.

This is giving us a more difficult external environment to plan for. It is the reason why you see Secretary Perry placing so much emphasis on the readiness of our forces because, in fact, as we look back over the past several years we find that our deployments are actually up by about a third dealing with the greater variance in our frame of reference.

As we have taken our forces down by about a third, we have taken our major investment accounts down even further. And this has caused what has come to be known as our pause in procurement. We have taken our procurement investment down by about two-thirds.

We have been able to take this procurement pause as a conscious strategy, recognizing that as our forces have come down what we have done is kept the new equipment and removed the older equipment from the inventory. This is a fine strategy during the transient period in which forces are being reduced.

As the forces come to a steady-state level we will need to re-initiate a procurement program again. So we are in a period of pause where we are looking to create entry ramps to be able to begin the development of new systems for the future. So this a very critical time in the Department's science and technology and research and development program—to be able to create entry ramps for the new systems that we will be proceeding with in the future.

That leads really to the second change. That is a change in the way that America fights in the future and what weapons systems we will be buying. I do not anticipate that across the board we will be replacing platform with platform. We will not be doing a complete recapitalization. The generation of new entry ramps gives up the opportunity to do some things differently in the future.

This change is captured in some circles by what is described as a revolution in military affairs. It is driven largely by the desire to make use of a wide range of new technologies to improve fundamentally our battlefield situation awareness and to shorten the time that it takes United States commanders to bring effective force to bear on an objective. The goal here is for United States forces to be able to exploit what is happening in the information revolution to achieve dominant battlefield awareness. What I mean by that is to know everything that is going on in a battlefield that might be 100 kilometers by 200 kilometers in size.

The second component, from a command and control perspective, is to be able to close the loop to achieve a dominant battlefield action cycle time—of which we can cause indirect fire systems to have a shorter cycle time than direct fire systems have today.

The third transition that we are dealing with is a change in the way America develops and fields its future weapon systems. This I would describe as a resources transition and one that I am promulgating very strongly in the Department in my position. This is aimed at how we

buy our weapon systems, placing far greater reliance than we have in the past on commercial sources to ensure that the Department fields technologically superior weapons systems at an affordable cost. And cost is something I want to underline.

As I look back at the paradigm on which the Department operated during the Cold War, cost played a much smaller role than it would be playing in the future. We operated in a situation in which we had very good intelligence information on what our primary adversary was doing. We had information about the weapon systems that we would be faced with and the future threats. We had good information on the characteristics of those systems and even on the time over which they were going to be fielded.

We could, in a sense, develop what I would describe as an F equals MA response to define the system that was required to counter that threat system. We could tell a very convincing story to the American people and to the Congress about what was needed to counter that system and when it was required.

In this environment performance was the sine qua non. Cost was whatever it had to be. It was a fallout. It was a dependent variable in this process. In the environment that we are in today, that is fundamentally changed. Cost is an independent variable in the process that we are managing in the future, and it is another reason that we are looking so much more strongly to commercial sources where cost is the key.

Over the past 30 years the evolutionary change in the industrial base that supports DOD has really been no less dramatic than the changes in the world order since the end of the Cold War. While DOD purchases have declined, America's commercial markets have continued to expand. In aggregate terms, commercial industry passed DOD in research and development spending way back in 1965. The disparity between DOD and commercial sector investment and research and development has been growing wider ever since.

This difference means that this nation's technological momentum is no longer driven to a greater extent by defense activities than commercial—in fact, quite the opposite. In this environment the Department of Defense has no choice but to move from dealing with separate industrial sectors for defense and commercial markets, but instead to move to an integrated national industrial base. And that is what we are about.

Leveraging commercial technology advances in this environment to create military advantages is critical to ensuring that our equipment remains affordable and the most advanced in the world. Now underpinning this framework is a fundamental, dual-use strategy. Here is where the Department's dual-use strategy and ARPA's Technology Reinvestment Program (TRP) are playing a significant role.

The intent is to leverage commercial technology advances to create a military advantage,

ensuring that the equipment we have remains the most advanced in the world and the most timely in terms of a fielding cycle time. Our objective is to marry the momentum of a vigorous, productive, and competitive commercial industrial base with the unique technologies and system-integration capabilities provided by our defense industrial base. A tighter linkage with commercial markets can shorten the cycle time for our major weapon systems as well as reduce the cost for inserting technological improvements into that system.

In this environment the Department can no longer afford a 15-year acquisition cycle when a comparable commercial turnover is less than 3 or 4 years. The issue here is not only cost but that the lives of our soldiers, sailors, marines, and airmen may depend on shortened acquisition times as well, because in the global market everyone—including our adversaries—has access to this growing commercial technology base. The military advantage will go the nation who has the best cycle time to be able to envision where this commercial technology may be applied, to capture it, to be able to integrate it into the major systems, and to train our forces to use it effectively. That cycle time is going to become more critical in the future.

In this kind of environment the system engineering and integration skills that have been developed in the current defense industrial base are going to end up becoming more important, not less important, in terms of being able to apply, to add software application glue to various hardware technologies or information system technologies that have been developed for commercial applications.

The Department's dual use of investment strategy is based around three main pillars. The first pillar involves leveraging the commercial sector's technology-based investment. Commercial industry is now the technological agent of change in information systems, telecommunication systems, and micro-electronics. Portions of the Defense Department's program in the past use to lead in aspects in each of these three sectors. That is no longer the case. The commercial markets are leading in each of these three arenas.

Our dual-use program is now tailored to leverage off the commercial technology base so that the taxpayer does not have to pay for the entire investment. It is easy to say this. It is really quite a bit harder to do it in the Department, because we need a cultural change to cause people from being accustomed to developing everything that they use on their own account as opposed to capturing what is being done commercially and applying it to defense purpose. That is a major cultural adjustment process that we have in place, and it will take us some time to actually bring that about.

The second pillar in this strategy is the dual-produce concept. Here the Department is placing a great deal of emphasis on taking advantage of commercial production to manufacture defense equipment. I am not so naive as to believe that we are going to have major defense systems being produced on commercial lines. On the other hand, we have a great opportunity

to make much broader use of commercial production of key subsystems and components that can be adapted and integrated into our defense systems, resulting in a warmer commercial production base, lower cost, and greater capability. Again, the system engineering and system integration skills will be key to successfully capturing and applying these commercial technologies.

The third piece of this strategy calls for the Department of Defense to make those investments that are needed to facilitate use of commercial components in defense systems. The objective here is to have components that are, in fact, designed for dual use. This pillar recognizes that our program of acquisition reform and dual-use technology investments are not by themselves sufficient to ensure use of commercial components.

A good example of the implementation of the Department's dual-use strategy is our investment in an electronic packaging technique—in fact, techniques in general. The particular technique I would illustrate is our work in something called Multi-Chip Modules (MCMs), modules that are used to capture and package their die and integrate them in effect at a broad level of integration on a chip.

DOD was the early leader in advancing this technology in the late 1980s and early 1990s. As we look to the future we can expect this MCM technology to find its way into more and more of our defense equipment and into more and more of our commercial equipment as well. The advantage of this MCM technology is of critical importance in military applications like smart weapons and commander control systems. These advantages will also be important for future leadership in portable and mobile communications and information processing for both defense and commercial applications.

The primary factor that has been constraining the use of technology has been cost. MCM technology today is still too expensive for many applications. The market is very small. Our studies, however, show that we can expect unit costs to come down by about a factor of ten or more as we move to large-scale production. Our strategy to make co-investments with commercial applications to get the costs down.

In 1990 when we began there was virtually no commercial market, and the entire market was taken up by the Department of Defense. We are now seeing significant growth in commercial applications so that today commercial MCM sales represent about half of the total market. Our projection is that this will grow to about a $700 million a year market by the year 2000, at which point the DOD share will be less than 10 percent.

As an illustration of the power provided here, I would illustrate for you our experience in global positioning system receivers. When the Department started out in this arena we developed a 17-pound Global Positioning System (GPS) receiver that cost as much as $35,000 in the very early rounds at the lead of production. We later went to commercial, off-the-shelf

fabrication of this receiver, and we were able to reduce the 17 pounds to 3 and the cost down to $1,500 per unit in large runs.

The MCM version of the GPS receiver is here in my hands. This is about an inch and a quarter hybrid MCM chip. This is a six-channel Global Positioning System receiver. All it needs to work is a display and an entry device. In large production lots this would be produced for $400. You can see the sort of edge this has for DOD, not only in the packing for us to get functionality in a small place, but also for the cost.

One of the programs on the forefront of our dual-use technology efforts is the Technology Reinvestment Project (TRP). One of the most important features of the TRP program is the element of cost sharing, not only leveraging the Department's resources, but also providing strong indication of the commercial potential for the project with the associated commercial matching investment.

The second key piece of the TRP process has to do with the fact that it is competitive. Particular earmarked programs are not being added to the Department's budget. Competitive forces are brought to bear, because the best rises to the top of the program.

TRP projects allow us to enhance our military capabilities by leveraging the investments and research and development made by industry and bringing industrial creativity to bear on problems of interest to the Department of Defense.

For example, one TRP project involves the use of composite materials to construct bridges. I use this example because it is one that has been criticized for the fact that bridge building would not seem to be a vital defense technology. Despite the criticism, this particular product does have important military applications. The Army Corps of Engineers is a partner in this project, because their technology may be used for tactical mobile bridges which require minimal side preparation. That is not the whole issue here.

More broadly, composite materials are extremely important for defense—especially with respect to our future aircraft and missile programs. Defense procurement thus far has largely sustained the whole production for composite materials. As the industry has come under severe pressure as a result of this procurement pause that I have been describing, we are in need of a broader base for a composite technology. Without an adequate base of composite manufacturers, higher costs would put future aircraft and missile systems in jeopardy. Hence, the composite bridge program also seeks a way to sustain and expand our overall production base for composite manufacturers.

If the project is successful and composite materials can be used for large structures like bridges, production volumes will increase and costs to DOD will come down accordingly. I have been in my job now for about five months so I can say that the TRP program was not

invented on my watch. I must say that if it did not exist today, a program like the TRP program would be precisely what I would be looking for to better leverage the Department's position by applying commercial technology not only for performance but for lower costs in the long run.

In summary, given DOD's new budget realities and the amount of research being conducted by commercial firms, we have no choice but to take an innovative approach to technology development and utilization. The examples I have used show how a dual-use strategy is improving the quality of our systems and reducing the cost of those systems, while updating our overall response to the adjustments we need to be making in the post-Cold War world. If we are to have assured and affordable access to the technologies needed for our future military systems, then we must reach out and exploit the technological advances being made in the commercial world. I believe that the strategy that I have outlined today is a prudent way to accomplish that goal with minimum cost. Thank you.

MARY L. GOOD
Under Secretary for Technology, United States Department of Commerce

I want to make a few remarks before talking about the ATP program in specifics. You will hear a little bit of a repeat as we go through some of these things from time to time, but I think that in some ways it reinforces what it is that we want to say.

If I could put the Clinton Administration's thoughts on why our science and technology program is as it is, we really do believe that the nation's science and technology initiatives are central both as an investment in the future and as the key to our continued economic security. As Paul has pointed out, that also that means that it also is a partial key to our security as well.

If you look at history in the last century in the United States, I think it is really rather easy to make this case in a rather straightforward way. I would like to say a few words about some of the government-sponsored programs in the past which have made such major contributions to these. Bow pointed out just a few, but I would like to target at least three of those which I think are so very important.

First of all, if you look at defense and space missions that we have had over the last 50 years, out of those have emerged the aircraft and aerospace technologies which have put us in a leadership position around the world—the electronic businesses which we all know about: electronics, computers, satellite communications, and advanced materials. All of these helped create our world-class computer, telecommunications, and aerospace industries.

If you look in the public health research arena, we have seen a flow of miracle drugs and miracle medical therapies that really are the heart of what is known as our pharmaceutical

industry and the biotechnology industry in the United States. That science base is the backbone of the biotechnology industry that we have today.

The fundamental science support that we have developed in our universities has delivered two things, and I think we want to be sure that we keep both of those in mind: The first thing that is has delivered is the best qualified scientists and engineers in the world, as well as the science base for the technological developments that we want to talk about.

Now, moving to the innovation system, our country's system of innovation still remains today among the best in the world, and most of us believe in some ways it is still the best. We still lead all other countries, if we just look at the total dollars that are spent on our research and development budget. You need to scratch the surface a bit and try to understand what is really going on in the United States research enterprise today, and what has been changing over the last 10 years. When you look at that, what has really been going on is change in a very fundamental way.

In the United States industry the mix of research and development activities has shifted. From the large semi-autonomous central laboratories and long-term exploratory research toward business units and business goals. We find that our industries today are devoting anywhere from 80 to 90 percent of all of their research and development resources to shorter-term product development and process improvement.

This shift to the near-term is being driven by the competitive pressures to downsize and streamline, move research and development closer to the customer, reduce costs, and improve quality. Moreover, limited availability of capital causes companies to focus on maximizing returns on existing investment and projects that achieve quick pay-backs.

The nature of the technology itself is also driving investment away from the mid- and long-term research and development, and that has to do with the issue about product life-cycles, which Paul has mentioned. These product life-cycles are getting shorter. For example, in the electronics industry the lifetime of a new model of personal computer today is less than two years, and a competitive player in commercial high technology may have to fund and manage three generations of technology simultaneously, one in full-scale production, one in pilot production, and one in manufacturing process design and development.

The second issue is that cost and complexity of technology development are increasing. It can take $350 million to find a new drug and bring it to market today, and that is one which has minimal problems associated with bringing it to the market. It can be much higher than that if there are unusual issues.

It is also true that things like manufacturing facilities, particularly in the electronics market, for example the price of a tag on a semiconductor fab today can exceed $1 billion, and the

next generation may run as much as two or three times that. Moreover, these technologies are increasingly multidisciplinary in nature. In short, cost and complexity may exceed the technical capabilities and financial resources that any individual firm can muster.

Third, today's enabling technologies have multiple uses. The potential applications can exceed the product portfolios of most firms, and an individual firm may not be able to justify the costly investment in research and development based on its segment of the technology's potential market.

This shift in research and development funding toward the near-term represents a rational response to today's competitive pressures and the nature of technology development. I think it is necessary that we understand it is a rational response to that. It is not an irrational response. Each company must make resource allocation decisions, based on its particular circumstances. Such decisions are not an area for government's attention: That is something we want to keep in mind. We are not talking about industrial policy in the usual sense, because the industrial sector is responsible for the production of competitive products and processes. The government cannot fulfill those obligations and must let the market drive where the private sector's technology resources are applied.

However, that shift in focus is cause for concern, because we are beginning to see a gap in the innovation system in funding for mid- and long-term research and development which threatens to dry up the wells of the new technology from which all of our companies will have to draw in the future to remain competitive.

Today we must rethink how the system works and what is required to optimize it for maximum production of high-quality jobs and wealth creation in the United States. We believe that we have no choice but to engage industry in partnerships to address the research gaps that we see emerging. If our public research and development investments are to continue to pay the kinds of economic dividends that we have enjoyed in the past, the government must try new ways to manage its own technology-related assets.

However, we must take a systematic approach, and I appreciated Bow's comments with respect to the system issue. We have to embrace a portfolio of initiatives that address the innovation system as a whole. Such an approach should provide the connections between the federally funded research and development base and infrastructure in government-peer reviewed research, mission-related technology development, and a whole range of policies—with the major investment made in technology by our industrial sector.

The linkages that we are talking about can really be of two kinds. The first is where the government really plays a catalytic role in encouraging cooperation within industry and in establishing a range of policies that promote United States innovation and competitiveness.

The second is where the government can be a partner with industry in planning public research and development investments, in joint research and development ventures, and in technology deployment. The graph that I have put up on the viewgraph points out the programs that we view today as partnership activities within the government sector. They are in a sense the bridge between the basic, fundamental research and the mission-related research that we do in the government and the commercially-competitive research and development which is done in the industry.

I am not going to speak to all of those programs. We would take the rest of the day to do that. The total cost in the 1995 budget of those bridges, if you will, including the Advanced Technology Program (ATP) and the TRP program, which are the two we are focusing on today—the whole cost of that package is about five percent of the government's budget. It seems to us that this kind of an expenditure to more rapidly move those technologies for which the $70 billion is being spent into the commercial market is a bargain if we can make them work.

Let me talk specifically about the ATP program, which is the one that I want to spend a bit of time on.

This program has generated a great deal of attention and, in fact, over the last few months it has had more attention than we really need or welcome, but be that as it may, and as Bow says, the discussion has been engaged. So let us talk a bit about this program and where it is going.

First of all, the ATP is an industry-driven, cost-shared vehicle which is aimed at doing what most single companies would not do, and that is invest in long-term, high-risk technology development before it is clear what the final product and size of the market may be. It is not product development, and it is not commercialization, but it is that gap between the science ideas and the ability to look at what the actual output technology might be that will become commercial products.

It devotes the bulk of its funds to strategic technology development programs which have aggressive, well-defined technology and business goals, and they involve interlocking research and development projects that complement and reinforce each other.

What I want to do is look at a couple of examples. This chart tells you what the budget for the ATP has been. It started in 1990 with a small $10 million budget which was used as a single pilot for what we call a "free-for-all competition" where you could submit any of your good ideas for long-term generic technology development. In 1991 the budget went to about $37 million; in 1992 it went to $49 million. It became apparent that we really needed to have some mechanism for better focusing this program, because we ended up with many more

proposals than we had any chance of funding in the program itself. The issue is how to best utilize the funds that we have.

We have chosen these focus programs which are on the next chart. These were designed by inviting industry to spend a lot of its own time and effort developing road maps and technologies gaps for industries as a whole. The choice here was generated out of better than 600 white papers that came in from the industry alone.

One of the big pluses of this program may very well be a metric which is very difficult to defend in today's hard metric environment, and that is that it has brought more industry people in to talk to each other than any program I think we have ever devised. It has provided a forum for big businesses talking to small businesses and small firms talking to other folks about the ideas that they have.

The first focus program was done in 1994. Let me speak to one of these so that you have an idea of why these are good choices. We always get asked, "How did you make this decision?"

First of all, the decision was really based on this absolute, wonderful, bottom-up contribution from the industry itself. Let us look, for example, at the DNA diagnostic one, which is at the top. We know, for example, that the biotechnology industry has been a very research-intensive industry in the past. Commercialization has been relatively difficult in many cases. At the same time, the Human Genome Project in the basic science portfolio has had a lot of expenditure, and today has great potential to fuel new product development and commercialization. The problem is that the methods, instruments, and data-handling protocols were not part of the basic science curriculum, and therefore that needs to be done.

For example, DNA analyses and sequence interpretation will have to speed up by a factor of 10, and the cost will have to fall to 1/10th to 1/100th of the present price tag, if it ever has a chance of being a commercially viable product.

The goal of the ATP program in DNA diagnostics is to develop cost-effective methods for sequencing, interpreting, and storing DNA sequences for diagnostic applications. When you look at that and understand what has to occur, development of the diagnostic tools here requires a multidisciplinary team—technical resources that many companies by themselves cannot muster. Individual companies are really hesitant to invest in the development of these tools, because a number of technical paths must be explored, any one of which could turn out to be the most suitable. So betting on any one of those technologies is all that most companies could hope to do, and even that would be a gamble. The ATP program reduces and dilutes that risk without distorting either the market or the pricing mechanisms, because it is clearly ahead of the market.

If you look at the second group of focus programs, let me pick again just one—and this one I admit I picked because it is the one I know the most about.

This one is the core technologies in chemical processing, which is represented up there by catalysis and biocatalysis. If you look at the chemical processing industry today, it is the only industry, other than aerospace, which has had a continuous high balance of trade for the last 30 years. It is actually made or not made by how well it uses catalytic processes and whether or not it will be able to involve its processes in the biocatalyst in the years to come.

Breakthroughs in this industry could lower operating costs associated with energy, raw materials, and environmental improvement: Decrease capital costs for investment in new processing technologies; and speed discovery of superior processes and particularly utilization of new chemistries that would advance technology competitiveness.

The issue in this particular technology is that if you look at what the industry is doing today, we have technologies here in the science base that have major applications which are in no way being utilized. For example, we have all of the science that we know about in molecular design. When I go to the industry I still find that 90 to 95 percent of the investment in catalysis-related research and development is still engineering-driven and targeted to near-term improvement.

There is less than two or three percent that is presently being devoted to the atomic and molecular design of new catalysts which have higher specificity and would actually impact this process. The focus here is for companies which would be willing to invest in that kind of a program for catalysis or biocatalysis, and it is the first time that this industry has ever really participated as an industry in government programs of this type.

Many of these technology initiatives are young. They have long-term goals, but they are beginning to bear some fruit. For example, early results in a couple of studies that we have actually been able to do indicate that the ATP program is improving the nation's technological capabilities.

First of all, they have expanded the research and development activity in many of the companies that participate, particularly in high-risk long-term research where we have the potential of high payoff. We have cost and time savings by having people work together. Many of the proposals that have come into the ATP are in a consortia form. We have a few companies that have improved their competitive standing. They have put together really valuable strategic business alliances, and the acceleration of the technology development is unique in many of these projects that are now underway.

Let me just say a few words about the design of these technology initiatives, because they are really designed to make a difference in the long run.

They are designed to create a federal technology enterprise that is more responsive to the economic needs of the nation. We would like to deliver in these partnership arrangements more bang for our public and our private research dollars. We would like to speed up the technology development and deployment to keep pace with today's short product life cycles. I think Paul is absolutely correct. From hereon the race of who wins will not be necessarily who has the best technology, but who uses it in the most effective way in the fastest way. It really is going to come down to a matter of speed and utility, and not so much just the total technology pool.

We also would like to build stronger, broad-based technology capabilities in the industry, and establish a modern manufacturing infrastructure.

In closing, let me just say that during this century the United States has built up the strongest base of scientific, technical, and business assets that the world has ever seen. These assets have served as a guarantor for our national security.

The Administration has taken important steps toward the future by setting forth a policy which recognizes that technology is the engine of economic growth, that the private sector is the agent through which we will achieve that growth, and that government can enable the private sector to effectively fulfill that role, rather than being an adversary. Thank you very much.

CRAIG FIELDS
Vice Chairman, Alliance Gaming

Thank you. A colleague called me yesterday to give me his summation of the meeting, because I was not able to be here for the first day. He termed the activities "A New Age National Security," and proceeded to make some humorous remarks about some of the presentations. I actually thought that this was a compliment because, in fact, we are in a new age. We cannot quite tell the difference between peace and war. It is not now black and white, it is shades of gray. It is not so clear who are friends and who are foes; again—not black and white, but shades of gray.

There are lots of different kinds of aggression other than direct military aggression—indirect, trade, and so on. It is not so clear what a country is anymore, and companies are more and more global. All of those concerns are the focus of this panel. We want to talk about what I will term "New Age National Security" from a technology point of view.

I have been in industry for about five years, and these issues have been on the edge of my consciousness but not in the center; so re-engaging a bit in anticipation of this meeting, I have to observe that there does not seem to be anything new. The exact same arguments are

coming to the surface again, just as they did in the late Eighties and did periodically before that. It is not really surprising. There have been about 2,500 years of known debate on the proper role of government, and there is no reason why we should start coming to agreement now.

Nevertheless, I would like to pursue some general remarks, and then one concrete suggestion about how we might change the nature of the debate that might be a little more productive.

There are three arenas of argumentation and discussion: One is politics, and Bow addressed that. Another is practice—how well things are going. The third is principle—what we should be doing.

A personal observation is that it is about 50-50 between politics and principle, and about 0 on practice. I do not have anything to say about politics here, because it is pretty straightforward. I do want to make some remarks on principle, the first being that we can constrain the argument on principle by just noting what is *not* going on. I do not see much effort from this Administration—perhaps none—to subsidize failing companies selected by politicians. I do not see effort to pay for developing and advertising actual products of companies. I do not see this Administration paying for land to be given to companies for their factories or paying for the factories. Yet there are cases, more than one, of all those things going on elsewhere around the world in the past. The debate can be focused just on technology, which should be a much more innocuous part of the discussion.

I want to start with DOD, but later branch out into issues concerned with Commerce, and then reflect a little on some of the things I have learned in industry in the last few years.

The most important thing I have learned is that quality companies, the Fords, the Motorolas, and many others, attend to the health and the fitness of their supplier base. They are realistic; they realize that things are not just going to come out all right if they sit back and wait and hope for the best. They spend money to assure that products are affordable from their suppliers. They spend money to assure that quality is high. And they spend money to assure that there are suppliers, that they are not faced with monopoly supply, and that there is not egregious supplier conflict of interest, namely, suppliers that have loyalties to their competitors or might even be their competitors too much and too often.

These are balancing acts. Again, it is not never black and white. You have to attend to these issues. You have to manage your supplier base. With that said, why should not DOD?

The focus for this panel is on technology, and I want to talk about technology and the DOD supplier base only. The other issues may or may not come up later.

The fact is that for many decades DOD has wanted things that no supplier knows how to

build or how to just supply. You simply did not find stealth aircraft a number of years ago as catalog items. You did not find tanks with reactive armor as catalog items. It is good to have these challenges, because the fact is that the best technology comes from practical challenges, not from working what I call "in the abstract."

If any of you remember your high school Russian, "povtoreniye - mat' ucheniya." Necessity is the mother of invention. I really believe in that.

DOD in fact needs things that people cannot build, and let me assert that a sensible CEO is not going to invest to produce those catalog items on Spec, because DOD is an unpredictable customer; Congressional funding is unpredictable; it just is not a good business investment. Hence, there is a long history of DOD investing in technology development in order to mitigate that risk—to make things possible, available, that otherwise would not be possible, would not be available.

Within that context, it seems to make absolutely perfect sense that if you can invest in technology that is not unique to the military: It is simply better for the Defense Department. It leads to lower-cost things and better-quality things than if you invest in technology that is unique to Defense. That will not always be possible, but it is frequently possible; it is commonly possible; and it is relevant and important for Defense—good for Defense—quite irrespective of whether that dual-use technology also helps the civilian economy.

Frequently, commonly, often it does. We should be very careful about what is advertised. The basic thrust should be, and is, in the vast majority of Defense technology investments I know—the dual-use ones—do in fact help Defense. So this debate on the funding of dual-use technology seems to me to be a little strange from the Defense perspective.

I want to branch out and talk about some issues that relate to both Defense and Commerce, and say that for both customers, funding technology is only one way to get it. There are a lot of other ways to get it. Mary, you alluded to some others. And let me assert that I actually think some of these others may be more productive and fruitful than directly funding technology, notwithstanding the value of funding technology. **[End of Tape]**

We have to get over the view that we will be 100 percent independent in everything. In fact, every company knows that you manage mutual dependence; you are not independent in everything. We can manage that mutual dependence. We have to get over the view that we can stop things happening elsewhere. The fact is, it is a lot better for us to run faster than to try to get others to run slower. These are attitudinal issues. I think they are widely shared at the moment within the Administration. And there is a lot of opportunity in the international arena for getting technology, other than just funding it.

I would say that, as always, there are dangers. I have alluded to some. If we really are going

to engage in dual-use activities in a widespread way—and if there is essentially instantaneous dissemination of everything everywhere—it is pretty hard to keep up the principles and philosophies that we have pursued for the last few decades, namely, achieving military superiority by technological superiority. You have to deal with other issues. Speed is one issue, and another is to be very thoughtful about where you are going to have strategic necessities and where you are going to have strategic differentiators.

For strategic necessities, you know you absolutely have to have it—but you expect others to have it too. For strategic differentiators, you know you absolutely are going to have to have it—and you really do try to stay ahead. Every company has to make those investment decisions. So does the Government.

The second area that I wanted to highlight, in addition to international technology cooperation as a means of getting technology above and beyond just funding it, is infrastructure. There are so many things that are in infrastructure. One is the national or global information infrastructure, which I think really promotes the development and dissemination of technology.

Some people seem to think that promoting the NII is really a code word for promoting the electronics industry. To me, that makes as much sense as believing that promoting the Interstate Highway System is a code for promoting the concrete industry. The fact is, that really is not the case. NII or GII helps all industries in a fairly even-handed manner, and it helps industries develop and employ technology.

A second aspect of infrastructure that is incredibly strong in this country, almost uniquely so is the venture capital industry. The government's role is to make sure it stays that way by keeping out of the way.

The venture capital industry is a tremendous asset in this country. It means that people can get a start, by and large. I might add that there is a social sort of halo around the venture capital industry, which is also important. In other words, people can have a failure and keep going. You do not find that in many other countries.

The last aspect of infrastructure that I wanted to highlight is the area of standards. Standards actually can advance technology. We have a smart community in this country that knows how to deal with standards, both formally and informally, ad hoc common specs, and I want to separate the standards issues into two categories just for simplicity. One is inter-operability. When the standard interfaces, things explode. We see that in the computer industry. The other is issues of quality and performance. I am really impressed with the emphasis on quality that came from the Baldrige Award, the ISO 9000. I believe restaurants are better because of the Michelin Guides. In fact, the government can play a real facilitating

role in dealing with quality, performance, and awards. Public relations motivate people, just to bring it down to the basest level.

With all that I have said, let me emphasize that there is nothing new in my remarks. I am the penultimate speaker. There are few crumbs left on the table, but had I been the first speaker it would have been impossible, I think, to say much new in the area of principle. So I would like to make a suggestion and to shift the debate a little away from principle to practice: Namely, is anything actually working, and how well is it working?

If TRP, ATP, and other ARPA programs exist, there is a tacit assumption that things are not fully working well. Actually, I have a good basis to believe they are. You cannot argue so well with success. What are the expectations set by these programs? What are the incentives for achieving success? How are we assessing performance? How well are they working? I think these are the right concerns; they are the concerns of most companies. If the company I work at now spent 100 percent of its time discussing the principles of its operation and zero percent discussing whether it was succeeding, that would not lead to a good outcome. For both the Congress and the Administration, I think this would be a very healthy shift in emphasis. If there is any spin-in from the industrial sector, I would like to say it is this business practice, not any particular technology. Thank you very much.

Seventh Panel Discussion Questions and Answers

W. BOWMAN CUTTER—*Questions*

Will adversary nations not see that information warfare techniques will be the best way to counter United States strategy? How vulnerable are we to information warfare? What is being done to defend our information system? With history as a guide, will we not someday need information warfare arms control?

In view of the diminution of the threat from the former Soviet Union and our record of having new systems not able to meet performance requirements, what is the hurry to shorten the cycle for major weapons programs? Why not make sure technologies work?

PAUL G. KAMINSKI—*Answers*

Let me comment on the last one first, Bow, if I may. The first comment is the two are not mutually exclusive, that a shortness and having things that work are not necessarily at odds. A key and reasonably new tool being used by the Department is this program called Advanced Concept Technology Demonstrations. The emphasis here is on the word "concept," which, as we are looking to do some things in a different way, the idea is to built a prototype system, to infuse the prototype with the key features that need investigation and evaluation, and before building a large number, to field that prototype system and get it in the hands of

users. We so often in the technology community underestimate how creative users can be in applying some of the equipment that is developed. I would also say in my own experience, very often the critical performance of the system is determined by how creatively it is employed. The idea of this Advanced Concept Technology Demonstration program is to field a small number of prototype systems, get them in the hands of the user, and then there are three outcomes that can happen.

The first outcome is that this is not very useful, and that is the end of that: we have made a fairly small investment by fielding the prototype system.

The second outcome can be that this is extremely useful, and we want this in large numbers. The plan then is to jump-start our acquisition system to put this in, not at a milestone 0, but at a milestone 2 kind of phase, where we are ready to complete engineering and development and put this into production. Now the risk ahead is the risk of being able to produce this in numbers, not the risk of whether this will work operationwise.

The third potential outcome is that this is not quite good enough, but please let us keep the prototype system because it is useful. That is not a bad outcome for some of our applications—in fact, for a number of information system applications.

Bow, let me take a whack at the earlier question, and let Craig comment as well.

There indeed is very high leverage to our information systems in terms of having platforms that are fielded today. One of the ways to get so much more out of those platforms is to equip them with what I would call "off-board" information, information driven from other sensors to provide a situation awareness, a picture of what is going on. That is very valuable to us. As it becomes clear to our adversaries how valuable that is to us, they will be looking at various means to remove that capability for us. So the information warfare aspects are very important.

This is a complex field. I think we pay significant attention to it in our military operations. We should be and will be paying more attention to it in our military operations. But I would note another issue that was not addressed in the question. It is that the information warfare is very broad. It is not limited to our military operations. It extends to our whole national fabric, and it is a complex issue that we are going to be dealing with as a country in many ways.

CRAIG FIELDS—Answers

The only thing that I would add on the question concerning information systems is that even in the narrower focus of military affairs, the breadth of systems that are related to battlefield success is greater than most people think. So it is not just Command and Control systems, it

is not just embedded systems in various aircraft, the weapon systems and so on, but it is also the systems of logistics, the systems of personnel, and the systems of medical support. It is not only systems that are owned and operated by the Defense Department, but it is the employment during wartime of civilian systems—plain old telephone systems. It is a very broad issue that has to get faced. It is one that DOD is facing jointly with NIST. They have to work hand-in-hand on this. As long as we can maintain a position ahead, which is true today, I think we can do quite well.

W. BOWMAN CUTTER—*Question*

How do you counter claims that fiscal policy, or any tax credit, capital gains, investment tax credit, etc., is more effective than federal technology partnerships in terms of stimulating technology innovation and commercialization?

MARY L. GOOD—*Answer*

The argument of whether you do "either or" is a false argument from the beginning. The tax infrastructure in the United States has always been used to focus on things we would like to have happen. For example, the whole issue of home ownership is really based on being allowed to deduct your interest rates from your taxes. Tax structure has always been used to focus on outcomes that the general public would like to see. Tax policy is very important. You can design a tax policy that is very inhibitory to private investment, that will be very inhibitory to private utility, and so the tax structure is extraordinarily important. It needs to be designed to the best of our ability to support investment and innovation—and clearly the development of both—creation of wealth within the United States. The issue is a false dichotomy, because just to fix the tax structure will not necessarily fix technology issues. One can prove that by simply looking at how people in the past have used those tax incentives.

The research and development tax credit is an interesting case. The Administration does believe that is an important tax credit and we should try to continue to have it. It would be very important to have it as a permanent tax credit.

There are a couple of reasons for that: One is that it is sort of symbolic, that you really do believe in research and development in the country. But much more importantly, there are industries for which it is very important. For example, the biotechnology industry, which is very research and development-intensive, can use it and has used it very effectively.

However, if you look at some of the other industries, what you find is that the research and development tax credit actually never changed anybody's behavior in the sense of either using more of their money for research and development, and the decision of how they spent their research and development was not based on whether or not their tax credits from the research

and development tax credit would improve.

So the issue is to look at the innovation model that is evolving today. You are absolutely right on with respect to understanding the innovation model and then filling in the gaps, particularly in a transition period, so that we will be in a position to actually fuel the new technologies beyond generation two.

Paul and I were in a meeting the day before yesterday. One of the major semiconductor companies in the world put up their data. What it said is that the three generations that I spoke to you about—the one that they are presently manufacturing, the one they have in pilot, and the one they are developing—their amount of research dollars that are spent beyond model two is less than four percent. This is one of the most profitable companies in the United States today. They do need to spend that kind of process and product improvement for those three models. But at some point, if you do not put money into something that is beyond model two, there will come a time when there will be no model three. They were making the argument that the investment that the Defense Department makes, particularly in engineering research, was absolutely crucial to their survival.

The issue between making choices, between the tax structure and technology development, is a false choice, I think. They really are different. You do want tax structures which are helpful to innovation and growth, but on the other hand they will not in and of themselves guarantee that we have a technology base that will also fuel that growth in the future.

W. BOWMAN CUTTER—*Question*

The dollar growth of the ATP program would stress the best-managed of organizations. Why should anyone believe Commerce is up to the job?

MARY L. GOOD—*Answer*

There are two reasons why this program works and why it has not stretched the capability of doing it correctly. I deliberately put that chart up for two reasons. One is that it is not as fast a growth as many other programs, number one. It started with a $10 million commitment in 1990, which allowed you to do a very well worked-out pilot to see how it worked. It moved the next time up to about $35 million or so, so you could regroup and do the kinds of things that needed to be done to revise the program. But once we have the process in place—this is a competitive program, we are not doing it in-house—once we have the right people in place and you have the competitive process in place, it is not a difficult program to expand, it just is not.

The other issue here is that the overhead on this program is very small. The total project management team at NIST is 55 people, for the whole $430 million program, because the

money is spent outside the government. In fact, it looks very much like what the National Science Foundation does in the sense that their overhead is about the same magnitude. For every dollar the government gives it, the National Science Foundation still delivers over ninety cents. That is true of ATP as well, and that is very important to remember.

Once you work out the mechanism for reviewing the programs—once you work that out and you have all of the reviewers placed and you have all of the cards of the people you have to call to do the reviews—it does not take very much to increase the output from $200 million to $300 million. It really does not. It is not a knowledge-intensive chore, once you have worked out the bugs to make it work.

W. BOWMAN CUTTER—*Question*

In the past dual-use has foundered on the legitimate need for Defense-unique characteristics. In the past these were met by MILSPECS and Defense Production, but now we must forego those. Are we not risking battlefield failures due to heat, interference, or whatever?

PAUL G. KAMINSKI—*Answer*

Yes, we are risking some of those as we move to some things that are untried or unproven. The issue is to try to make informed judgments, Bow, on where commercial equipment can be applied and where it cannot be applied. Our move away from MILSPECS wholly in the Department causes us to have to bring some more thought to the process and more carefully look at the pieces. Our major thrust has to be on the side of pushing forward much more aggressively.

I can remember experiences back about 10 years ago, where it was absolutely required that we have ceramic packaging for our Defense semiconductors because they were used in very hardship environments, and we could not operate any other way.

I remember being at one of the DELCO operations in Kokomo, Indiana, looking at their semiconductor line, and what was being produced there were semiconductors for spark controls. These were going on top of an engine block, and they were being encapsulated in plastic. They were not having any problems with them at all. I could not think of a much more hardship environment either, from the standpoint of vibration, electromagnetic interference, or the fuel contaminants that were around.

That opened some of our eyes a few years back. In fact, Bill Perry and I were together involved in seeing that operation. The way I would describe this is there is risk in moving wholly away from Military Specifications. There are areas in which a military classification is probably appropriate. But if we balance the gains versus the losses, our experience in the

past has been relying wholly on Military Specifications. What we need to be doing is moving this back to an even keel, to trade the risks and the rewards knowledgeably.

G. BOWMAN CUTTER—*Questions*

There are too many federally-funded laboratories. All federal laboratory budgets are being cut. When will we wake up to the fact that we are cutting the best, and the best without reference to quality? Why do not we fund only the best and have truly national laboratories that work with industry and are not tied to the parochialism of any one government department?

CRAIG FIELDS—*Answers*

Why do not I say some words in support of Mary's budget level first? I actually would like to, and get on to that question later on.

The thing that made me supportive of your budget growth, Mary, was the following calculation: This actually was asked of me by Congressional folks a few years ago when it was being talked about. The way it operates, ATP is not unlike the way ARPA operates, or DARPA operates, and the limiting factor is people. In ARPA it is replacing people, it is folks coming and going. In your case it was scaling up. I have had some experience with ARPA as to the approximate amount of money someone can sensibly manage and achieve good outcomes. You have had some experience, in hiring: How many could you reasonably hire in a year? The fact is that your budget growth is well within the range of hiring good staff, within that mechanism. Now, with regard to the laboratory issue, there are really two parts to the issue, and I think they have to be carefully separated. One was the concerns about quality, and the second was the concerns about management oversight. They are really very different.

With regard to quality, I agree with the questioner. I would like to have the best people. If we have to downsize I would just as soon performance be one of the major factors in deciding what we are going to do. I do not like budget cutting just at the same percent from everybody. I think that is, if you will excuse the vernacular, a cop-out in management, and I do not know what else to say about it. So I am in agreement.

With regard to management oversight, there I really can support the notion that there should be one person, organization, agency, whatever you like, overseeing all the federal laboratories, national laboratories, whatever, because in fact, almost inevitably they can, should, and will have different expertise, different capabilities, different foci, and different sort of technical directions. If you are going to have management oversight at the federal level, you have to know what is going on, and that really is in the mission agencies, and it is different among the mission agencies. Furthermore, by having that management in the mission agencies you

stay close to customers, which I think is absolutely critical, rather than being further away from customers.

W. BOWMAN CUTTER—*Questions*

Has there been any word thus far concerning what has been decided about TRP in the conference on the DOD supplemental? If TRP does not continue in fiscal years 1996 and 1997, will the dual use and matched funding programs continue within ARPA programs?

PAUL G. KAMINSKI—*Answers*

With respect to the first question, I do not really have good insight today on what is likely to come out of the conference. My best guess would be that it will be a position between that taken by the Senate and the House, and that the ATRP program will survive, but it will be wounded somewhat in this process.

With respect to the second question, I think this dual-use program that I was describing is at the core of what the Department is doing, and it will continue. And, in fact, this dual-use program also is not very new. If I look back at the history of ARPA—we have been at this a couple of decades, at least, doing this in a fundamental base, leveraging off of what is being done commercially. This is not a very new idea.

The scope has been expanded somewhat, and I am pushing on this much harder to be able to feed our major Defense systems with a richer stock of commercial components and subsystems where it makes sense to do that.

W. BOWMAN CUTTER—*Questions*

Real-time intelligence and acceleration of Command Control functions to revolutionary speed is high-tech intensive and will affect both Force structure and operational doctrine. How are these advances being adjusted to within the rest of the Defense establishment and Defense institutions? Can they be affected in the absence of significant procurement?

PAUL G. KAMINSKI—*Answers*

Eventual adjustment of introduction of technology to reduce Force structure is a slow process, because it takes operational acceptance of the technology—to really be convinced it works in such a way that people are willing to trade Force structure in exchange for that. I think we have some very enlightened military leadership in the Department today, a group of people who are willing to make those trades, but there still is the "show me" aspect of it that is a real issue that we have to work through.

You can see how this advanced concept technology demonstration idea might be a factor in this process, in being able to deploy equipment, and in showing in how it does begin to work.

I would cite for you an example concerning slowness of this process: About 20 years ago we first proclaimed the value of precision-guided weapons, the idea of one weapon and one target, and 20 years ago it was mostly a proclamation and not much of a reality. In the last 10 or 12 years it has begun to change and become a reality, as was illustrated in Desert Storm.

We are just now beginning to make adjustments in our Force tables and logistics to be moving in that direction, because it is been sufficiently proven to people. We have a fair amount yet to go to bring that to closure.

These advances can be affected in the absence of significant procurement, but certainly they will be affected much more with growth in procurement. Let me just comment a bit on the Department's plans here. We are in the midst of a procurement pause because of the transient that I was describing in Force structure. As the Force structure reaches steady state, which it will do over the next year, our investment in new systems will have to increase. The plan in our future-years Defense program is to increase procurement by 47 percent.

There is still leverage in these applications. The Army has a program; and it is going forward in terms of digitizing our battlefield: Putting digital communications into the major platforms and netting them all together so the commander of a tank has a picture of what his whole unit is doing, where they are, where the enemy is deployed, and what the objective is. I think you can see that with a small investment in an applique system, you can greatly multiply investment in the tank.

It still requires procurement to buy and deploy the system, but there is opportunity for information systems to collect, diffuse, and provide external information to offer leverages that are usually 10-to-1, and sometimes 100-to-1, vis-a-vis the base platform that was in place. A more expansive procurement program is planned to get the full, broad application.

CRAIG FIELDS—*Answers*

Every company that is trying to employ new technology that is analogous to the Advanced Command and Control and Intelligence technology you allude to has to undergo a process with highly compensated consultants, called "re-engineering" or "re-invention" and change the business practices and business structure in order to get real effects on the business, rather than just get the boxes on the desks. The same is true for the Department: The strategy and doctrine will have to change. This is not a simple matter. The way it is being approached, which is very good, is to heavily employ the new technology in concert with game-simulation exercises: there is no theory; you can not go to a book; there is no equation; and you have to

work it out. This is going to accelerate the process of genuine impact on military affairs.

W. BOWMAN CUTTER—*Question*

How do you feel about bringing together participants across a value chain of industry (or direct competitors) in consortia and in ventures like this?

CRAIG FIELDS—*Answer*

We have 10 or 15 years of experience with these cooperative ventures now. There are a few hundred in the United States, along with many abroad. I do not know that any two are exactly alike, and that is actually good news. It means you can look at them and get some sense of what works and what does not work, because every consortium is unique. I will take the time to give a speech on what I used to call *Twelve Rules of Consorting,* subtitled *Everything Is Possible, Nothing is Probable.*

It makes a lot of sense to have consortia that have ending points, because people change their goals and ideas, so having off-ramps is critical. There are about 11 other rules like that. The most successful consortia (there are very successful ones) obey the rules that we have learned.

W. BOWMAN CUTTER—*Questions*

In many of the ATP programs, i.e., tools for DNA diagnostics, what percent of the total investment is subject to being supported by the ATP funds? In dollar terms, is it large or modest in terms of the total? And if it is small, why does it make a difference?

MARY L. GOOD—*Answers*

It would be of the order of about a $50 million program. These are significant programs. That is why it was thought appropriate to move toward the targeted programs. Without that, it is very difficult to have an impact that you can measure in a reasonable amount of time. Each of those programs has relatively large pieces of the allocation for any given year. They are designed to be long-term, and they are five years in duration. The funding can be as much as $2 million per year per company. It can indeed be a significant amount of funding; people can do something worthwhile with it.

I think the issue here is ensuring that funding is relative to what the companies are trying to accomplish. There are projects here that do not require a large amount of funding. There are others that unless you give them that order of magnitude, it will take too long, or they will not be able to have the resources and people to get them.

The question is quite relevant. We do feel in the targeted areas that these are relatively large

chunks of the budget; enough to have an impact, and clearly the companies do have an impact. The fact that there is a cosharing arrangement means that we are leveraging those projects so that the size of the project is twice the size of the government funding. When you think about getting $2 million from the government, to which you are adding $2 million of your own, you are now talking about a $4 million research and development project. Those of you that have managed research and development projects on generic technology or pre-competitive technology in the private sector know that a $4 million a year project is a respectable project that has enough rationale, resources, and people to move it effectively.

W. BOWMAN CUTTER—*Question*

Mary, there is a rumor that ATP's budget will be reduced and the program canceled. What is going to happen to ATP?

MARY L. GOOD—*Answer*

Our thought is that this rumor is not correct. Everything remains to be seen. Let me tell you where it is. The 1995 rescission in the House bill is $107 million, so it would pull it back from $430 million to about $320 million. The rescission, however, in the Senate is $32 million, so we will end up with a conference for the 1995 dollars somewhere between those two numbers.

We hope for the best, but we do not know yet. That conference may actually be ongoing at this moment. The program for 1995 will be reduced from what we had hoped, but it is by no means a dead program, I think.

We have been asked in some of the hearings how big a program like ATP should ultimately become: This is not a program that should grow indefinitely—it should not become a miniNational Science Foundation for ATP. We would like for it to be large enough to be a national program, because to really measure and understand what value it has, one needs to be able to reach a national audience. Our view is that somewhere in the neighborhood of $700 million it can become a real national program. This would allow us to have about 20 of the focus programs and one free-for-all program. That would allow you to turn over about five focus programs every year, and you would end up with an equilibrium kind of arrangement, which is what one would ultimately like to do. We do not visualize that this program should be unending, nor should it grow forever.

W. BOWMAN CUTTER—*Question*

In some cases, components developed overseas may have the highest performance and be the least expensive. DOD off-the-shelf procurement would appear to favor use of these components. How does this relate to our economic and national security?

CRAIG FIELDS—*Answer*

It is really quite different on the economic side than on the military side. On the economic side, DOD's quantity of purchasing is such a small percent of almost anything we do globally that it would be pretty unlikely that DOD's buying components (except in some very extreme cases) from a foreign company would genuinely hurt the United States economy. I think that is not a reasonable likelihood, although there could always be an exception.

One of the more interesting questions: Is there too much dependency on foreign sources in some components and in some weapons systems? The bottom line is that it is really hard to know. There is hardly a weapon system around (at least a modern one) that does not use some foreign technology and components, but that does not imply necessarily a vulnerability. If simple re-engineering would make it possible to use a domestic component, well, in an emergency that would be fine. Or perhaps with a little re-engineering we could use domestic components, but in fact, there would be just a little decrease in performance, that might be fine.

Perhaps there is not a monopoly supply. Yes, we are buying it from one company in one foreign country, but there are a bunch of other foreign countries with companies selling the same thing. You are not faced with a monopoly.

My general sense is that while there may be some dependence, there is not a lot of vulnerability. This has to be aggressively, actively managed. Many of the same issues are applied to domestic sources. If there is only one United States company selling something, it makes me anxious even though it is a United States company.

Part of sort of my investigation of this was to do a little mini study for on economic warfare, and it is hard to make that work. The most concerted economic warfare of all time was the COCOM activity. Even there, it kept the countries just a little behind for a long period of time. Look at the international cooperation that took. In reality, this is not a big problem—just one that has to be constantly attended to.

W. BOWMAN CUTTER—*Question*

Mary, how does ATP and other technology regime efforts deal with ownership of intellectual property rights?

MARY L. GOOD—*Answer*

That is obviously a very important question about the intellectual property ownership of the rights. We do have a problem in the sense that the agencies across the government have different regulatory rules for intellectual property delivery. That is a problem, because when I

look at all of those partnership arrangements up there, the ways intellectual property is handled is almost as numerous as the number of agencies. One has to work each of those.

The ATP program, however is pretty straightforward. The intellectual property belongs to the private-sector investors. It is just that simple.

If it is a consortia, the consortia itself must work out how it will divide the intellectual property rights. That is part of the contract. We do not get involved in how they do that. The consortia has to work it out among themselves. We will not finalize a contract until they have worked out how they are going to divide the intellectual property among themselves.

We do have one problem in the ATP, it is intellectual property with respect to universities and non-profits. The original legislation was written so that the intellectual property could not reside with non-profits. We think that is probably not correct. The language that we are trying to get would let the consortia decide who owns the intellectual property. If there are university partners (and in about half of the projects there *are* university partners) the consortia should be able to decide if it wants the university to keep some of the property rights. Universities can negotiate for that: We do not think we should deny intellectual property rights to the universities by statute, but that ought to be decided by the people who are there.

There are other issues that have to do with the kinds of companies that can be funded. That, of course, is in the ATP language. It says that the projects must be in the best interest of the United States, and the final decision is up to the Secretary of Commerce to make that decision.

If the language says that it is a wholly American-owned company, then there have to be rules that say that they do a substantial amount of research and development in the United States, they have manufacturing in the United States, and that the country of ownership does have reciprocity. So there are safeguards there. The issue is to try to get the research and development done here and get at least a portion of the manufacturing done here, but not all of it necessarily.

W. BOWMAN CUTTER—*Questions*

In 10 to 15 years United States industry will fall far behind, because "breakthrough" products from other nations will capture our product refinement markets. How can we best prevent this scenario? What can or should be done outside of government? What roles are required of government?

CRAIG FIELDS—*Answers*

Without taking anything away from large companies, I think the strength of the venture capital industry and entrepreneurship in the United States is so profound, it is such a competitive advantage, that the probability of the outcome that was described, the peril, is vanishingly small. And that whole culture of venture capital, of entrepreneurship really does not need so much government help as to make sure that nothing happens in our Tax Code or whatever that hurts it.

I do not know any particulars at the moment that I would raise—but if there is anything to be vigilant about, it would be that. That would be my first reaction.

MARY L. GOOD—*Answers*

The only way that the outcome that is predicted there could happen is if we decided all of a sudden to simply gut the infrastructure of the country. That could be done. You could make that decision. I do not expect any of us to do so. But other than that, I think that, the outcome that is predicted is not a likely scenario.

On the other hand, there are some things that we ought to think about. This whole business about ensuring that we have a technology pool that everybody can continue to draw from is really very important. It may very well be that this problem of long-term research and development in the companies today is somewhat short-term, it is a little hard to say. But presently, with all of the competitive pressures which the companies are feeling, they have to go after what is a competitive product at a competitive price, at a quality that they can sell. It is important that we understand that.

Both the Academy of Engineering and the Council on Competitiveness have a study underway to look at how industrial research in particular is done today and how products come out of it.

We do need to understand the innovations system in the United States and how it has changed; we need to be able to articulate that to people. Most people who make decisions on how we spend our money do not understand the interaction between large companies, small companies, and start-up companies, and the fact that all of them are necessary for the infrastructure that keeps us afloat.

Much of the start-up intellectual power comes from people who learned how to do business in a big company, took some technology that was there, and managed to move with that and do something really entrepreneurial with it.

Secondly, people do not understand the relationship between large manufacturing companies and the supplier chain—the fact that you have got a lot of small manufacturers who are the

suppliers to big companies: Without the health of the big companies, the little ones do not survive either. It is a very integrated system that works very well. We need to understand that each of them have a role to play and each of them are very important. The infrastructure needs to be designed so that all of them can simultaneously do well. I get very incensed about this question about corporate welfare—that the government should never provide any support of any kind to large companies. In many cases they are the ones who have the resources to make that particular technology grow. If you can get them to spend their money doing long-term work and bringing some small companies along with them, the end result of that can create whole new industries that simply would not happen without the support of all of those people at the same time.

We need to have a much better picture of the innovation scheme: How it works, how fundamental science works, how the people work, and how the whole thing matures into products and processes and into jobs and wealth. We just do not articulate that very well, and we really do not give people a real understanding that small companies with no big companies does not work, as well as the other way around.

In the United States today, over 80 percent of research and development is paid for by less than 50 large manufacturing companies. If you do not understand that manufacturing and bigger companies are important, those numbers will get you there fairly quickly.

W. BOWMAN CUTTER—*Summary*

In conclusion, I think that if there is one theme that although we did not plan it, it came through in the remarks of all of the panel members, it is this notion that there is such a thing as an innovations system and that ours is changing. And if you take the references that Paul made while he was here, to cycle time, that Mary has just finished making to the need to look across the whole supplier chain of an industry, to Craig's comments with respect to the significance of the venture capital industry, I think that you get the glimmer of the point that we are, that we have been trying to make, that we have a new system of innovation that is evolving in this country. It includes such components as cycle time, supplier chain, and venture capital industry that really did not exist significantly 15 years ago. It is of enormous importance to the future of this country, both for our economic and national security. It is reflected in programs of the kind that Paul and Mary stressed today. We hope to begin to deal appropriately with that system. Thank you all very much for participating with that system.

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WRAP UP

AL GORE
Vice President of the United States

Thank you very much, Jack [Gibbons]. I also want to thank the National Academy of Sciences for hosting us at this facility. We are looking forward to the work that will be done in the wake of this conference. I can assure you your efforts will not go for naught. We are eagerly anticipating the ideas and suggestions and recommendations that will come out of your deliberations.

I remember reading once about the great physicist I. I. Rabi, who talked about the role his mother played in fostering his love of learning. She was not the only mother to ask about school when the kids got home early in the afternoon, but while the other parents often asked their kids, "Did anything happen in school?" or " What did you learn today?" Dr. Rabi's mother asked, he said, "What good questions did you ask today?" I made a mental note when I ran across that—it is a pretty good one for parents, and at conferences like this, it is a good approach also. Finding answers is not always the point. Sometimes it is an achievement to ask the right questions. Over the past two days you have discussed and debated an ambitious variety of questions related to the role of science and technology in protecting our nation's national security and helping us achieve global stability.

I would like to discuss today one of the questions this Administration has grappled with this last two years and two months. What is the relationship between science and technology on the one hand and national security on the other? In order to even attempt to answer that question, we have to define national security. During the last half-century, the definition has seemed relatively simple.

Protecting our national security has meant safeguarding us from military attack and preventing all of those preliminary developments which might make a military attack more rather than less probable. Now, of course, the Cold War has ended, and while we can in no way relax our determination to maintain the best and most capable Armed Forces on earth, everyone realizes that it is time to take a broader view of national security.

We have defined the new approaches we believe are necessary in basically three categories: Economic Revitalization, Military Security and maintenance of the readiness of our armed forces, and promotion of Sustainable Development. It is important to make the effort to understand how the context within which we pursue national security has changed. We often, of course, understand the world through the use of metaphors. The very phrase "national security" is a metaphor through which we try to grasp the new threats in the new world. It is a military metaphor.

Science and technology has helped to create many of the new challenges that we face as it will help us find many of the solutions that we need. That was true at the dawn of the nuclear age and during the Cold War, and it is true now. In exploring the nature of the military metaphor that pervades our discussion of national security in the post-Cold War era, it might be helpful to try to identify some of the aspects of the metaphor that are opposite to the new challenges and some that are not.

At the dawn of the nuclear age it became readily apparent that a new discovery coming out of science had given humankind a new power with which to pursue an old activity. Nuclear war thus became understood as very different from war. War is an age-old habit of human civilization, but with the new technology produced by nuclear physics, the consequences of all-out war were suddenly transformed. Consequently, we were required to think anew about the age-old habit that now had new consequences.

A second aspect of the military metaphor is that it has a global dimension. Before the world wars of this century—World War I, World War II, and the Cold War—wars were principally regional in nature, and military historians were accustomed to speaking of conflicts in three categories: Local Conflicts, Regional or Theater Conflicts, and then Strategic Conflicts, which acquired a global dimension. Strategic came to mean a war which involved the existence of the nation requiring a response, which organized all of the assets available to a nation: military, economic, psychological, cultural (victory gardens), all harnessed in a coherent national approach to win the strategic conflict.

Having lived with this metaphor for a half-century, it is natural for us to apply it in our effort to reassess the threats to national security in the post-Cold War era. But like all metaphors, this one has limitations. It assumes implicitly an external threat, separate from us, to which we respond comprehensively and forcefully. Some of the changes now underway affect the context within which we confront challenges. Let me revisit now the three categories I mentioned at the outset—Economic Revitalization, Military Security, and Sustainable Development—and try to illustrate the point about the change in context.

If we are pursuing Economic Revitalization, it is not sufficient to identify some external threat to which we can respond by deploying new tools and new approaches in an effort to win the struggle with this external threat. Protectionists define the world of economics in terms of that metaphor, but it is entirely inadequate. Markets are now global in nature. The tools of national economic policy are limited in their utility by interaction with tools employed by other nation states. Look, for example, at the control of interest rates—which used to be almost entirely within the province of national policy makers, but now will be affected by decisions made tomorrow in markets from London to Singapore. Look at the corporation, which used to be defined in a national context, but is now, of course, multinational in form.

Similarly, when we try to revitalize our economy by creating more jobs, we have to take into

account the struggle that all industrial nations are now having in the effort to create new jobs. Any effort to simply apply new technologies coming out of new science in order to create enhanced employment opportunities will run headlong into a whole series of complications.

To use an analogy, the Industrial Revolution led to a sharp reduction in the number of jobs in agriculture, the primary source of employment for most of our nations in existence. Over a period of 100 to 130 years, the retroactive application of the fruits of the Industrial Revolution to the work done on farms led to the hemorrhaging of jobs in agriculture. Fifty percent of the jobs were on farms at the time of the Civil War; now a little over two percent of the jobs in America are on farms.

We use the Industrial Revolution again as a metaphor to try and understand the Information Revolution. In some ways it applies and in some ways it does not. In this context, the metaphor is illuminating, because just as the fruits of the Industrial Revolution were applied retroactively to mechanized farming which in turn led to a massive loss of employment on the farm, in a similar way the fruits of the information revolution when applied retroactively to numerically-controlled machines, computer-assisted manufacturing, and automation of all factory processes leads to a rapid thinning out of several categories of employment in manufacturing.

Five years after the end of World War II, 34 percent of America's work force was employed in factories. Today, 50 years later, less than 17 percent of America's work force is employed in factories. To revisit the metaphor, the Industrial Revolution not only led to the loss of older jobs but created a large number of new occupations unknown before they were created. In the same way the information revolution, while it is causing the loss of many factory jobs, is of course opening up a great many new occupations that we did not realize existed only 10 years ago. This particular metaphor does not apply in that the short period of time during which this transition is taking place is very different from the long period of adjustment that accompanied the Industrial Revolution.

So the effort to apply science and technology to our strategic goal of economic revitalization must take into account the comprehensive changes that are accompanying the scientific and technological changes themselves. As always, more knowledge, more research, and more investment is better and will help us to create new jobs, revitalize our economy, and cope with the changes. But a reflexive investment of faith and confidence in that approach by itself can be self-defeating unless we go about it intelligently. That is why we are looking forward to your recommendations concerning that particular challenge. We need your help in thinking through the best ways science and technology can help us achieve this strategic goal without simply urging us to put more money into science and technology. What is the deeper relationship?

The second goal: Military Preparedness. Again we fall back on the way we used to address

this question and assume that the role which ought to be played by science and technology is to assure us that we are on the cutting edge of any new developments that can have military applications lest we be taken by surprise, and at the same time inform us of countermeasures and defensive steps that we must be aware of before any potential aggressor is aware of them. And that needs to be done. But right now, the world is chilled by the specter of killings in Burundi that are all too reminiscent of the early stages of the horrific massacre in neighboring Rwanda, and there is precious little that science and technology can do to equip military forces to deal with this horrendous loss of life. What could we have done differently in Somalia? What are the new threats around the world to which militaries are being asked to respond?

We fall back again on the notion that what we most fear is an aggressive ideology capturing the motivations of a nation state and compelling it to aim its weapons of war against us. And again, without diminishing the importance that threat, we need to also ask the question: How can science and technology assist us in coping with the new challenges that often feature a multi-factorial assault on the integrity of a society, causing a rapid decay and descent into chaos? I am not particularly fond of the word "chaos" as it is so often used to describe the foreign policy challenge exemplified by Rwanda or Bosnia or Somalia, but there is no question that the word is appropriate in that "chaos" is something that defies traditional step-by-step, logical analysis.

It is the symbol of a family of problems so complex that in order to understand them we have to ask for assistance from science and technology—with complexity theory, with the use of new analytical techniques that might allow us to identify those changes that have leverage over the future. And then in a preventive strategy, enable us to address the causes of society breakdown before it reaches the stage that militaries are asked to respond.

During the harsh impact of the Industrial Revolution, William Butler Yeats wrote these famous words, "Things fall apart the center cannot hold. Mere anarchy is loosed upon the world. The blood-dimmed tide is loosed and everywhere the ceremony of innocence is drowned. The best lack all conviction while the worst are full of passionate intensity." Those words seem curiously descriptive of some of the new challenges into which our military has been sometimes now thrust.

The third challenge which goes under the heading "Sustainable Development" is one that I have spent a good deal of time attempting to address. I have come to believe that the problem that we call global climate change, now the subject of discussions in Berlin, and the problem of the loss of living species at such an unprecedented rate—unprecedented since the disappearance of the dinosaurs at least—the loss of rain forest, the poisoning of our air and water, and other challenges of that scale are all symptoms of a deeper underlying crisis in the

context of our relationship to the earth's environment. I believe that a radical change has taken place in that relationship in our lifetimes because of the confluence of three factors. One of them is the scientific and technological revolution itself.

Harkening back to the metaphor of nuclear weapons, just as nuclear weapons changed the consequences of all-out war, the emergence of new tools for exploiting the earth have transformed the consequences of all-out exploitation. Fishing with a hook or a small net has trivial consequences. Vacuuming the oceans with 40-mile drift nets and sophisticated electronic equipment to precisely locate the schools of fish has an entirely different set of consequences. None of the new technologies for exploiting the earth for sustenance is anywhere nearly as dramatic as nuclear weapons, but all of them taken together have completely transformed the consequences of all-out exploitation.

My friend Sherwood Rowland, who is here with his wife, Joan, was, the discoverer of the relationship between chlorofluorocarbons and the depletion of the stratospheric ozone layer along with Marlo Molina two decades ago. There was tremendous resistance to the assertion Sherry Rowland made, because it was inconceivable to most people, even in the sciences, that there could be such large consequences flowing from the act of using a new chemical compound. And yet, the air we are breathing in this auditorium right now has six times as many chlorine atoms in each lungful as it did 50 years ago because of chorofluorocarbons. That does not hurt our health so far as we know, but as Dr. Rowland pointed out, it certainly poses a strategic threat to the relationship between humankind and the earth's environment. He was vindicated by the evidence, of course, and yet we face similar consequences now unfolding that people still resist. One debate being debated again now in Berlin has to do with the consequences of the rapid accumulation of greenhouse gases, principally CO_2, but also methane, nitrous oxide, and other trace gases.

I brought a chart, really two charts if you will forgive me, but I will just use the one. [CHART DISPLAY] This looks more complicated than it is and many of you are familiar with it. It has two lines. The bottom line represents temperature from 160,000 years ago until the present time. This is the last Ice Age. This is the next-to-last Ice Age. And this is a period of great warming in between the Ice Ages. It was around this time that the West Antarctic Ice Sheet slipped off the tops of the islands pinning it up, and sea level rose 23 feet, I believe. In New York City, this is the difference between a nice day like today and having a mile of ice over your head.

The second line on the graph represents carbon dioxide. It is measured of course in the ice cores which contain annual layers of ice reflecting the snow that fell that year in Antarctica, which being a desert technically, has low amounts of precipitation which produces very thin layers, which preserves a large number of the layers. And each layer contains tiny bubbles of air within which scientists can measure the relative incidence of oxygen-16 to oxygen-18. Correct? Which in turn is a very sensitive measure of atmospheric temperature at the time

when that layer came down. And that is where the temperature line comes from. It also contains the parts per million of carbon dioxide. Now, there are two points that I want to make with this graph.

Number one: There seems to be a relationship between the two lines. The precise nature of the relationship is not clearly understood. There may be a two-way causal relationship. But the associative relationship is certainly provocative.

It reminds me of a story that I always remember about my sixth grade class when we studied geography and the teacher pulled down a map of the world and one of my classmates was forever curious about the relationship between the east coast of South America and the west coast of Africa. And if you can see them in your mind's eye, you can readily imagine a sixth grader asking the question as he finally worked up his courage to do one day, "Did they ever fit together?" And the teacher, faithfully representing the scientific consensus in 1959, said "That is the most ridiculous thing I have ever heard." But later scientific evidence vindicated that sixth grader. What the sixth grader had noticed was a relationship which to my eyes at least, having gone through that experience, is not very different from the associative relationship between these two lines.

The second point I want to make is what is happening to CO_2 right now? It is going up much more and much more rapidly than anything we have ever seen and we have ever measured. It is above here now, it is above 360 now and it is on the way up. In roughly 40 to 50 years at the current rate of increase, here is what it will be. Within the lifetimes of people in this auditorium. [Now I need your help.] It is right about there now and it is going here certainly within the lifetimes of our children. If I live as many years as I have already lived I will see this also. [Now, if you do not mind holding it there for a minute.]

The prevailing political consensus in the world is "Hey, that is fine—no problem—looks okay to me. You see any difficulty with that? I do not know—looks okay to me." When in fact the burden of proof ought to fall on those who say this is perfectly all right. Because if temperature on a global basis and greenhouse gas concentrations on a global basis have moved up and down in relative lock-step for as far back as we can measure, and now by our own actions, we are causing a truly radical and unprecedented change in the concentration of greenhouse gases in the atmosphere, should not we ask the question, "What might that do to temperatures?"

The news is filled with the images of this new 50 mile long iceberg off the Larson Shelf in West Antarctica which has just broken off, and people say, "Oh well, we do not know what that means," and we do not, but it is provocative. Since the last time we saw the breakup of the West Antarctic ice shelf was here and since we are now here on CO_2 and since eight of the ten hottest years since we have measured have been in the last decade and a half, maybe we ought to shift that burden of proof. [Okay you can put that down.]

I said there were three factors which have caused a radical change in the relationship between human civilization and the ecological system of the earth. And the new powers coming out of the accelerating scientific and technological revolution represent one. I will do the other two very briefly. You know them.

The second one is the population explosion. We are adding the equivalent of one China's worth of people every 10 years. That, like the developments on this chart, are unprecedented and brand new. It took more than 10,000 generations of human beings before we reached a population of 2 billion people toward the end of World War II. And in my 47 years, we have gone from a little over 2 billion to 5 and one-half billion. If I live another 47 years, God willing, we will go to 9 billion, perhaps 10 billion. That is a big change, because if it takes 10,000 generations to reach 2 billion, and then one human lifetime to go from 2 billion to 10 billion, that is a radical change.

The third cause of this transformed relationship is the most subtle but the most important—there has been a change in our way of thinking associated with modernism which has led too many to discount the importance of the future consequences of present actions. I do not pretend to understand why that has taken place, but many have commented upon it, and some have suggested some causes.

The Cartesian Revolution for all its blessings also carried with it an implicit assumption that we as human beings are separate from the environment in which we live. That enabled many useful insights to occur but also obscured some fundamental truths. I also believe that to a lesser degree the dawn of the nuclear age added incrementally to a certain fatalistic attitude which tipped the scales for many who always struggle with the necessity of taking the future into account when it impinges upon what one wishes to do in the present. I think for many when that balance was tipped there was more of a willingness to discount the future.

In order to respond to this third challenge to our national security, I think that we have to address all three of the related causes. We have to make efforts to stabilize world population, and under President Clinton's leadership at Cairo, the United States led the world to the formation of a new consensus that emphasizes the empowerment of women, the enhancement of education and literacy, the availability of culturally appropriate forms of contraception and the enhancement of child survival rates in order to give parents the confidence that their children will survive and thus induce a preference for smaller families.

Secondly, we need your help in understanding how science and technology can help us accelerate the development of new approaches to exploiting the earth for sustenance that do not carry with them the same consequences for vulnerable parts of the earth's ecological system, such as the atmosphere, but not limited to the atmosphere. And we need your help in understanding how to avoid the mistaken belief that there is some technological silver bullet that will by itself solve this problem. That is not part of the solution, that is more of the

problem. But science and technology must play an absolutely critical role. We must also, however, address that third factor which is our way of thinking about our relationship to the earth and the context in which we pursue all our objectives: the political, social, and cultural context as well as the environmental context.

We need your specific advice on policies that you will find outlined in materials that the Administration is submitting to you and to the Congress on cooperative threat reduction, the security of nuclear weapons, specific programs like the Coral Reef Initiative and our climate change action plan. But more than that, we need your help in understanding the approach that we must take.

The great scientist, Archimedes, made his famous statement, "Give me a place on which to stand, and I will move the earth." He was challenged to put his words into action, and according to the historians, he arranged a series of pulleys and cogs that allowed him to pull a ship out of the Syracusan Fleet from the water onto the beach. Today in addressing the relationship between science and technology to national security we must operate as a cooperative team trying to "move the earth" in a sense toward freedom, justice, opportunity, and sustainable development. In order to succeed we must work together and inform our efforts with a clear sense of the moral dimension that ought to inform this struggle with a sense of urgency.

There is a palpable sense in the hearts of many that we are living in a time in which the changes we witness are so rapid that the margin for error is reduced and the necessity for finding right answers is enhanced. It is precisely for that reason that President Clinton asked all of you to invest the time and effort you have invested in this conference. We eagerly anticipate your advice and suggestions and for your participation we are profoundly grateful. Thank you.

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