DOE/OR/21400--T477

Testimony of

Alvin W. Trivelpiece

Director

OAK RIDGE NATIONAL LABORATORY

SCIENCE, ENVIRONMENT AND TECHNOLOGY SUMMIT: A LONG TERM NATIONAL SCIENCE STRATEGY

before the

SUBCOMMITTEE ON BASIC RESEARCH

COMMITTEE ON SCIENCE

U.S. HOUSE OF REPRESENTATIVES

Held in Oak Ridge, Tennessee

June 1, 1995

OAK RIDGE NATIONAL LABORATORY

Oak Ridge, Tennessee 37831

Managed by

Lockheed Martin Energy Systems, Inc.

for the

U.S. Department of Energy

under Contract No. DE-AC05-84OR21400

Mister Chairman and Members of the Subcommittees, thank you for taking time from your busy schedules to hold this hearing in Oak Ridge. It gives us a wonderful opportunity to discuss our nation's science and technology needs in the 21st century. I am honored and pleased to have been invited to testify before this Subcommittee to present my views on the subject of the Federal government's role in a long term science strategy for the nation. Although the viewpoints I will provide today are largely my own, I have solicited the views of the directors of the other Department of Energy (DOE) national laboratories and several of my colleagues. I also want to congratulate Representative Wamp for his initiative, enthusiasm, and dedication that brought about this Summit on Science, Environment and Technology. It provides a great opportunity to highlight the kinds of science and technology that are important not just to this region and the facilities that are sited here, but also to the nation. In addition, it allows us to call attention to the pivotal role that science and technology play in many aspects of our everyday lives. In this period of budgetary stringencies, it is imperative to know what the benefits and consequences are when federal programs are reduced or modified. Many of the changes being considered will cause immediate and irreparable harm to science and technology programs that are important to our nation. Such changes should not be made blindly. I hope that the activities associated with this Summit help shed light on the pros and cons of some of the proposed changes in particular elements of the government's science and technology programs.

It has been said many times, in many ways, that World War II forever changed the way that we did many things. That is certainly true of the research and development enterprise in the United States and around the world. As a result of the war time efforts, the model of a single professor working with a few graduate students in isolation at a university was replaced by an approach that involved teams of scientists and engineers working in a collaborative manner on a common problem or set of problems. The development of nuclear weapons and radar are two of the most dramatic examples growing out of the WW II experience. One of the principal entities that was caused by, and initiated much of, the change in the way that research was conducted was the Atomic Energy Commission (AEC), which was created in 1947. It in turn became the Energy Research and Development Administration (ERDA) in 1976, followed shortly thereafter by the establishment of the DOE in 1977. These entities have fostered and supported a superb system of national laboratories, a collection of imaginative educational programs, and programs of outstanding research at our universities.

From their beginnings, the DOE national laboratories have been leaders in using a multidisciplinary approach to solve large, complex scientific and technical problems. These laboratories have created and developed unique facilities and instrumentation for attacking problems at the forefront of science and technology, and they have provided the opportunity for the science community at large to use these facilities in many imaginative and productive ways. I believe that if they are properly supported and managed, the DOE national laboratories will remain a unique source of new knowledge in many areas of science and technology of value to the United States.

However, I am concerned, that in what appears to be a wild rush to control the cost of the federal government's functions, immediate and irreparable damage, that later will be greatly regretted, will be done to the DOE national laboratories and other elements of our nation's science and technology enterprise. Just because the Cold War is "over" doesn't mean that the need for scientific and technical advances has suddenly evaporated. Quite the contrary. The problems of energy supply and use, as well as concomitant problems to the environment, are more acute than ever. Weapons of mass destruction, nuclear and nonnuclear, and their proliferation remain a serious international threat. The need for technical means to deal with espionage and terrorism has grown substantially. The opportunity to make key advances in various areas of biology and molecular structure has never been greater. Advances in supercomputers and information transmission have put us at a threshold of scientific and technical advances that our nation cannot afford to miss. At a time when the U.S. industry is decreasing its R & D commitment, the need to maintain the ability of the DOE laboratories to respond to complex, multi-disciplinary national problems is greater than ever.

Can the DOE national labs do it all? Certainly not.

But without these labs, the rate of making productive advances in some areas of interest would be substantially diminished. I believe that the idea of closing the labs and transferring the funds to industrial research labs or universities is ill-conceived and not likely to produce the results that those who espouse it believe that it will.

On the other hand, can the labs be operated better? Certainly!

Have we changed our operations to meet the contemporary challenges that we face? Yes!

Are we being given credit and recognition for the progress that we have made in this regard? No!

Do we have a long way yet to go before we should be satisfied? You bet!

Suppose that the national laboratories were applying for a job, and that you were the interviewer for your company or institution. What would you want to know about us? Usually most interviews boil down to just two questions. What have you done? What can you do? Using the Hearing Charter as a guide, I would like to provide a partial answer to these questions as they pertain to the DOE national labs.

The first of the interviewer's questions is, "What have you done?"

I could list the individuals who have received Nobel prizes for work done that involved some aspect of a project at one of the labs. You have just heard from one of them, Professor Clifford Shull. It is easy to see that what he did many years ago has had a profound effect on many areas of today's science and technology. No one would question the value of the investment that made it possible for him and his colleagues to do their seminal work. I could list many other technical accomplishments of a similar nature, but these have been written about extensively and there isn't time to discuss them here. Rather, I want to go over a few items that help set the stage for suggesting how we might be more useful as a set of laboratories to the nation.

Originally established to support our country's research and development efforts during the Manhattan Project, the DOE national laboratories have evolved into broadened missions in response to national needs. The goal of the Manhattan Project was to harness nuclear energy and use it to create nuclear weapons. Along with this goal came the need to understand the biological effects of ionizing radiation and the possible benefits to humans from nuclear materials. From this beginning, the biological, environmental, and health programs expanded to cover all forms of energy production. A significant outgrowth of this program was the development of medical radioisotopes. This development set off a collection of activities that led to the creation of the field of nuclear medicine, the development of flow cytometry, and research on the efforts to map the human genome. It is estimated that each year more than 100 million Americans receive diagnosis or therapy using some aspect of nuclear medicine. The value of the role of isotopes to the world is well stated in a remark made by an earlier director of the Oak Ridge National Laboratory (ORNL), Dr. Alvin Weinberg. He said, "If at some time a heavenly angel should ask what the laboratory in the hills of East Tennessee did to enlarge man's life and make it better, I daresay the production of radioisotopes for scientific research and medical treatment will surely rate as a candidate for the very first place." I believe that the value to the world in terms of the knowledge gained from the use of stable and radioactive isotopes has more than repaid the entire investment made in the system of DOE laboratories since their beginning.

The Federal Nonnuclear Energy Research and Development Act of 1974 authorized major research efforts into renewable energy sources and other nonnuclear energy technologies. This legislation enabled the national laobratories to take on new roles and missions that applied their capablilities to the nation's energy needs. Some of these efforts, such as fossil energy, were transferred from the Department of Interior. Currently, the Department's energy research and development efforts in this area are being analyzed by the Secretary of Energy's Advisory Board Task Force on Strategic Energy Research and Development. This independent task force is charged with gathering information for a report designed to help set the priorities of DOE's applied energy research programs.

Until the Stevenson-Wydler Technology Innovation Act of 1980, technology transfer from federal laboratories was not emphasized. In fact, in many situations, there were significant restrictions on collaboration. It wasn't until the National Competitiveness Technology Transfer Act of 1989 that government-owned, contractor-operated laboratories could participate in Cooperative Research and Development Agreements (CRADAs) with industry and universities. Technology transfer is an important aspect of the operation of the national laboratories. It occurs in many ways, such as through CRADAs and the licensing of intellectual property. Technology transfer also occurs through stimulating discussions at conferences, publication of research results, operation of scientific user facilities, and interactions with visitors to national laboratories. Interacting with outside guests and visitors on a collaborating basis is very different from interacting with your DOE program sponsor. These guests and visitors are frequently interested in the user facilities at the national labs that provide them with unique opportunities for research and development. The labs support the work of these guest scientists and engineers not only through facility operation but also by providing office space, food service, access to libraries, and other functions. These support activities do add to our overhead costs, but added costs are small and the benefits are great. New business activities lead to employment and new taxes, which in turn more than offset the small additional costs that we incur as a result of having guest scientists and engineers at the labs.

In a related effort, the missions of the national laboratories were expanded to explicitly include some educational activities. I believe that technology transfer also occurs when K-12 students and their teachers spend some time at a national lab. Some of these young people might be inspired to pursue careers in mathematics, science, or engineering as a result of their experience.

The things that they learn make them better trained, and I believe that some of them gain specific knowledge that they may use later in their careers. This is every bit as much technology transfer as a patent or a publication. Over 24,000 precollege students visit ORNL annually, and other DOE labs have similar experience with their precollege visitors. The same benefit to the general circumstance of tech transfer is obtained by the Department's many programs for undergraduate and graduate students, some of which date back almost to the beginnings of the DOE national laboratories. DOE is not in the education business and does not compete with academic institutions in any way. It would be shameful not to use the resources of the Department to give some of our students the opportunity to participate in programs that give them a better grasp of what science and technology are all about. I want to take this opportunity to congratulate Secretaries of Energy Herrington, Watkins, and O'Leary, for their strong encouragement of education programs at the DOE national laboratories. Without their support it would be much more difficult to have our facilities used give some of our young people some exposure to working scientists and engineers, and as a result, perhaps inspire some of them to pursue careers in these fields of study.

Now let us turn to the other aspect of an interview.

What can we do?

To answer this question, it is necessary to first speculate on what might need to be done. I ask you to join me in a flight of fancy and try to imagine what the world might be like in the year 2030. What kind of a world might we like to have our children inherit? What kind of a world could it be if we do the right things?

For instance:
Imagine that in 2030 genetic diseases are curable. Through knowledge of the genetic code, a single drop of blood is used to diagnose an illness and design an individual's unique treatment. A supercomputer tailors the medicines to the specific needs of the patient and causes them to be produced, if they are not already off-the-shelf items.
Imagine that in 2030 energy supplies are increasingly non-depletable and secure.

Imagine that in 2030 poverty, terrorism, and threats of war are small, that the economic gap between developed and developing countries is closing with population stabilization due to sustainable economic development.

Imagine that in 2030 degradation of the environment has greatly diminished, and that natural systems are scientifically understood well enough to be protected and improved while allowing economic growth.

Imagine that in 2030 education is universally available as the global village shrinks, and that everyone has immediate and unfettered access to the information superhighway: anytime, anywhere, and any place.

Imagine that in 2030 housing choices and transportation choices are not constrained by energy or environmental costs.

Imagine that in 2030 water treatment plants are capable of producing unlimited quantities of pure drinking water at a low cost everywhere in the world.

Imagine that in 2030 manufacturing is pollution-free, and that the by-products of manufacturing are recaptured for other uses.

Obviously, I don't know if all or any of the above listed desirable outcomes will occur. I do know that they will not, if we do not work to achieve them. By what means will we get there? Through the talent and creativity of our people. What institutions are needed to capitalize on this talent and creativity? Universities, industry and national laboratories.

In that regard, I believe that the DOE national laboratories have the capability to play a key role in the process of developing a knowledge base from which the science and technology essential to achieve a better world will be created. These labs have a history of meeting the needs of other federal agencies, universities, and industry, and supporting activities at local, state, and regional levels of government and with other countries. The multidisciplinary activities of the national laboratories are needed to help understand complex social, economic, and environmental systems and their interactions so that the impacts of technology and policy options can be projected. They have demonstrated success in developing cross-cutting critical foundations for energy and environmental technologies in areas such as materials; sensors and instrumentation; computing and communications; and biotechnology.

The DOE's national laboratories are one of the keys to a better future for our nation. It is possible that we could achieve the future that I have suggested without the national labs, but I believe that the process would not be as sure or as certain. In any event, it is likely that the functions that the labs now provide would have to be recreated in some other way that would almost certainly be more expensive and less effective in the long run. One thing seems clear, without better science and technology we won't achieve desirable goals for 2030. We will not succeed without a systematic effort to know more about the problems that we face, although at times I suspect that some people believe that we shouldn't advance the state of our knowledge in science and technology.

Now I would like to address the questions posed in the Hearing Charter.

1. With the end of the Cold War, some have proposed that national science and technology policy be oriented towards: international economic competition; civilian technology development; a shorter term return on results and a more strategic focus; interdisciplinary and interagency program orientation; and a team/center/consortia focus in the conduct of research and development. Please comment on these proposed policy directions.

It is easy to make broad and sweeping proposals on various policy approaches to do things in an interdisciplinary manner involving various entities. It is a tad more difficult to bring about a practical result based on such sweeping policy pronouncements. In many cases, policy is the result of a lot of separate programmatic actions, rather than the other way around. It would seem to me that we should first focus on what needs to be done, then determine what funding is going to be needed to carry out the program or project, and last, give consideration to the best way of doing it. The landscape is littered with projects that have been overconstrained by policy to be done in a particular manner that was not the best approach to a particular scientific or technical problem. Mistakes of this sort are not the exclusive property of the federal government by any means. One of the classic mistakes that is made in trying to establish a policy that will govern collaboration in science and technology among various entities is the assumption that proximity and agreements will cause it to occur. Groups in universities have been put on the same floor of a particular building with the belief and expectation that they will naturally collaborate. Sometimes this occurs, but it is more often the case that two scientists or engineers decide to collaborate no matter what their institutions or governments do to prevent it. By the same token, putting them in adjoining offices may not lead to collaboration, but rather hostility. Making it easy for scientists and engineers to collaborate when they wish to do so is what is needed. Many petty impediments are put in the way of effective collaboration. Making it easier for scientists and engineers to travel and take equipment with them would be beneficial. But, it is not the specific problems that cause the difficulties, but the fear that something might go wrong that has led to the bureaucratic accretion that stifles institutions at all levels. There is fear that additional policy changes may be forthcoming that will further load the system with nonvalued added activities. To explore this, I am going to pose some rhetorical questions regarding the Department's laboratories and their functions.

Have the DOE laboratories done things that have contributed to the economic competitiveness of the United States? Yes.

Should they be encouraged to do what they can to do better in this regard? Yes.

Nonetheless, the labs should not be converted into job shops that have as a principal task the requirement of servicing industry. In this regard, the Galvin Task Force is correct in making the recommendation that economic competitiveness should not be a primary mission of the DOE national laboratories. Collaborations with industry and universities should be viewed as resulting from the labs' missions, but they should not be a primary lab mission. Through their partnerships with industry, the Department's national laboratories help maximize the value of the public investment by increasing the prospects of getting taxpayer-financed innovations to the marketplace. Technology transfer takes many forms. Technology developed through CRADAs is but one of them. The publication of research results in scientific journals is another form - one that I believe is less appreciated. DOE's research and development efforts that are published should be available to anyone who chooses to read the scientific literature and take advantage of the research. There is concern that other nations gain by our openness. This is undoubtedly true, but our collective failure to capitalize on the results that we produce should not be a prime argument for turning off the research enterprise that produces innovation or new knowledge.

Many of the technology successes that have grown out of the national laboratories have their origins in their science programs. I would like to give two examples that illustrate a circumstance where the successful outcome of energy efficiency projects was based on some aspect of fundamental science.

Alternative-fuel vehicles offer both potentially lowered emissions and freedom from dependence on petroleum for transportation. These vehicles can be powered by alcohol fuels that are converted from biomass - plant matter such as stems or branches. ORNL manages DOE's Biofuels Feedstock Development Program, a national program for the development and demonstration of commercially viable biomass supply systems. This program is done in close coordination with the National Renewable Energy Laboratory, which is developing new processes for converting plant biomes to fuels. The research program involves universities, the U.S. Department of Agriculture, and industry collaborators. Contributing to the foundation for this effort is the science supported by the DOE Office of Health and Environmental Research on global climate change. By studying the basic response of plants to the stresses of the environment, it is possible to determine the effects of global climate change and why plants exhibit pest, disease, or drought tolerance. These results can then be used by the Biofuels Program to develop increased yields. This activity is a result of natural collaboration by which the various parties felt that they could make better progress by so doing, and not the result of a high-level policy decision that mandated collaboration between these specific entities.

Over the last several years, I have heard several terms in science hearings that I hadn't heard before. These are terms like "directed basic research" and "strategic basic research." I'm not sure what they mean. Generally, research should be allowed to be investigator-driven. Even so, the government has a responsibility through its political processes to pick the general areas that are to receive more or less emphasis. The areas that are emphasized change as a function of time in response to discoveries or lack of acceptable progress. A good example is provided by the field of high-temperature superconductivity. Before the discovery of high-temperature superconductors, it was difficult to find scientists who wanted to work in this field. After the Nobel prize winning work by Muller and Bednorz, there wasn't enough support to fund all the interesting work that was being proposed. As another example, suppose that you tried to make a more energy-efficient mobile home using materials that are commercially available - that is not basic research. On the other hand, you can try to develop a clearer understanding of heat transfer in wood or metal - that is basic research. Understanding phase changes in metal mixtures may not have an immediate application, but some day that research may provide some benefit to improving welding processes. Similarly, understanding the properties of ionized gas interactions may lead to new energy sources.

There is a growing paranoia against so-called corporate welfare. There is also an increasing concern for relevance in research. This leads to a conflict between a valuable cooperation between industry and national labs and a concern that such cooperation is a form of corporate welfare. I believe, that in the case of cost-shared partnerships between the government and industry, this fear is unfounded. Contractual arrangements are negotiated before the project begins and before the end result can be evaluated. In any case, although results can be hoped for, there is not a way to guarantee them. A number of features can be included in the contract negotiations, including royalty payments and license fees, to ensure a direct and immediate return to the U.S. government of significant funds if the project is successful. The federal government also profits from the benefits to local and national economies when employment and sales are generated by a new product. It is worth noting that our nation's international competitors consciously use their national laboratories to improve their competitive posture in the global marketplace. In DOE's partnership programs, technologies are developed only when there is a substantial public purpose--enhanced energy security--and when private investments cannot be assumed. While there is room to debate the appropriate funding levels for applied energy research and development, I believe it is inappropriate to terminate the federal role in energy research and development. Our eventual energy security depends on this.

One indication of new ideas and innovation is the recognition received for technical usefulness, importance, and uniqueness. Every year, *R & D Magazine* honors the top 100 innovations in applied science by presenting its R&D 100 Awards. Recognized widely as a symbol of excellence, the awards are pursued by universities, national research facilities, and private industries worldwide. Extremely diverse, these projects are cited for significant advancements in such fields as medicine, environmental science, advanced materials, and analytical instrumentation. In 1994, the DOE received 28 R&D 100 Awards for an all-time total of 392. ORNL ranks fourth among institutions in the all-time competition, with 74 awards won since 1967.

One of the criteria for judging basic and applied research activities is excellence, the same standard that is used at evaluating research and teaching at universities and other institutions. National laboratories have much in common with universities because graduate education is an important element at both institutions. Some national laboratories, like Lawrence Berkeley Laboratory (LBL), are integrally connected with institutions like the University of California. At other laboratories, such as ORNL, the cooperation with institutions such as The University of Tennessee is not as great but is still significant. The National Science Foundation (NSF) issues an annual report detailing the financial support provided to universities' external research and development efforts. The latest report indicates DOE support to universities totals about $700 million. Unfortunately, this number excludes the support provided by the national laboratories to the university community. This support, when combined with the direct DOE grants, totals well over $1 billion. But even this total does not take into account the work done at institutions such as Fermi National Accelerator Laboratory, which exists primarily to serve research that is initiated at universities and other labs. At The University of Tennessee, over 20 percent of the $72 million in external research and development is supplied by ORNL, with significant additional funds provided by other DOE facilities in Oak Ridge. These numbers only provide the financial picture and do not measure the intellectual contribution of the national laboratories. Another measure is the contribution made to graduate education through involvement of graduate students at the national labs. Over 500 graduate students now actively participate in research projects at the LBL alone. All of these examples point to close ties between universities and the national labs. Management of the national laboratories is, in essence, a trustee responsibility that is similar to the management responsibility of the trustees of major universities.

An impressive statistic is the 15,000 scientists and engineers who visit DOE laboratories for an extended period of time. ORNL had over 4000 guest scientists and engineers (defined as those who stay more than two weeks) last year with about 30 percent of them from industry. This represents a significant financial commitment by universities and industry in the belief that the DOE national laboratories are a national resource.

The definition of useful performance metrics for research and development institutions like the national laboratories is fraught with difficulty. Many of the lab missions are built around long-range objectives, while most metrics are designed for short-term assessments. This sometimes is likened to pulling the carrots out of the ground to see if the roots are still growing. Those metrics that are conveniently quantified, like the number of scientific papers produced or the number of CRADAs in effect, tend to measure the process rather than the impact, such as increased scientific knowledge, new technologies, or more jobs.

2. *With the Administration and the Congress projecting decreasing Federal budget support for research and development over the next five to seven years, how must the relationships between the Federal laboratories, the research universities, and industry evolve to assure adequate science and technology investment for the nation's future.*

I have had the good fortune to visit research institutions in many countries, and I have had the opportunity to meet with delegations visiting the United States from other countries. It is my impression that most of these countries envy our system of national laboratories. In many cases they have set up institutions that are similar to ours. Therefore, I find it perplexing to learn that there are recommendations to establish a version of the Defense Base Closing Commission to decide which of our national laboratories should be closed. Research laboratories are not the same as military bases in the sense that even though base closing may be painful and economically disruptive in a particular location, the process is easier to reverse than the closing of a major national laboratory. If the need arises, the bases can be reopened. The military function they performed can be completely restored, even though it may be at another site. With research labs it is a little different. The processes that bring together a group of productive scientists and engineers into a multiprogram activity are not so well understood. It may take years to get a productive group going and only a few minutes to kill it. Like many of my colleagues, I am distressed that several large industrial laboratories have significantly weakened there long-term commitments to R & D in the course of downsizing and realignment. Bell Labs and IBM are the most recent to come to mind It would be difficult to recreate a research institution like Bell Labs here in the United States. It is my understanding that as a condition of doing business in both Singapore and China, AT&T is setting up research institutions like Bell Labs in those countries. This pattern worries me. I hope that it worries you also.

If the present round of budget considerations is going to reduce the support for research, then I believe that the Administration and the Congress should agree on what programs or projects are going to be continued and which are going to be eliminated, rather than asking which institutions should be affected. If a given program reduction results in a reduction at a national laboratory or university, so be it. The institution(s) best able to perform the program should either be assigned to do the work or allowed to propose to compete for it. Making a decision to close a facility that is best qualified to do a particular project, and then deciding to expand that particular project makes no sense at all.

As an example of how program cuts affect a laboratory, consider the decision to stop work on one version of a new production reactor. This programmatic decision resulted in a $14 million reduction of work at ORNL. As a result, I had to make the necessary changes at ORNL to accommodate this reduction. If, on the other hand, I had been given the instruction to reduce programs at ORNL by $14 million I would not know where to begin. The appropriated funds for the various projects at ORNL have been apportioned to the Laboratory, and the work should be performed in accordance with the appropriation language that permits their expenditure. We are not allowed to spend them for some purpose other than that for which they were appropriated. So if I am instructed to reduce the activities at ORNL by some percentage, I don't have a basis for deciding which of the programs I am supposed to reduce or stop.

I am sometimes frustrated by the challenge in reports and speeches that the laboratories must change. While I don't disagree that we should change as the circumstances change, I am astonished that there is so little recognition of how much we have changed in the past few years. Some have said that the labs should be more open and bring in industry and have more interactions with universities. Well, we have changed, a lot. As I mentioned, at ORNL we now have more than 4000 guest scientists and engineers per year. About one third of them are from industrial organizations. We aren't saturated with visitors, but it is clear that another doubling would be tough to accommodate. All of this change has occurred in the last ten years or so. Most of the activities that have led to this change started over ten years ago. But, leaving my frustrations aside, there is another aspect to this openness and collaboration that needs to be considered. Having guest scientists and engineers visit is one thing, but working closely with them on collaborative projects is another effort that must increasingly become the norm as the competition for increasingly scarce funding continues. The experience at ORNL is similar to that at other DOE national laboratories, all of which have shown a great interest in collaboration. We recently analyzed ORNL's publications in scientific journals and discovered that about 70 percent were co-authored with members of other institutions. This rate has doubled over the past decade.

The national science and technology infrastructure, which produces the scientific discoveries and technological innovation that underpin our nation's economic competitiveness and social well-being, is based on a foundation of academic, industrial, and federal laboratory research and development. These institutions play complementary roles in serving the national interest. Basic research initiated by individual investigators has been the academic model. Industry focuses on short-term, product-driven research and development. Federal laboratories have addressed complex, applied interdisciplinary science and technology issues as well as work in the fundamental sciences.

The DOE national laboratories are an essential component of this system. Their ability to conduct large-scale, long-term, integrated research projects has produced a remarkable set of contributions, ranging from fundamental scientific discoveries to commercial products, that have improved national security, economic productivity, human health, and environmental conditions. The success of the national laboratories in applying science and technology to national challenges derives in part from a special organizational structure that supports long-term, high-risk, problem-focused research and development. Successful projects have been characterized by interdisciplinary integration of science and engineering, focused project management, defined cost and time schedules, and relevant delivery of solutions to problems. The report of the Task Force on Alternative Futures for the Department of Energy National Laboratories (the Galvin Task Force) notes, "One of the great strengths of the multiprogram laboratories derives from the diversity of technical expertise that can be brought to bear from within these laboratories on specific scientific and technical challenges."

In recent years, DOE and other agencies have increasingly managed research using the academic model, supporting small projects that are reviewed individually. The Galvin Task Force called attention to the "institutional fragmentation" that has resulted from the funding of hundreds of small projects, led by individual investigators, that do not take advantage of the unique research and development capabilities of the national laboratories. To assure adequate science and technology investments for the future, DOE should fund projects less on a retail basis and more on a wholesale basis that leaves some of the programmatic decision process to the directors of the labs. Several recommendations in the Galvin commission's report call for greater integration of research at the laboratories as a means of counteracting this fragmentation and improving the laboratories' ability to contribute to solving important national problems. As the nation moves toward the development of a long-term science strategy, the definition of the role to be played by the national laboratories assumes even greater urgency. New research and development management approaches are needed to sustain the technical integrity and excellence of the scientific programs at the national laboratories and to prepare the laboratories to respond to the challenges of the future.

It is tempting to summarize this section by saying that only the most relevant or most excellent programs should be funded, that the best performer should be the one to do the work, and further that the best way to make this determination is via the process of peer review. Although I have personally benefited from the peer review process in the conduct of my own research in the past, I am not a believer in the notion that it should be the only path to assignment of funds for basic or applied research. Peer review is a means of maintaining the *status quo.*

There are examples of situations where outstanding research was not funded in timely manner because the work did not fit neatly into one of the predetermined categories for which funding was available. Much of the new and interesting work in most areas of science and engineering does not fit into such neat categories. There needs to be maintained a system, whether at universities, in industry, or at national laboratories, in which it is possible to try new things without regard to the guarantee of success. In this regard, the three entities need to have a better way to communicate with each other than by suggesting that, if the funds are to be cut, then the cut should come out of the other sector.

3. Would integration of all Federal science and technology agencies into a single, cabinet-level department contribute to more efficient support for research and development?

I have never been a fan of the idea of a single cabinet agency for science and engineering research support. This opinion is based in part on my experience during the twenty years that I was a professor of engineering and physics, and in part on my service as a federal employee. I know that the idea has a certain current popular appeal, but I believe that it is a bad idea for several reasons. The appeal for a single agency is the argument of efficiency; namely, the belief that such an agency would eliminate duplicate programs that the present system is believed to cause. I don't believe that the assumption is correct. The present system does not produce duplication of research, unless some federal employee is intentionally spending the federal funds entrusted to him or her in a manner that causes that to happen, which would be unwise if not illegal. Even if duplication of funding for similar programs were to occur, the scientists or engineers involved in the project would eventually have to publish the work based on the funding. It is unlikely that promotion to a better job code or tenure in a university would occur, or for that matter that funding would be continued, if it could be shown that the work was identical to someone else's. This might even raise the consideration of scientific fraud or plagiarism if such duplication were to occur. Since such events are exceedingly rare, it would seem that reduction of nonexistent duplication should not be the basis for the establishment of a science agency. The present system may be a little inefficient, but it is certainly effective. The current system provides a variety of approaches to solving the Nation's research and development challenges. While there may be an overlap in the goals of some of the research, the matter of duplication of research results is well taken care of by the time-honored tradition of the goal of scientists to be first to publish results.

Agencies do collaborate now to increase efficiency in research and development support. Collaboration exists between the DOE and the NSF is in the area of nuclear science. The Nuclear Science Advisory Committee is responsible for developing a long-range plan (roughly every 5 years), and advises both the DOE and the NSF. However, this does not imply joint funding of major projects. What it does imply is that the community coordinates projects across both agencies to maximize the new science and eliminate the possibility of duplication. This is planning in response to the new directions identified by the whole nuclear physics community. Hopefully, this means that by the time these proposals go to Congress for funding, the nuclear physics community has completed all of its internal discussion and battles over priorities, and now speaks with one voice. Discussions are under way to identify the highest priority for new construction once the Relativistic Heavy-Ion Collider at Brookhaven is complete. This could lead to a future DOE construction project. The advisory committee is noting similar needs at universities, and they will likely be NSF projects. Recommendations are also being made for terminating older facilities. I believe this mode of joint facilities planning provides for maximum budget impact on the science. Since this result is obtained by seeking the advice of those who are expert in the field, it is more likely to be productive than policy set by a single cabinet agency research director. The example that is frequently cited as a reason not to have a czar of science is the sad experience of biology in Russia under the leadership of Lysenko. In the 1930s, Lysenko, who called himself a geneticist, was advocating the scientifically utterly discredited idea of inheritance of acquired characteristics, and was applying it to "improvements" of agricultural crops and animals. Because his claims were in tune with the Soviet regime's ideology, he rose to a high status from which he had the power to control the country's scientific establishment. I don't believe that the risk of such a situation would be desirable in the United States.

It would be nice if the situation were as simple as I have described it. It is not. Well meaning scientists and engineers have strongly held views on which are the best problems to work on and on what approach to use to solve them. This leads to some hot debate and confusion among those who are not scientists to determine what is the best way to decide on a rational way to fund research. Tempting as it may be, a single agency for all of U.S. science and engineering research is not the answer.

4. What is the appropriate role of the National Science Foundation and the research universities in research and development in the energy and environmental sciences? How is this best integrated with DOE-supported research?

Considering all of the sources for the support of academic science and engineering, both the NSF and the DOE provide support at about the same level. The NSF focuses its resources on support for fundamental research in our nation's colleges and universities; the exception is in the biomedical sciences where the National Institutes of Health is the primary sponsor. Most of this support is designated for individual principal investigators or other small teams. Academic researchers rely on the NSF because it also supports research facilities, like accelerators and observatories, and other academic facilities modernization programs.

An important consideration is that the concept of multiple funding sources is not bad. This is just the opposite approach of having a single science agency. Agencies with specific missions may hesitate to fund an outstanding idea because its relevance to the agency's mission cannot be clearly demonstrated. The NSF can fund quality projects in areas for which relevance is unknown; that is part of the mission of the NSF.

The DOE is sometimes criticized because it is believed that too much of its research and development are in areas that are not obviously related to energy, such as health and environmental sciences. Some of these DOE programs have their origin in the Atomic Energy Act of 1946, which provided for research and development activities directed to "the preservation and enhancement of a viable environment by developing more efficient methods to meet the Nation's energy needs." The environment is invariably affected by energy production and supply: producing energy involves substances that come out of the ground and eventually go back into the ground; while these energy resources are out of the ground, they can affect people, plants, air, and water. Also mandated in the Atomic Energy Act of 1946 was the need to understand the consequences of radioactive materials and "the protection of health and the promotion of safety during research and production activities." From work to develop an understanding of the effects of large doses of radiation and chemical substances, DOE researchers have moved to improving their understanding of the long-term, low-dose effects as well. The disadvantages of using laboratory animals for such studies led to present efforts to understand these effects at a molecular level. DOE's pioneering involvement in these programs flowed from the need to understand the effects of exposure to radiation and chemicals on plants, humans, animals, and the environment. It was this need to understand these effects that led DOE to start the Human Genome Program. Thus, DOE's health related and environmental research programs are a natural—and legally mandated—part of its mission.

Environmental science programs within the DOE national laboratories are unique in the federal system, representing one of the largest pools of environmental research talent in the world. The programs draw on interdisciplinary capabilities in science, computing, instrumentation, and engineering to address the most significant and complex environmental issues facing the nation.. The laboratories' interdisciplinary research has focused on mission-oriented issues of DOE and thus has been tied to real problems. In addressing the environmental challenges resulting from past missions, DOE is rapidly becoming a leader in responsible management of environmental resources.

The NSF has been the leader in funding methodological development research for many branches of the scientific community, and I understand that funding for one of these programs, the Social, Behavioral, and Economic Sciences Program, recently has been singled out for elimination. This is a bad idea. It is clearly not enough to solve a particular "energy or environmental" problem from an exclusively scientific or engineering perspective. In many cases, the social aspect of following or not following a particular course of action can have a strong influence on the outcome of events. For example, France has been more successful in causing nuclear power to be accepted as an energy source than has been the United States. Little has been done to study what they did and why it worked. Wouldn't it be advisable to put a small fraction of the funding for a particular energy technology into understanding how to improve its insertion into our economy and society? It might be a lot cheaper in the long run if we did. In this regard, we have found in recent years that the inclusion of the social sciences in our multidisciplinary teams is crucial in accomplishing our mission. We now know that research and development investments and technological innovations are more likely to pay off if economic and user acceptance issues are factored into research and development strategies relatively early in the process, before the technologies are fully molded. History is replete with examples of technological solutions that went awry because proponents did not develop technologies that accommodated economic and social preferences. In addition to the experiences with nuclear power, experience with supersonic transport and hazardous waste suggest that the economic and social environment in which technologies must operate is exerting a much stronger constraint over technologies today than has been true in the past.

To illustrate my point, let me mention a few recent ORNL activities related to technology development that have benefited from the application of social, behavioral, and economic sciences. While these examples represent the application of recent developments in the social, behavioral, and economic sciences, they could not have been accomplished without the methodologies having been first developed in a basic research context.

For a number of years ORNL has been examining the best ways to dispose of chemical weapons currently stored at facilities in different parts of the United States. Our work includes the examination of emergency evacuation measures in addition to the best technological measures for destruction of the weapons. Our work on emergency evacuation from these sites directly applies recent basic research in behavioral and social science to reduce the loss of life and property. For example, basic research on cognitive information processing and social relations coupled with field studies of human response to emergency warnings has led to new warning technology and warning messages which are much more effective in getting people to protect themselves in an emergency. The implications of our work extend beyond chemical weapons, as a recent ORNL report on warning systems is now required reading for all National Weather Service forecasters. Likewise, the techniques developed by our social scientists have led to more effective training and public education programs that are, unfortunately, making the headlines in our daily newspapers. Immediately after the Japanese subway chemical attack, the New York Transit Authority used a training course and video entitled "Act Fast," which was produced by ORNL for the Federal Emergency Management Agency, to train emergency personnel on how to respond to a similar chemical agent attack if it occurred in New York City.

The social and economic sciences also play a major role in evaluating the effectiveness of government programs. For example, during 1994 ORNL completed a three-year evaluation of the nation's single largest conservation program - DOE's low-income Weatherization Assistance Program. The goals of the Program are to decrease national energy consumption and to reduce the impact of high fuel costs on low-income households, particularly those of the elderly and the handicapped. A comparison of costs and benefits based on a range of assumptions concluded that the Program is a cost-effective government investment. Also, as a result of the findings of this evaluation, DOE has initiated major changes in the program to reflect the practices which were identified to be the most cost effective.

A final example that illustrates my point is a recently completed study that developed a method for estimating the externalities associated with the generation of electric power from six different fuel cycles: coal, biomass, nuclear, hydropower, oil and natural gas. Externalities are the costs, such as health and environmental costs, that the technologies impose on third parties. In other words, the impacts that producers and consumers do not take into account during the normal course of business. This study will significantly improve full-cost accounting in conducting benefit-cost analysis and will provide important guidance to states in understanding the health and environmental impacts of proposed electrical generation technologies. I should mention that this study was done in collaboration with the European Union so that for the first time, a similar methodology was applied to power generation technologies on both sides of the Atlantic. The comparison of results that this arrangement will permit is badly needed for international collaboration on technology research and development for power systems. This study has generated international interest, and a division of McGraw-Hill is publishing the multivolume study.

While these examples are not meant to be exhaustive, they do illustrate the value of social, behavioral, and economic research throughout the research and development process. Most comprehensive studies of federal energy research and development have recognized that the current level of investment in these branches of scientific research is not sufficient to address the complex issues we face as a society. The Office of Technology Assessment, the General Accounting Office, and DOE's National Energy Strategy have all concluded that DOE would benefit from greater support and use of economic, behavioral, and social science research. Furthermore, our own experiences in the application of these sciences indicate that there is need for improving their foundations. We know that a better understanding of individual decision making in a social, behavioral, and economic context can help us to improve the allocation of our scarce resources for energy and technology research and development. I believe that NSF has an important role in this area that supports and is complementary to DOE programs.

The national laboratories are institutions that collectively serve the national needs in broad areas of science and technology. Yet they are barred from participation in some areas where they could be assets for the nation. They are not eligible for direct funding on a competitive basis to perform research awarded by the NSF. If DOE's national laboratories can provide access to research facilities for academic institutions, it would seem that it would also be in the national interest for funding from government agencies to be similarly available on a competitive basis to the national laboratories. Thus, one of the best ways to integrate programs between DOE and NSF is to allow joint funding of programs where that is appropriate, or to have more joint advisory committee such as the Nuclear Science Advisory Committee.

5. What are the DOE and national laboratories doing to establish clear mission statements for the labs which can be utilized for future budget decisions and long-term strategic planning?

The question implies that the mission statements of the DOE's laboratories are not clear. I believe that they are clear and simple. The problem is that taken at face value they do not differentiate one lab from another in a simple and concise manner. The same could be said of universities. Their mission statements would all sound similar and would not distinguish one institution from another. And yet, they vary greatly in the emphasis which they give to different functions within them. Some emphasize science and others liberal arts or business, even though each would have some activities in all of these areas, even if it was not the most excellent. Suppose that universities were asked to focus their efforts so that they could be made more efficient by terminating those activities that are duplicated at some other university. Maybe one university has an English department, while another has a physics department, and still another has neither, but does have a football team. This would be a silly approach to operating the universities in our country.

What about the DOE national laboratories? Should one of them do physics and another one do chemistry? No, that doesn't make sense either. Part of the problem with mission statements is that the effort to reduce the diverse collection of activities at any of the labs to one sentence yields nearly identical sentences. I believe the better question to ask is, what is being done by DOE and its laboratories to ensure that the highest quality work is being funded consistent with the requirements of the DOE Act, and the other pieces of enabling legislation that precede it? The various reviews that have recently been conducted as well as those now under way should help, but this is a never ending process. The various advisory committees that help the DOE in assessing the quality of its programs should be continued. The visiting committees of distinguished scientists and industry leaders that each laboratory has to help insure the excellence of its programs should be continued. Periodic comparisons of the quality and excellence of the work done at all national labs with that being done at academic institutions and industry would be advisable. There is no simple answer to the question posed, because it is based on a faulty premise.

6. *What is the DOE doing to establish lead labs and Centers of Excellence within the lab system?*

There has been some experience with the concept of the lead laboratory and it has not been good. In good times, a lead laboratory typically may send half of the work to other laboratories, universities or industrial labs, and everyone is happy. Then the budget drops, and instead of looking for the best place for a research project, the lead lab finds that the best place is in house. While there are no short-term solutions to this problem, in the long term, a courageous DOE program manager needs to recall the program for management by Headquarters.

In a sense, the Centers of Excellence are indicative of the core competencies identified by each of the national laboratories in preparation for the Galvin Task Force visit. These Centers of Excellence are determined by the DOE program managers who have the decision on placing support for research and development activities at any given institution. The DOE national laboratories do not operate in a vacuum or an ivory tower. They respond to national needs as directed by their DOE program managers. The rich heritage of research in the DOE's national laboratories is continually evaluated by the program managers within the Department. There is no truck full of federal funds that pulls up to the laboratories, unloads, and then drives away without giving thoughtful directions as to how that money is to be spent. I believe that the managers of the research programs in the Department should be given credit for their guidance. The laboratories were initially set up in a competitive environment, and to some extent, that environment still exists. Each of the laboratories annually submits proposals for research tasks to be funded by the DOE; ORNL alone submits about 750 such proposals for consideration. If a researcher is not responsive to the sponsor or if the researcher is not capable of performing a research task, funds are not forthcoming. The program manager evaluates these proposals to see where the work should be done. A few of the other criteria used to determine which research warrants funding are innovative approaches, collaborative and cooperative efforts, and scientific and technical excellence. This programmatic guidance is then sent to the laboratories where the research is performed. This research review pattern is the same, whether in the basic science activities of the Office of Energy Research or in the more applied areas such as activities of Energy Efficiency and Renewable Energy.

The scientific community has long relied on the peer review process to evaluate its output, on the principle that the main "customer" of scientific knowledge is the broad community itself. One of the problems with peer review is who forms the membership of the peer review teams. Although highly qualified, they tend to follow the mainstream of the field. While receiving funding for new ideas is never easy, it is more difficult for those researchers not in the mainstream to receive funding or to receive timely recognition for new ideas that provide refreshment and renewal. Despite the imperfections of this process, it has served us well and forms the basis of most program funding choices. For the traditional "mission" areas, this is still the best measure of performance. However, as the laboratories have increased their emphasis on economic competitiveness and education, other sectors of the nation have become important as customers and, therefore, as evaluators. Reviews by these new customers should be used to assess the performance of the laboratories in their new roles. Both customer surveys and proposal reviews are obvious mechanisms. Depending on the role, the appropriate customer may be private industry, academia, other Federal agencies, or state or local governments.

7. *What further, if anything should the Federal government be doing in the area of technology transfer from the national labs?*

A superficial view of the DOE laboratory system might lead one to conclude that some of the laboratories have duplicative or overlapping programs. A closer inspection reveals that each laboratory addresses different elements of science or technology. Bob Galvin stated in his report that the sum of the various laboratories' capabilities in a particular area created in effect a "virtual laboratory," the capability of which was greater than the sum of the individual parts. There is a clear benefit to the nation and the economy in providing improved customer access to the best technologies of the DOE's national laboratory system, regardless of their laboratory of origin. This observation has suggested that multidisciplinary and multilaboratory teaming on projects and the creation of Virtual Technology Centers between the laboratories are good things to do. This also was recognized in the Galvin Committee's recommendations.

Teaming between laboratories is not new to the DOE or its laboratory system. The Manhattan Project and the Atoms for Peace program were carried out by interlaboratory teams. More recently, laboratories have teamed on many programs that benefit industry consortia. The transportation industry (USCAR), the textile industry (AMTEX), and programs for the oil and gas industry (U.S. Oil and Gas Partnerships) are a few examples. The DOE Basic Energy Sciences Center of Excellence for the Synthesis and Processing of Advanced Materials that was started in 1992 is another example of a program that integrates the capabilities of many laboratories.

The idea of a multilaboratory Virtual Technology Center is a more recent development, though the laboratories were moving in this direction before the advent of the Galvin Committee. These centers are made up of scientists and engineers with a specific technology focus and a formal way of working together, with industry, with universities, and with other customers. Rather than requiring customers to find which lab is best suited to their needs, the Virtual Technology Center does this for them - in effect providing "one stop shopping." A particularly useful feature that has been incorporated into this idea is the user facility concept, which allows industry and academia direct and immediate access to laboratory facilities and equipment.

Virtual Technology Centers differ from projects or programs in that they represent the basic competencies of the laboratory system and serve many projects or programs. Advisory boards made up of customer representatives from academia and industry provide guidance and help develop roadmaps for the advancement of technology. The inclusion of customer representatives on the advisory boards, something that has been done for decades within the laboratory system, and their participation in developing the technology roadmaps helps assure the relevance of the research and development performed by the centers.

The first virtual technology center for bioprocessing was formed in 1993, a second is being formed in advanced robotics technology, and over a dozen other centers are in the embryonic stage of formation. Integrating competencies across the laboratories through a virtual center would be expected to accelerate the advancement of technology, assure customer accessibility to the best resources, aid retention of core competencies, reduce cost, and help the laboratory system be a technology provider of choice for specific technologies in the 21st century. All of these benefits are particularly useful in a time of constrained federal support.

In summary, a policy that supports the formation of virtual technology centers, in particular with support for a built in user center(s), is moving in the right direction.

Work for other federal agencies and for the public and private sector directly supports DOE's goals. This work also stimulates new research and development initiatives, is a key part of the technology transfer function, and helps to sustain and build the laboratories' core competencies. Although Work for Others (WFO) funding comes primarily from other Federal agencies, work with the private sector is increasing. In this manner, WFO provides benefits to the nation. WFO has served as the primary mechanism for providing DOE's highly specialized and/or unique technical capabilities to non-DOE entities. As DOE's budgets have declined, it has also served as a means of retaining, and advancing, scientific and technical excellence within DOE. To the benefit of DOE, the capabilities and advancements made with WFO funding have often found ready application within DOE itself. The report of the Task Force on Alternative Futures for the National Laboratories (the Galvin Task Force) noted, "There is abundant evidence for the beneficial role the national laboratories could play in helping resolve national problems in the numerous advances that they have already made."

Clearly, both DOE and its laboratories benefit from WFO. However, several impediments are imposed by the requirements governing the WFO program. Since FY 1989, DOE has seen a continual decrease in WFO funding. In FY 1995, the amount of new WFO funds coming into DOE has dropped significantly. Among likely reasons for this decrease, one is the decline in research dollars available from the Department of Defense (DOD) and other federal agencies. Another likely reason that is not so obvious involves sections of two acts passed by Congress: (1) the National Defense Authorization Act of 1994 (November 1993), Sect. 844, "Department of Defense Purchases through Other Agencies" (also known as the "Levin amendment"), and (2) the Federal Acquisition Streamlining Act of 1994 (November 1994), Public Law 103-355, Sect. 1074, "Economy Act Procedures." This legislation was intended to streamline work between agencies while ensuring an end to past abuses reported by the DOD Inspector General. The result of this legislation has been a series of letters and procedures implemented by DOD that make obtaining approval for Economy Act orders increasingly difficult and labor intensive. Although these DOD actions are applicable to all Economy Act orders, the primary agency affected is DOE. Unfortunately, these letters and procedures have often gone beyond the strict requirements of the legislation. Even ongoing DOD projects at DOE that have been very successful are seeing difficulty in obtaining continuation funding. As other federal agencies begin to implement the Streamlining Act of 1994, which contains language that is very similar to that in the Levin amendment, it is expected that work with these agencies will become increasingly difficult. Actions to reverse this negative trend in WFO funding could include (1) direct, high-level meetings between DOE and other Federal agencies, DOD in particular; (2) strong direction to revisions currently being considered to the Federal Acquisition Regulations; (3) discussions with members of Congress and their staff to seek non-legislative means to clarify Congressional intent with emphasis on streamlining and removal of bureaucratic hurdles; and (4) new legislative language with emphasis on actions that streamline but still restrict system abuses.

Another impediment to work with other organizations is DOE's imposition of an "added factor" of 4.3 per cent on work for other federal agencies and a surcharge of 23 per cent (depreciation plus added factor) for work for private industry, except for a few areas directly related to nuclear energy. This severely limits DOE's ability to work with private industry. The DOE added factor policy should be revised to allow waivers in areas outside nuclear energy that have been added to the missions of the national laboratories since the creation of the AEC. The report of the Galvin Task Force notes that DOE "will, among other actions, have to consider reducing its cost-recovery fees levied on all WFO. These fees now signal that contributions to the tasks faced by other agencies of government are not a high priority with the Department." A significant reduction in the DOE added factor and a streamlined process for the granting of waivers for work benefiting any DOE program would promote technology transfer.

Elaborate oversight of WFO by DOE constitutes an additional impediment. The present approval process for WFO, while it has been significantly improved, remains cumbersome and requires unique knowledge to negotiate certain steps. The schedule and timing of the process are not always appropriate or necessary, and delays can preclude rapid response to opportunities.

The report of the Galvin Task Force states that DOE "must take positive steps to encourage" the national laboratories to contribute to the solution of national problems and recommends that "The national laboratories... should become in fact, as well as in name, national laboratories." The national laboratories need to be national laboratories in more than name only. I believe that DOE is committed to working aggressively with other agencies to match laboratory capabilities with national research and development needs. At ORNL, we are hopeful that one result will be increased opportunities for the national laboratories to participate in some important research areas in solicitations by other federal agencies (notably the Environmental Protection Agency, the NSF, and the U.S. Department of Agriculture). ORNL also looks forward to the comprehensive report on work for other agencies that is being prepared for presentation to the Laboratory Operating Board.

Federal law, regulations, and DOE orders all require that a valid appropriation or budgetary resource exist before obligations may be made or costs incurred for work performed at a national laboratory. In compliance with guidance from DOE (letter of June 29, 1994, from Thomas T. Tamura. DOE Principal Deputy Assistant Secretary, Human Resources and Administration, to Alvin W. Trivelpiece, Director, ORNL), a cash advance is now required for proprietary work in user facilities sufficient to maintain a 90-day prepayment. This guidance is not consistent with industry's customary practice of not paying in advance for work to be performed; it is offensive to potential customers; it is overly complicated to manage; and it creates a barrier to encouraging industrial participation in DOE work.

SUMMARY

The DOE national laboratories have a valuable roles to play in the nation's long-term science and technology enterprise, but they must be managed so as to take effective advantage of their unique attributes. I hope that the Congress and the Administration will work together to find ways to continue the work at the laboratories and not succumb to pressures to do away with them.