CONF-9007140--1

CONF-9007140--1

DE90 015165

DEPARTMENT OF ENERGY NATIONAL LABORATORIES

Alvin W. Trivelpiece

Director

Oak Ridge National Laboratory

Testimony Before the

Subcommittee on Energy Research and Development

Committee on Energy and Natural Resources

United States Senate

July 25, 1990

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TESTIMONY
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Alvin W. Trivelpiece
Oak Ridge National Laboratory

Mr. Chairman and Members of the Subcommittee, I am pleased to have the opportunity to testify before this Subcommittee to present my views on the current operations and future mission of the Department of Energy's national laboratories and, specifically, to focus on the activities of the Oak Ridge National Laboratory. Because I served for six years as the director of the Office of Energy Research and am now the director of Oak Ridge National Laboratory, I believe I have a unique appreciation for the diversity and strengths of the Department of Energy's laboratories.

My previous testimony before this Subcommittee has made you aware how important I believe science and technology are to the economic health and well-being of the Nation. It is important that these programs be well-funded. The Department of Energy has played a pivotal role in funding this nationwide collection of activities and I believe it will continue this role in the future. DOE is a leader in energy and science and in national security. I concur with the statement made before this Committee on February 22, 1989 by Secretary of Energy-Designate James C. Watkins. He said that "the Department of Energy's national laboratories are home to some of the world's brightest and most innovative scientists and engineers. These creative minds are a precious national asset...."

The relationship between the Department and the national laboratories began to evolve in the 1940s when the Manhattan Project was expanded into the Atomic Energy Commission. In those early days, the majority of the Commission-sponsored research was performed by a complex of national laboratories through a unique contractual partnership with universities and industry. Several of the Government-owned, contractor-operated laboratories were multidisciplinary because of the need for expertise in virtually all of the sciences. This was true not only for the Manhattan Project but also later when nuclear power research became a laboratory mission. The multidisciplinary nature of the laboratories' missions expanded even more with the establishment of the Energy Research and Development Administration. Today, the DOE laboratory complex comprises the largest group of Government-owned, contractor-operated facilities in the U.S. and, indeed, the world.

The accomplishments of the Department's research laboratories are extensive, evidenced by a summary early history and some of its most notable achievements. I would like to summarize ORNL's early history and mention of a few of its notable achievements. ORNL began as a pilot plant during the Manhattan Project. Clinton Laboratories, its original name, was set up to test the plutonium production methods planned by the University of Chicago's Metallurgical Laboratory. That mission led to Oak Ridge being assigned the responsibility of building and operating a reactor to serve as a pilot plant for the large-scale production operations at Hanford, Washington. Even though it was only the second reactor ever to be constructed, it was the first to employ forced cooling, and to incorporate provisions for shielding, controls, and some other special operating requirements. Later, Oak Ridge began a program of nuclear technology education. This training course was so successful that ORNL was selected to supply trained personnel for the Atomic Energy Commission's reactor development program. The course became the Oak Ridge School of Reactor Technology. Among the graduates of this program in the early 1950s was the Secretary of Energy Watkins.

In 1955, ORNL built and then shipped an operable swimming pool reactor, then reassembled it on the grounds of the old League of Nations in Geneva for the first United Nations International Conference for the Peaceful Uses of Atomic Energy. At this conference, Liane Russell, still a member of the ORNL Biology Division, delivered a paper on studies of the effects of radiation on mouse embryos. The findings she reported resulted in a change in medical practice, as doctors became more aware of the potential hazards of x-rays on pregnant women.

ORNL constructed the first heavy-ion cyclotron and founded the field of heavy-ion physics by establishing the general properties of heavy ion elastic, transfer reactions, and compound nuclear reactions. The giant quadrupole resonance was discovered and established as a general property of nuclear matter. ORNL was the first to measure damage of reactor neutron (thermal and fast) radiation in metals and alloys. This paved the way for the development of an important area of materials science. The first measurements of radiation-induced creep were made and the importance of this phenomenon in nuclear reactor structural components was established and widely recognized in the world energy community. The world is a better place because ORNL's contributions as part of the Department of Energy. The first cyclotron especially designed to produce large quantities of radioisotopes for medical research was constructed at the Laboratory. The Department has supported the nuclear medicine industry and the medical isotope needs of customers throughout the world with ORNL's production of medical isotopes that are not commercially available.

Many significant accomplishments in the area of nuclear reactor engineering are attributable to ORNL, including the development of theories and data which are the foundation of the shield design for reactors and other radiation sources throughout the world. The design of pressure vessels has been greatly improved through applications of the theory and data from the ORNL Heavy Section Steel Program Staff were recently honored by the Nuclear Regulatory Commission for "25 years of continuous outstanding research accomplishment." The results of this program have provided an assurance of safety necessary for the light water reactor pressure vessel which has been accepted by regulatory bodies in the United States and other countries. The first major research reactor, the Materials Testing Reactor, was designed at ORNL. Reactor development is continuing beyond the High-Flux Isotope Reactor to the next generation of research reactor, the Advanced Neutron Source.

Materials science is a discipline in which ORNL research has had a significant impact. Hastelloy N alloy was developed and commercialized at ORNL for high-temperature structural service. Low-swelling, radiation-resistant alloys were invented and developed at ORNL for liquid-metal fast breeder reactor and fusion devices. The 9-Cr 1-Mo steel used in fossil and nuclear power plant structures was commercialized here. These efforts in materials development continue today with products such as the iron and nickel aluminides, which offer increased performance to assist national efforts in improved energy efficiencies.

ORNL's health and environmental research activities have had a worldwide impact. For many decades, the Laboratory has served as the prinicpal developer and reference source for models and techniques for estimating radiation doses received by humans. These models and techniques have been uniformly adopted by essentially all nations through the recommendations of the International Commission on Radiological Protection.

ORNL's research and analysis of power plant effects have resulted in both national criteria for water temperatures necessary to protect aquatic life (adopted by the National Academy of Sciences and the Environmental Protection Agency) and guidelines for the siting, design, and operation of power station condenser cooling systems.

The Department of Energy national laboratory system is composed of not only multiprogram laboratories, like those represented on this panel, but also single program laboratories like the Princeton Plasma Physics Laboratory, Fermi National Accelerator Laboratory, Oak Ridge Associated Universities, Solar Energy Research Institute, and the Stanford Linear Accelerator Center. The unique role of these laboratories in the DOE complex can be seen in the accomplishments of one, the Ames Laboratory. This facility developed the process for uranium production during the Manhattan Project. Since that time, this process has produced all of the uranium used in the western world. The ion exchange process for separating the lanthanide (rare earth) elements was developed at Ames. Worldwide recognition has been gained by Ames for its materials synthesis and processing capabilities in metals, polymers, composites and nanocrystalline materials. It produces quantities, with world-record purity levels, of over half of the naturally occurring metals and many other elements, compounds, and single crystals. These materials are requisite to forefront materials research programs in the United States and throughout the world. Ames has developed techniques and instrumentation for inductively coupled plasma - atomic emission spectroscopy and inductively coupled plasma - mass spectroscopy. These developments have revolutionized the science of analytical chemistry and resulted in major new worldwide activity.

Designated by Executive Order as a National Center for Basic Scientific Information on Superconductivity, Ames established and still publishes the High Tc Update , one of the world's leading information sources in the area of superconductivity. The first proof that the 1-2-3 high temperature superconductors (yttrium barium copper oxides) are metals was established at Ames. Ames is now patenting a unique process for the production of high temperature superconducting wires. With Iowa State University, they have established a unique technology-development, -transfer, and

-utilization enterprise which is being increasingly recognized as a model worthy of replication. Ames maintains one of the largest, if not the largest, (relative to size of the operations budget) graduate student and postdoctoral training programs in the entire national laboratory system. Approximately 175 graduate students and 40 postdoctoral associates are in residence at any time. Since its inception in 1947, Ames Laboratory has "graduated" over 1350 Ph.D. and 1000 M.S. students.

National laboratories do not exist in isolation. They have a long history of relationships with the university and industrial communities through a variety of mechanisms. Some laboratories have particularly close relationships with universities because their operating contractor is a university or university consortium. Large numbers of university faculty and students (sometimes up to 20% of the full-time equivalent staff) work for extended periods at almost all the labs. Other kinds of relationships have also been developed. The University of Tennessee, Knoxville, and the Oak Ridge National Laboratory are collaborating on a joint Distinguished Scientist program among a host of joint ventures.

Laboratory relationships with industry have also been significant. The history of the development of the nuclear power industry is but one example of the fruits of such relationships. Currently, relationships take the form of subcontracting with industry for technical and engineering analyses and component and hardware development, and participation by industrial scientists on DOE laboratory advisory and peer review groups. Today industry personnel and Laboratory staff work side by side to solve common problems using DOE user facilities. Several facilities merit particular mention. The Combustion Research Facility at Sandia-Livermore facilitates laser diagnostics studies of combustion systems. The National Synchrotron Light Source at Brookhaven National Laboratory serves the physics, materials, chemical and biological research communities. Industrial users have contributed to the NSLS by building beam lines to meet specific research needs. IBM has built a special beam line to conduct research on x-ray lithography, a process of great potential in the production of computer chips. These industry-funded beam lines are also made available for a portion of the time to the general research community.

To continue, at Oak Ridge National Laboratory, cooperative arrangements have resulted in a Roof Research Center complex that is partially funded by industry. Our capabilities in roof research are enhanced by a large-scale climate simulator which we are using in tests for Attic Seal, Inc., a small innovative roofing company. This user facility can measure performance of attic insulation products in one day for a range of temperatures representing all seasons and all locations in the United States. Increased knowledge of the thermal efficiency of insulating materials will lead to reduction in heating and cooling requirements of residential buildings. In another activity conducted at the facility, the Society of the Plastics Industry and the Polyisocyanurate Insulation Manufacturers Association, the National Roofing Contractors Association and ORNL are studying the impact of replacing CFCs in foam insulation boards. These CFC-based products have a 60% share of the flat roofing market and currently provide substantial energy savings benefits. Before the industry switches to alternative products to reduce the ozone depletion potential believed to be connected to the use of CFCs, these strategies must be tested for thermal and mechanical acceptability.

Within this fiscal year, the High Temperature Superconductivity Pilot Center at ORNL has increased to a total of 15 its number of cooperative agreements with industry. Industry is sharing more than half of the costs in this program. This shows the potential of the laboratories in working with industry in the materials science areas. Other recent achievements include signing a patent license agreement on plasma-etching technology with SEMATECH and a collaborative agreement with Garrett Ceramic Components, Inc., for research on gelcasting.

The Oak Ridge Detector Center was established this fiscal year as an interface organization with detector collaborators from universities, industries, and foreign countries. ORNL will be a major U.S. base for the research, design, integration, and construction of the Lone Star (L*) detector, one of the detectors proposed for the Superconducting Super Collider.

Over the years, the national laboratory system and its programs have been the subject of several reviews. At the request of the Deputy Secretary in 1981, the Energy Research Advisory Board examined the roles of the national laboratories (<u>Final Report of the Multiprogram Laboratory Panel</u>, Energy Research Advisory Board, September 1982). I testified on "The Future of the Department of Energy's Multiprogram Laboratories" before the House of Representatives Committee on Science and Technology, Subcommittee on Energy Development and Applications, and the Subcommittee on Energy Research and Production on December 2, 1982. ERAB found that, "The multiprogram national laboratories complex constitute an impressive national and research and development asset. Moreover, it possesses capabilities for the performance of large-scale, long-term, high-risk, multidisciplinary research and development." They also made several recommendations, such as continuing review of the roles and missions of the laboratories, improvement of the institutional planning process, and increased cooperative use of facilities by universities and industry.

Several other reviews of the national laboratories have focused on similar issues. Ensuring that governmental research and development establishments are assigned significant and challenging work, simplifying management controls, and giving laboratory directors more authority to command resources and make administrative decisions was also mentioned in the Bell report to the President in April 1962. To make effective use of the technical and management capabilities in the field by increasing the delegation of program execution authority to the field is a recommendation of the December 1975 report to the Field and Laboratory Utilization Group that was convened at the beginning of ERDA. These are reports are all referenced in "The role of the National Laboratories in Energy R&D", Hearings before the House of Representatives Committee on Science and Technology, Subcommittee on Fossil and Nuclear Energy Research, Development and Demonstration, November 2, and 3, 1977 and May 16, 1978. The recommendations of the sixties and seventies are consistent with what ERAB has concluded.

While I was Director of the Office of Energy Research, I was involved in an assessment of the Office of Basic Energy Sciences Program. Out of approximately 1200 active projects, a sample of 129 projects was selected for review by panels of scientific peers (An assessment of the Basic Energy Sciences Program, Report DOE/ER--0123 V 1 and 2). The panels rated individual projects on the basis of quality of science, quality of the project team, and probable impact on the Department's mission.Overall, the peer review panels gave this program high ratings in quality of science, quality of project team, and mission impact. Based on ratings of the sample projects, the peer review examination found a large percentage, about 60%, of active projects to be of high quality overall; indeed, 10% were rated to be of exceptional excellence. Only a small fraction, about 10%, were judged as having significant shortcomings.

The President's Private Sector Survey on Cost Control in their "Task Force Report on the Department of Energy, the Federal Energy Regulatory Commission, and the Nuclear Regulatory Commission" (April 15, 1983) recommended several initiatives relating to missions, laboratory management, increased participation and collaboration with private industry.

George Keyworth, the President's Science Advisor, established the Federal Laboratory Review Panel to review the federal laboratories and to recommend actions to improve their use and performance. Chaired by David Packard, this Panel in their report ("Report of the White House Science Council", May 1983) made recommendations concerning mission; personnel; funding; management; and interactions with universities, industries and users.

Recommendations assessing national needs have been prepared by several review committees. Several reports have focused on the needs of the materials science community. At the request of George Keyworth, the National Research Council prepared a report on the priorities for major materials facilities (Major Facilities for Materials Research and Related Disciplines, Major Materials Facilities Committee, Commission on Physical Sciences, Mathematics, and Resources, National Academy Press, 1984) . Under the direction of co-chairmen Frederick Sietz and Dean Eastman, the Committee recommended construction of a 6-GeV Synchrotron Radiation Facility, an Advanced Steady State Neutron Source Facility, a 1-2 GeV Synchrotron Radiation Facility, and a High-Intensity Pulsed Neutron Source Facility. These recommendations were reiterated by a recent National Research Council report (Materials Science and Engineering for the 1990s, Maintaining Competitiveness in the Age of Materials, Committee on Materials Science and Engineering, National Research Council, National Academy Press, 1989).

On October 2-4, and 22-24, 1985, the Task Force on Science Policy of the House of Representatives Committee on Science and Technology held hearings on "Science in the Mission Agencies and Federal Laboratories." I testified on these activities relating to the Department of Energy and its relationship with the federal laboratories.

The Department of Energy and its contractors have been recognized as leaders in our national R&D effort. In the 1989 competition, the Department of Energy laboratories and facilities won 18 R&D 100 awards. It is no accident for this organization to be recognized as producing this many of the 100 most significant technical developments in the previous calendar year. Neither was this just a single occurrence. Over the previous 26 years, the Department and its laboratories have received more than 250 awards, with Argonne and ORNL among the top eight award winners.

The magazine High Technology Business, in its November-December 1989 issue ("Technology hits and misses of the 1980's"), features three results from Department of Energy research in the twenty key technology developments of the last decade: ORNL's nickel aluminide alloys and whisker-toughened ceramics and Brookhaven's National Synchrotron Light Source. ORNL and the other facilities of Martin Marietta Energy Systems have 44 license agreements in effect as of July 1, 1990. These have generated royalties in excess of $1.1 million and product sales of about $27 million.

In his July 6, 1990, memorandum to directors of Department of Energy laboratories, Secretary Watkins provided policy guidance for the FY 1991 through FY 1996 institutional planning process. He highlighted several objectives needing integration: "Technology transfer is a mission for the National Laboratories and the DOE. High priority on making the Department's resources available to improve mathematics and science education...consider the opportunities that exist to address challenges in environment, safety, and health...." Several efforts in these areas are of particular interest.

Technology transfer efforts throughout the Department are important to the Department's mission. Recent accomplishments in technology transfer from DOE and its laboratories have been highlighted in the Department's publication Technology '89. This publication provides summaries of technology transfer highlights from the previous year and ways for industry and universities to interact with both the multiprogram and single program laboratories.

According to July, 1990 issue of DOE This Month, scientists from Brookhaven, ORNL, and Sandia were the latest announced winners of Federal Laboratory Consortium Awards for Excellence. At Brookhaven, Leonard Hamilton and Paul Moskowitz were cited for their work with the photovoltaics industry, identifying health and safety hazards, as well as risk management approaches for new manufacturing materials. Brookhaven's Meyer Steinberg was honored for his efforts in promoting industrial acceptance of HYDROCARB, a novel process for making clean carbon fuels. Pete Witze and Elson Porter of Sandia-Livermore were recognized for initiating a partnership with industry leading to commercialization of a fiber-optic-instrumented spark-plug probe for seeing inside auto engines while they are running. Bob Blewer of Sandia-Albuquerque was recognized for his role in the development of technology for use in chemical-vapor-deposited tungsten and in transfer of the technology for use in commercial microelectronics processes and products.

ORNL's Victor J. Tennery was honored for conceptualizing, starting, and managing the High-Temperature Materials Laboratory. Users represent more than 80 universities, industrial firms, and other government facilities. In FY 1989, external use amounted to a total of 581 industry, 248 university, and 9 other government laboratories user days. In addition, there were 31 proprietary user days of the facilities at full cost recovery. HTML is showing increased activity during this fiscal year.

Last year, more than 15,000 students participated in ORNL educational programs. Many of these students are in precollege activities designed to spark interest in science and mathematics education. Programs and activities were presented at our Ecological and Physical Sciences Study Center. Last week, I met some of the students that participated in the DOE High School Honors Program at ORNL. They represented all states and several foreign countries. Each of the national laboratories participating in this program focuses on a different subject. At ORNL, the students study environmental sciences for their two-week period. We have programs for high school and college teachers, high school and college students, and joint graduate programs with The University of Tennessee, Knoxville, in biomedical and environmental sciences. ORNL is continuing to expand our contacts within the minority educational community. For example, we are participating with the Science and Technology Alliance, along with Sandia and Los Alamos National Laboratories in an effort to increase the representation of Blacks, American Indians, and Hispanics in DOE's scientific and engineering programs. We have also adopted Vine Middle School in Knoxville, a predominantly Black institution as part of Secretary Watkins Adopt-A-School program. A recently signed joint agreement between the Department of Energy and the Appalachian Regional Commission will provide educational experiences at ORNL for students and teachers. An agreement, between DOE and Coca-Cola also involves ORNL and Washington, D.C. high school students. Martin Marietta Corporation has committed $1 million for a three year program with The University of Tennessee, Knoxville, to enhance science and mathematics education in this area.

Environmental research and development is an important research area at ORNL. The diversity of the research program can be seen through several examples. Through our Carbon Dioxide Information Analysis Center, ORNL has become a center of expertise in the investigation of the effect of increasing carbon dioxide and changing climate on natural and societal resources. The Center's data holdings include such diverse information as tree-ring chronologies, surface air temperature anomalies, and atmospheric carbon dioxide concentrations. The Center has recently been asked to apply for certification as World Data Center A. If successful, this would be the first time since 1956 that this designation has been awarded.

ORNL has founded the concept of "systems ecology," using mathematical models to integrate information on radionuclide transport in ecological systems both on land and in water. This was diversified to include contaminants and other features of the growth and energy budgets of ecosystems. Our ecologists took the lead in the environmental impact analysis for the National Environmental Policy Act environmental impact statements for nuclear power plants, including the full range of nonradiological and radiological issues. During the 1960s, pioneering studies were performed at ORNL on the radionuclide transport in terrestrial plants and waterborne transport of radioactive contaminants down the Clinch River. Revelations of mercury contamination and other environmental ills on the Oak Ridge Reservation again involved the ORNL scientists in monitoring and testing local effluents for toxicity. The Laboratory provided rapid and extensive assistance during the Three Mile Island incident making, chemical, and isotopic measurements. ORNL developed the process for the cleanup of the water from the containment building.

The use of the major research performers -- federal laboratories, universities, and industry -- has resulted over the years in a balanced approach aimed at using the best performer for a given task. The private sector provides technological advances of interest to the marketplace in close cooperation with the national laboratories. Long-term research in the national interest beyond what can be expected from private industry is an appropriate federal role. It is important to maintain core basic and applied research programs in the laboratories, particularly in situations where capital-intensive equipment is required, long-term research is involved, or where research aimed at developing new energy technologies involves large uncertainties or important energy-related environmental factors.

The importance of university involvement is stressed in two ways: developing new and innovative scientific and technical concepts, and preparing and training students. Our commitment to training students for future science and engineering careers extends to the precollege level.

Both the universities and the laboratories are key links to the transfer of technology to the private sector. This transfer of knowledge, and ultimately, technology into use in the private sector where it can contribute to the nation's economic health and well-being and national security is our overriding goal. Through the Department's R&D Laboratory Technology Transfer Program, managed by the Office of Energy Research, and legislation like the National Competitiveness Technology Transfer Act. My colleagues in other facilities in Oak Ridge are enthusiastic about the Advanced Manufacturing Initiative agreement announced on July 18, 1990, by Secretary Watkins. Success in initiatives of this type, the user facilities, the High-Temperature Superconductivity Pilot Center concept, with the serendipity available at the national laboratories, will benefit not only technology transfer but our national competitiveness, as well.

There is immense value to the nation in the R&D programs supported by the Department of Energy and of the R&D performers who carry them out. Other major contributors that are not recognized as frequently are the Department of Energy staff who provide the long-term programmatic direction for these activities. I appreciate their dedication and service to this national mission.