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NEW TECHNOLOGIES ON ECONOMIC COMPETITIVENESS

HEARINGS

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

NINETY-NINTH CONGRESS

FIRST SESSION

ON

EFFECT OF NEW TECHNOLOGIES ON ECONOMIC COMPETITIVENESS: TECHNOLOGY TRANSFER

APRIL 17, MAY 2, AND JULY 1, 1985

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WEDNESDAY, APRIL 17, 1985

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:38 a.m., in room 253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff members assigned to these hearings: Cassie Phillips and Charlene Woods, staff counsels; and Pat Windham, minority professional staff member.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to our hearing this morning to examine whether federally developed technologies are being transferred to the private sector and State and local governments in an appropriate fashion.

The need for practical transfer of research results to the marketplace appears to be greater than ever. The President's Commission on Industrial Competitiveness has warned that the United States is losing its ability to compete in world markets. The Commission's 1985 report notes that the United States has lost world market share in 7 out of 10 high-technology sectors. Although foreign trade barriers and the strength of the dollar are contributing factors to this decline, Business Week stated that the basic problem is the failure of American high technology companies to translate new technology consistently into competitive products. The Commission on Industrial Competitiveness agreed and also noted that the United States has failed to apply its own technologies to manufacturing. Robotics, automation, and statistical quality control were all first developed in the United States, but in recent years they have been more effectively applied in other countries.

Much of the new technology that is available for utilization is developed in Federal laboratories. The Federal Government funds approximately half of this Nation's total research and development, and much of this work is performed in Government-owned laboratories. The scientific and engineering expertise, the technology base, the facilities and equipment within these laboratories are valuable natural resources. More effective utilization of the research

results and research capabilities of Federal laboratories will promote economic growth and enhance industry's ability to compete in international markets.

At today's hearing, we will look at how technology transfer is being accomlished and examine methods to improve the transfer of Government technology. We will also examine the effectiveness of the Stevenson-Wydler Technology Innovation Act in promoting technology transfer efforts and consider whether any changes to the Stevenson-Wydler Act are appropriate.

We are pleased to have with us today several witnesses who will aid in the evaluation of present technology transfer efforts.

I would like to welcome all of you and thank you for taking the time to share this valuable information with the committee.

Senator Riegle, do you have a statement?

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Mr. Chairman, I want to thank you for scheduling this hearing. I believe that our national competitiveness, particularly in technology, is the most critical issue facing the long-term economic security of this Nation.

I am particularly pleased that today we will have the opportunity to hear from a member of the President's Commission on Industrial Competitiveness. I have read the Commission report and it is a lucid statement of the problems we are facing:

> Our ability to compete internationally faces unprecedented challenge from abroad. Our world leadership is at stake and so is our ability to provide for our people the standard of living and opportunities to which they aspire.
>
> Americans must take on the challenge of competitiveness as the economic agenda for the next decade.

We cannot continue to create jobs, compete in the world economy and retain our standard of living without a technological advantage. To keep our edge we must do everything we can to foster innovation and the infrastructure in American manufacturing. This includes education, basic research and technology transfer.

The need to act could not be clearer. Yet, I am disturbed to note that instead of moving ahead we are going back and forth in an effort to save the few programs already in existence.

Today's hearing focuses specifically on the Stevenson Wydler Innovation Act of 1980. Stevenson Wydler is the one program enacted over the past 5 years that addresses the problem. Yet the administration has virtually ignored the program.

Two weeks ago we looked at the technology transfer side of the program. Today we will look at the need for industrial technology centers and the organization of R&D within the executive branch. Not one cent has been requested for the centers. The National Technology Board mandated by the act has still not been established. And now the administration is proposing to eliminate the Office of Productivity, Technology and Innovation.

Other nations are engaging in concerted, coordinated efforts to build-up their national competitiveness. We cannot expect to compete unless we are willing to make critical investments in our own long-term competitive future.

Today's hearing should give us an opportunity to learn more about technological innovation and our ability to compete in world

markets. I only hope that this is also the beginning of an effort by Congress and the administration to work together with industry, universities and labor to ensure that our Nation remains on the cutting edge of technological change.

Senator Hollings has a statement for the record

[The statement follows:]

OPENING STATEMENT BY SENATOR HOLLINGS

Mr. Chairman, American industry is in trouble. We are losing the international economic contest, particularly in the crucial area of manufacturing. Our staggering trade deficits testify to the challenge that we face and our failure to meet it.

Our Federal government must act to improve the competitiveness of American industries, or we will lose them. We must bring down the value of the dollar by reducing our massive budget deficits. We must begin enforcing trade laws which are already on the books. And we must act to maintain and strengthen America's role as the world leader in science and technology.

Last year the Federal government spent some $48 billion on research and development. Yet the President's own Commission on Industrial Competitiveness concluded that not nearly enough of this enormous Federal effort is devoted to improving industrial competitiveness. The Commission singled out manufacturing technology as one area which needs particular emphasis.

The National Science Foundation and the National Bureau of Standards are doing what they can to strengthen industrial technology, but these agencies comprise only a small part of our overall Federal R&D effort. They cannot do it all. This point leads us to the subject of today's hearing: the transfer of unclassified technology from other Federal agencies, and particularly technology from Federal laboratories, to the states and private business.

The Federal laboratories possess an immense amount of scientific expertise. They create a large number of new inventions. Yet only five percent of Federally-owned patents are ever utilized. Although we cannot expect the Federal laboratories to provide the solutions to our Nation's problems of competitiveness, we must ensure that their vast reservoir of talent and inventions is better utilized to support economic development in this country.

Today we will review several programs to improve the transfer of Federal technology to the States and industry, including the Federal Laboratory Consortium, NASA's Technology Utilization Program, and the laboratory offices created under section 11 of the Stevenson-Wydler Technology Innovation Act. We will also review how well these programs are working with exciting new state efforts to provide technical information and assistance to business. I look forward to seeing our witnesses' suggestions on how to improve the process of technology transfer and how to ensure that Federal R&D does more to promote industrial competitiveness.

Senator GORTON. We will begin with our first panel: Dr. Eugene Stark, Chairman, Federal Laboratory Consortium for Technology Transfer; Gen. Richard H. Thompson, commanding general, U.S. Army Materiel Command; and Mr. Isaac T. Gillam, Assistant Administrator for Commercial Programs, NASA.

Welcome, and we will begin with Dr. Stark.

STATEMENT OF EUGENE E. STARK, JR., CHAIRMAN, FEDERAL LABORATORY CONSORTIUM FOR TECHNOLOGY TRANSFER, LOS ALAMOS, NM

Mr. STARK. Thank you very much, Mr. Chairman. I am very pleased to be here on behalf of the Federal Laboratory Consortium for Technology Transfer and in the company of individuals whose organizations have made outstanding commitments and results in Federal technology transfer.

Sir, the Federal laboratories have demonstrated that they have a wealth of resources, technology and expertise that can and must be made pragmatically available for use in the U.S. public and private sectors. But my feeling is that, overall, on a nationwide basis, this

process is operating at less than 50 percent effectiveness. I would like to address very briefly some of the processes and methods of technology transfer and what might be done to make this a more effective overall process.

The process of technology transfer is one that encompasses a variety of methods. The method used in a specific transfer will depend very much on the laboratory in which the technology was developed, its state of development, the identity of the user and the type of technology in and of itself.

The keys to this process in making it work are active efforts by the laboratories to make their technology pragmatically available on the outside; person-to-person interaction by the laboratory researchers with the potential users of technology; and networking among the laboratories to share ideas, share technology, and to multiply their resources and effectiveness on a fully nationwide basis.

The methods of Federal technology transfer are varied, but include, for example, visits, workshops, and presentations, also the use of specialized user facilities within the laboratories, exchange of personnel, cooperative or collaborative programs, volunteer programs established by the laboratories, technical assistance, entrepreneurship by individuals working within the laboratories, as well as licensing of intellectual property.

As one very specific example in your own home State of Washington, the Pacific Northwest Laboratory has established an outstanding program which not only assists in detail the city of Spokane, but has established liaisons and people on assignment in the city of Seattle for university and industry relations, and through the network of our Federal Laboratory Consortium specifically has forged contacts between various agencies in Washington State government and private organizations, such as the Boeing Corporation with a number of Federal laboratories nationwide to provide the widest possible resource to the constituents in the State of of Washington.

I believe, sir, that the Stevenson-Wydler Act clearly gave permission for technology transfer from the Federal laboratories that did not already have that as a permission or as a mission. What appears needed now is a mandate for effective technology transfer.

I think that the actions required to make it work fall into three categories. First, a long-term commitment by and cooperation among the administration and Congress, the agencies and the laboratories, to make this a truly national resource and a long-term national activity. Second, a further development of the resource; that is, insuring that all laboratories make active efforts in technology transfer and cooperate together. Third, the development of demand, making it clear to the public and private sectors, to large and small business, and to universities that the technology and expertise of Federal laboratories are both valuable to them and are pragmatically available to them.

Along those lines, I would propose six specific initiatives to strengthen Federal laboratory technology transfer.

The first would be a very clear mandate for effective technology transfer from each agency and laboratory, decentralized to the laboratory so that it has a stake in its own results and develops its

own program, but with one very important aspect, and that is that every major laboratory should have one professional assigned full time to technology transfer. Only in that way can the process of institutional change and acclimatization to technology transfer take place and can true accountability on an institutional and personal basis be developed.

Second, technology transfer should be required as a part of each Federal laboratory program so that identified moneys can be made available by the agencies for technology transfer and the individuals within those programs can be expected to make active efforts in technology transfer.

Third, I propose that there be special access to Federal lab technology for small business, universities and state and local governments. This would encompass both active efforts by the laboratories to work closely with those potential users of technology in order to establish long-term cooperative arrangements, and also to streamline any procedures needed for collaborative arrangements between the laboratories and those entities.

Fourth, I would propose strengthening the cooperation of the Federal laboratories through our Federal Laboratory Consortium for Technology Transfer. The first aspect would be stronger networking among the laboratories to provide efficient access of all public and private sector groups across the country to all the Federal laboratories across the country, while at the same time making for efficient use of each laboratory's resources. The second would be increased marketing of technology transfer to individual organizations as well as to user groups, such as the Conference of Mayors, trade associations, and others who represent a number of potential users of technology. The third area would strengthen our developing methods of technology transfer, providing training for new professionals, and assistance to laboratories in establishing or strengthening their programs.

The fifth initiative that I would suggest is developing national and regional forums to network the networks.

We find among the witness list for today's hearing representatives from the OTTO organization, from PENNTAP and others who represent a number of users. There are many university groups who are interested in sharing resources, and, of course, we do have the Federal Laboratory Consortium and its regional groups around the country.

There are many networks that involve potential users of technology and also networks of people involved in sources of technology.

We need to network these networks together to make technology transfer work better on a national basis.

Finally, the sixth initiative that I would mention is to strengthen the use of intellectual property through pragmatic availability, for example, of patent licenses on as much as possible a decentralized basis so that marketing the use of intellectual property can be tied very closely to the source of that intellectual property.

Thank you very much.

[The statement follows:]

STATEMENT OF EUGENE E. STARK, JR., CHAIRMAN, FEDERAL LABORATORY CONSORTIUM FOR TECHNOLOGY TRANSFER

Mr. Chairman and Members of the Subcommittee: It is an honor to appear before you on behalf of the Federal Laboratory Consortium for Technology Transfer to discuss the Stevenson-Wydler Technology Innovation Act.

The nation's need to maintain a strong economy and international leadership in science, technology, and their translation into international competitiveness demands that the federal facilities engaged in research, development, engineering and testing ensure that their unclassified technology is made pragmatically available to the US public and private sectors. Outstanding examples of transfer and technical assistance make it clear that there is a wealth of valuable technology in these facilities—but this process is operating overall at less than 50% effectiveness.

This Statement summarizes a perspective on federal technology transfer, the vital networking and support role of the Federal Laboratory Consortium, an analysis of the issues raised by this Subcommittee, and a set of proposed initiatives to strengthen federal technology transfer.

FEDERAL TECHNOLOGY TRANSFER—A PERSPECTIVE

Most federal laboratories' technology transfer programs have developed over the last decade. The strongest lessons learned from the experience of this decade (as well as NASA's longer-running program) include the value of personal interactions and the fact that many different methods of transfer must be employed. The variety of methods described below is needed to adapt the transfer process to the type of technology to be transferred, its stage of development, the location and technical expertise of the receiving organization, the mission and institutional culture of the laboratory, and other factors. Even more important than the method of transfer is the process of linking a potential source of technology with a potential user of that technology. This active linkage process is an important element in successful transfer.

Past technology transfer efforts have already proven valuable to the public and private sectors. Specific examples will be given later, but the list of technology transfer clients includes:

Small Business—The role of small business in new-job creation and innovation is impressive. Informal technical assistance is provided by laboratory staffs; laboratory technologies are adopted and commercialized by small businesses; and some laboratory employees become entrepreneurs and establish technology-based enterprises. Federal laboratories also participate in broader programs to strengthen small and minority-owned enterprises through special procurement programs and through the Small Business Innovation Research program. These activities can significantly strengthen local economic development efforts.

Large Industry—Growing competition in international markets and the role of technology-based goods in US exports have focused attention on industrial innovation and productivity in the past decade. The federal laboratories contribute to these needs through the adaptation of their new technologies by industry, the creation of special staff-development opportunities and their ability to address specific technical needs of industry.

Universities—The federal laboratories provide important research and collaboration opportunities for faculty and students.

State and Local Governments—Through technical assistance and transfer of technology, federal laboratories are a resource for these governments in their efforts to enhance productivity and solve problems, particularly as demands on their services are growing.

Key role of personal contacts

The primary underlying approach in virtually all technology transfers is the key role of person-to-person interactions. A definitive study make at the Sandia Laboratories identified the characteristics of over 72 successful transfers.[1] The results show that the key events initiating the transfer were overwhelmingly face-to-face contacts including presentations, conferences, workshops and personal discussions.

Analyzing the methods used in then transferring the technology, person-to-person interaction was employed in 42% of the successful transfers; reports and journal ar-

[1] "Technology Transfer at Sandia National Laboratories: First Annual Report," Sandia Report SAND83-0345, March 1983.

ticles were a factor in only 25% of the cases. Preliminary analysis of new results covering 163 successful transfers by Sandia reinforces these results.

Personnel exchanges

Temporary assignment of technical staff to another organization can be a very effective means of gaining either existing know-how or detailed perspectives on a technical program from hands-on involvement. The Research Associates program at the National Bureau of Standards (NBS) permits use of unique facilities and expertise that would otherwise be unavailable to the sponsoring companies or trade associations. Through this mechanism, for example, a significant fraction of dental-care and fire-protection innovations and tests are made by industry representatives working at the Bureau. The Los Alamos National Laboratory has an Industrial Staff Member program for a one-way assignment of industry staff, with recent participation by Westinghouse, Grumman, and SCIPCO.

Many laboratories have similar programs with universities, with staff receiving release time to teach at local universities, and sabbatical programs for year-long full-time assignments at universities or other technical institutions. There are also many programs for faculty and graduate students to perform research at the laboratories.

Under the Intergovernmental Personnel Act (IPA), many laboratories, particularly in the Department of Defense (DOD), have assigned staff as science advisors to state and local government groups, and university and public-sector staff have taken temporary assignments within the laboratories. As examples, there have been IPA assignments by the Naval Underwater Systems Center to the Connecticut State Legislature, by the Naval Ocean Systems Center to the Governors' office in Oregon, and by the Navy Personnel R&D Center to SANDTAC, the San Diego Technology Action Center. Sandia Laboratories provides its staff release time for teaching at the University of New Mexico (UNM); the Oak Ridge National Laboratory and the Lawrence Livermore National Laboratory have special arrangements for their staffs to serve as faculty at local universities.

Collaboration and use of special facilities

Some government agencies support joint laboratory-industry programs to take advantage of special laboratory facilities or expertise and with immediate technology transfer opportunities for the private partner. Such relationships also permit the market-oriented expertise of the company to help direct the technical program in ways that will hasten commercial applications. Examples of this approach include joint programs under development between the steel industry and DOE's National Laboratories, several NASA programs, the Center for Process Control at the University of Tennessee (in cooperation with the Oak Ridge National Laboratory) and a National Institutes of Health-sponsored program to develop a nucleic-acid sequence data bank to support the genetic engineering industry (involving Bolt, Beranek and Newman and Los Alamos).

Special centers have been developed to draw upon the expertise of laboratories, universities and industry. These typically focus on broad areas of technology that can be pursued cooperatively, at least until specific market opportunities arise. A Center for Advanced Research in Biotechnology was recently formed by the NBS, the University of Maryland and Montgomery County, MD. Lawrence Livermore National Laboratory is cooperating with the National Tooling and Machining Foundation to exploit and develop expertise in precision machining. The Federal laboratories in New Mexico are cooperating with a Center for Explosive Technology Research at New Mexico Tech and a Plant Genetic Engineering Laboratory at New Mexico State University, and UNM Center for Non-Invasive Medical Diagnostics.

In an initiative of Senator Domenici's, the federal laboratories in New Mexico and several major US corporations have joined with the state's technical universities to create Riotech. This new organization is dedicated to the strengthening of engineering education in the universities, technology transfer from the laboratories, and innovative technology for US industry.

When the laboratories have expertise not otherwise pragmatically available, they can perform industry-funded R&D. Recent procedural changes by the DOE permit an industrial sponsor to gain title to resulting patents and data. Industry-funded projects can be accepted by NBS, NASA, DOD, and DOE facilities.

One special mechanism is the formation of computer software users' groups, benefiting the originators and all users of major scientific programs through sharing of problems, improvements and new applications.

Cooperation with broker organizations

There are some "broker" organizations who determine the needs of a group of similar organizations and match these needs to technology resources. PENNTAP is one of the oldest such organizations, serving the state of Pennsylvania. Public Technology, Inc., serves this function for many city and county governments. The Ohio Technology Transfer Organization (OTTO), operating through the state's community college net, assists small businesses. A formal Memorandum of Understanding between the State of Ohio and the Aeronautical Systems Division at Wright-Patterson Air Force Base has strengthened OTTO's linkage to this facility, and to all federal laboratories through the FLC network.

Several states have Small Business Development Centers that provide a wide range of assistance to small businesses. Many public interest groups, such as the National Governors' Association, the National League of Cities and the US Conference of Mayors have special programs to assist their members. Many of these groups work with federal laboratories through the Federal Laboratory Consortium because it provides efficient central access to many laboratories.

Professional and trade associations have some special programs that assist in creating demand pull. The American Society of Mechanical Engineers has a special state and local government relations office. The Society of Manufacturing Engineers recently compiled a detailed compendium of manufacturing technologies needed by industry.

Technical assistance—institutional and individual volunteerism

As noted earlier, there are mechanisms for Laboratory staff to work directly with state and local governments and universities on programs of mutual benefit.

Under the Stevenson-Wydler Act's mandate, many laboratories solicit or receive requests for technical assistance in state and local government problems. Similar assistance is often provided to industry.

Another rapidly spreading model involves special volunteer programs for employees and retirees of federal laboratories. The Naval Underwater Systems Center developed Technical Volunteer Services with active and retired employees, with a primary focus on community needs in Connecticut, Rhode Island and Massachusetts. Aided by the efforts the Federal Laboratory Consortium, this model has been duplicated at several other laboratories.

Creation of demand

Because successful technology transfer is often not a major goal of federal laboratory programs, there can be a chicken-and-egg problem of finding needs and available technology to fill those needs if the source and potential user of the technology are not already working together. Both federal laboratories and outside organizations approach this issue by developing efficient forums in which a variety of technology areas can be described to many potential users, or needs described to potential sources.

Several types of conferences have been developed, including the Industry-Federal Laboratory Conferences organized by a nonprofit corporation, Technology Transfer Conferences, Inc., in cooperation with the FLC. Through cooperation of several laboratories in the Federal Laboratory Consortium, major conferences and expositions have been organized in Philadelphia, Baltimore and Albuquerque, covering a broad range of technical areas. Specific areas have been the focus of workshops aimed at developing collaboration partners, including one in materials at Oak Ridge and one on plant biotechnology at Los Alamos. The Industrial Research Institute, through the IRI-National Laboratory Working Group has organized "Spotlight" conferences at Argonne, Brookhaven and Oak Ridge. The American Institute of Aeronautics and Astronautics has organized for NASA a series of in-depth conferences at NASA's research centers. The Commercial Development Association, comprising primarily chemical companies, has sponsored visits to Sandia, Los Alamos and Brookhaven.

Of particular note are special efforts to develop policy forums of public and industry officials and laboratories to strengthen the environment for technology transfer and to develop new initiatives to accelerate the transfer process. The RGK Foundation and the IC ^{2} Institute at the University of Texas at Austin have sponsored two such conferences.

Entrepreneurship

The entrepreneurs spinning out of all technical institutions are creating genuine excitement and rapid commercial innovation. The federal laboratories can claim many such spinoffs, and some have activities that encourage entrepreneurship.

The Federal Laboratory Consortium is cooperating in a project with the US Conference of Mayors to link federal laboratories with cities to encourage technology-based economic development. The Los Alamos National Laboratory co-sponsored a workshop on small-business "incubator" facilities to assist a local effort to develop an incubator, which recently began operation.

Several employees left the Harry Diamond Laboratory to commercialize a fluidic pyrometer technology that can measure molten steel temperature with sufficient accuracy and lifetime to assist in process control. They joined a small company, Accumetrix, located in Virginia. Through FLC contacts, early materials needs in the original laboratory project were answered by personnel at the National Bureau of Standards.

A particularly innovative approach was used in a transfer recently initiated from the Los Alamos National Laboratory. A new small business, Mesa Diagnostics, was organized specifically to commercialize laser-based systems for rapid identification of bacteria and viruses. It obtained financial backing from several venture capital funds and research funding from a major pooled R&D limited partnership fund, and negotiated a patent license from the University of California, the operator of the Los Alamos facility. Mesa Diagnostics is funding completion of the needed research by Los Alamos under a contract with the Department of Energy.

Licensing of intellectual property

Beginning with passage of the Bayh-Dole Act in 1980, there has been a growing effort to make patents developed at government expense pragmatically available for commercial applications. Because many government-sponsored inventions require a significant further investment in development before they can achieve commercial sales, the lack of availability of exclusive licenses has been the Achilles' heel of some potential technology transfers.

This method of transfer from the federal laboratories is in its infancy, but early results indicate that the incentive provided by exclusive licenses and the royalty-based incentive to inventors and their organizations are catalyzing the careful development of licensing programs for federal technology. So far, the more effective marketers of license opportunities have been the inventors and their immediate organizations.

The role of institutional culture

The role of MIT's staff in creating the technology-based industry around Route 128 is well known. Studies of other institutions by MIT [2] have indicated why MIT has succeeded where other good universities have not spawned such activity: Applications of science and technology, consultation, and entrepreneurship by the staff at MIT is strongly encouraged by the Institute's culture. Such activity is respected, is a positive consideration in faculty promotions, and is viewed as strengthening MIT's research and educational roles.

Without belaboring the importance of this observation, we must conclude that effective federal technology transfer must rely on: (a) a genuine, long-term commitment by the Administration, the Congress, the agencies and the federal facilities to make it work; and (b) the design of each facility's program to complement its existing institutional culture.

Illustrative examples

The Pacific Northwest Laboratory has made significant efforts to assist organizations throughout Washington state. It has established a satellite office in Seattle with staff engaged in industry and university relations. Cooperation has been established with the city of Spokane, including a workshop on use of remote sensing data for city planning, and with the Small Business Development Center at the Washington State University. It also hosted a recent FLC semiannual meeting in Seattle that has led to contacts with federal laboratories across the country for both public agencies in Washington and companies such as the Boeing Corporation.

The US Army Construction Engineering Research Laboratory (CERL) developed a portable washer that uses high-pressure hot water with vacuum retrieval of the waste water. The washer is ideal for cleaning and sanitizing refuse dumpsters, cleaning up chemical and oil spills, and on-site cleaning of equipment. Design specifications were transferred to two independent companies for marketing of the washer.

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[2] Dr. Nancy S. Dorfman, *presentation to Technology Transfer Society Annual Meeting*, Boston, June 26, 1984.

X-ray flourescence, a nondestructive method of elemental chemical analysis, was developed by Lawrence Berkeley Laboratory. This analysis method, based on the phenomena on x-ray emission, can be used for material studies, resource exploration, archaeology, criminology, trace analysis, and other studies. This technology is available to companies such as North American Refractories through commercially sold x-ray test units. North American Refractories uses three units that employ this method to analyze mineral ores and refractory products. The method is relatively clean and quick and is capable of reducing the 50 to 100 man-hours needed for conventional wet chemistry methods to less than one hour.

The City of Callaway, Florida consulted the Air Force Civil Engineering Center regarding the preparation of a statement of work and the selection of a contractor to prepare the city plan required by the state. The consultation and the follow-up evaluation of the plan were both done on a volunteer basis.

Applications concepts for microcomputers are available to the public and private sectors through a series of three videotape training packages offered by the Lawrence Livermore National Laboratory (LLNL). The California Department of Water Resources concluded that the method of monitoring water flow rate and accumulated water volume at the Oroville Dam was inefficient and susceptible to errors. The installation of a microcomputer system, adapted from LLNL's system provided the greater speed and accuracy needed for operating the Dam's turbines.

THE FEDERAL LABORATORY CONSORTIUM FOR TECHNOLOGY TRANSFER (FLC)

The FLC is a partnership of over 200 federal research and development laboratories and centers. Members are responsible for ~ 85% of all federal laboratory research and development. Its goal is to provide the environment, the operational structure and the transfer mechanisms to support the fullest domestic use of unclassified federal technology. The Consortium's role is to assist its member laboratories in: Development of effective technology transfer methods and mechanisms; Transfer of federally developed technology to domestic public and private organizations; Application of federal talent, where appropriate, to domestic public and private needs; Establishment of networks with the rest of the technical community to refer requests or engage in cooperative efforts.

The FLC provides the only interagency, interlaboratory forum on technology transfer, and therefore facilitates significant cooperation among these institutions. Important results include: training of individuals newly assigned to technology transfer; the transfer of new technology transfer or cooperative mechanisms among the laboratories; and increased effectiveness and efficiency of each laboratory's transfer program through national outreach activities and efficient brokerage of technology needs and opportunities. Particularly as laboratories begin new or expanded efforts in technology transfer, this interpersonal network of experienced individuals has been a valuable resource for these laboratories in developing programs that are both effective and complementary to their organizational cultures and missions. This cooperation has also proven directly valuable to the laboratories' missions through interlaboratory cooperation and laboratory-laboratory technology transfer.

The FLC is organized into six regional groups, each with a designated Regional Coordinator. These Coordinators form the FLC's operational backbone by serving both as (a) primary referral points in the network, brokering requests from their regions to the appropriate laboratories; and (b) organizers of special regional projects and efforts to market the availability of technology transfer to industry, state and local governments and universities in their areas. The FLC is governed by its member laboratories' appointed representatives through an elected Executive Committee; it has an advisory committee drawn from representatives of users. It holds national meetings semiannually as a forum for formal and informal exchange of information among member laboratories' representatives, and representatives from state and local government, universities, industry and Congress.

Networking

Because it represents a large resource of federal laboratories, the FLC can establish relationships with many organizations and groups representing potential users of laboratory technology.

Memoranda of Understanding—Several formal Memoranda of Understanding have been generated between the FLC and entities that share its interest in technology transfer. Existing agreements are with: Training Resources and Data Exchange; the Department of Commerce; US Conference of Mayors; Public Technology, Inc.;

Florida Small Business Development Centers (and the Southeast Region, FLC); NASA Industrial Applications Center (and Farwest Region, FLC).

For the several states and areas without major federal laboratories, the FLC network can provide a unique opportunity to make federal technology and assistance available through the FLC regional coordinators. Two examples of enhanced interactions with such states have resulted from holding FLC-sponsored meetings: As a result of an FLC semiannual meeting in 1983 in Biloxi, numerous contacts and transfers were made between laboratories across the country and state agencies in Mississippi. At this FLC meeting, the representative from the Army Aviation Systems Command in St. Louis met a university professor who is now the science advisor to the Governor of Missouri. As a result of this contact, this representative will participate in an economic development conference sponsored by the Governor's office.

Because federal technology transfer is very resource limited, this mechanism has not been extended to all such states and locales. Special efforts by out-of-state laboratories have been made, for example, with Missouri, Oklahoma, Texas, Oregon, Mississippi, Hawaii, Arizona and Nevada.

COMET Electronic Mail System—Sandia National Laboratories have provided access to use their COMET Electronic Mail System to the FLC Executive Committee and representatives in the Sandia-coordinated Mid-Continent Region. It is used to circulate requests for information and assistance from FLC clients to the six regions via the Regional Coordinators.

One example illustrates its utility. The ORTA at Argonne National Laboratory relayed a request for information on electroluminescent signs to regional coordinators via COMET. Ninety minutes later, the ORTA at the National Bureau of Standards had relayed the request to a local expert who telephoned the requestor in Minnesota that day.

Examples of Networking Results—The Naval Underwater Systems Center heard about a computer software learning program developed at the Navy Personnel R&D Center. The program was created to teach vocabulary and literal comprehension specifically for Navy terminology and technical reading, but can be used to enhance those skills in any content area. NUSC decided to test it in a local school system for which their volunteer service was helping to develop a computer curriculum and computer requirements design. A workshop at NUSC, given by the NPRDC developer of the program, was attended by the Army Human Engineering Laboratory representative and he is now experimenting with it for a Reading Skill Improvement Program for the National Commission on Libraries and Information Science and the Baltimore County Public School System. To that end, a workshop was held at Harry Diamond Laboratory to train volunteer teachers to use the program.

A volunteer effort to provide an energy assessment for the East Lyme (CT) High School had direct benefit to a newly purchased industrial plant in Cambridge, Ohio: A request for assistance from a local assistance group, TRACES, to the Wright-Patterson Air Force Base was networked to the Naval Underwater Systems Center, which provided contacts on the project at East Lyme.

The Naval Air Development Center, PENNTAP and the FLC cooperated in transferring the Navy Preventive Maintenance Program to local governments through workshops and other assistance.

Through the FLC, the Naval Air Development Center (NADC) compiled information from three other agencies' laboratories on waste management, disposal and incineration for energy production. NADC is working with a consortium of townships in Pennsylvania to demonstrate and transfer this technology.

Development and replication of transfer methods

Developing a technology transfer project within a laboratory can be time-consuming in addressing all operational and policy issues. The FLC assists both in developing transfer methods and in documenting successful approaches and transferring them to other laboratories.

Technical Volunteer Services—FLC member laboratories such as the Naval Underwater Systems Center (NUSC), along with several other public and private organizations, have taken the lead in establishing Technical Volunteer Services, available to communities surrounding their laboratories.

The FLC, with support from the Departments of the Army and Navy, the Administration on Aging, and individual laboratories, has been the vehicle for providing information, encouragement, training and assistance in establishing a TVS in all interested laboratories.

The FLC holds informational and training sessions on the intricacies of establishing volunteer services at its semiannual meetings. The FLC provides the forum for

exchange of information and experiences, as well as the sharing of training aids among the laboratories.

The extension of this concept to other laboratories through the FLC has resulted in nine new programs in the past two and one-half years.

Professor Lester W. Cory of Southeastern Massachusetts University will be honored by the President this month as one of ten outstanding volunteers for 1985. He is being honored for his work on behalf of the handicapped, which began when he was on an Intergovernmental Personnel Act assignment to the Naval Underwater System Center (NUSC). His supervisor at NUSC made the personal contact that initiated his volunteer work, which was supported by efforts of other NUSC staff. These volunteer efforts have provided custom computerized communications systems to over 20 profoundly disabled individuals.

Expertise Data Base—The FLC, in cooperation with the Naval Material Command, supported development of a Technology Transfer Data Base at the Naval Weapons Center. Within the laboratory, it is used to locate individual technical experts for both mission requirements and for response to technology transfer inquiries. Although this detailed information is available only within the laboratory, for security and other reasons, a summary data base will be made available to other laboratories as a resource base for technology transfer referrals. Ultimately, through the FLC, it could be an important resource for all federal laboratories' internal operations, other mission needs, and technology transfer.

Technology Transfer Program Planning—The US Forest Service has developed a technology transfer program planning process to ensure rapid transfer of its developments in each program. Information on this process has been transferred to other laboratories through the FLC for their use.

Federal Laboratories Resource Directory—The FLC has taken the lead in proposing an interagency effort to develop a directory of federal laboratories, their major program areas and key capabilities.

The directory is intended to be an automated data base with inputs from the participating agencies. Two categories of applications are envisioned: information dissemination and laboratory management. A committee of FLC, Agency and CUFT representatives is working on locating a funding source and agreeing on specifications.

Marketing

Developing interest in potential users of federal technology, and making the links between the source and user of a technology are formidable tasks. These are assisted by the FLC through nationwide outreach activities (brochures, exhibits, articles), and the networking functions described earlier.

FLC-Industry Workshops—One need in effective networking is to provoke efficient communication between disparate groups. In cooperation with Technology Transfer Conferences, Inc., three laboratory-industry workshops have been held. Each workshop gives exposure of ~ 10 laboratories to ~ 30 major companies. Most laboratories report followup interactions based on these workshops, which are especially useful to smaller laboratories that are not known well by industry.

Newsletters—TECTRA is an online interactive computerized data bank of successful technology transfer cases. TECTRA is the first system that has compiled information and documented user experience with successful federal laboratory innovations. In 1984 over 2500 requests for further information were received, based upon TECTRA's monthly newsletter.

TECLAB is a computerized data base of new technologies developed by federal laboratories and available for commercialization. A TECLAB case newsletter is published monthly as part of the research project funded by the Department of Commerce Minority Business Development Agency and the FLC. The newsletter and search service are provided at no cost to the requestor. 7600 copies of the newsletter were distributed in 1984, yielding 1500 requests for further information.

Surveys of subscribers to these newsletters have indicated strong interest in their technologies and good response from the laboratories in followup contacts. These are projects of the School of Business and Public Administration at California State University, Sacramento.

Recognition

Awards for excellence in technology transfer were established in 1984 to recognize laboratory employees who have been responsible for important transfers, but for whom technology transfer is not a major job responsibility. These and awards for FLC representatives and others help provide recognition and incentives for effective technology transfer.

Training

Through the FLC, both formal and informal training assists individuals new to technology transfer or those interested in new methodologies. About 25 new laboratory representatives receive orientation at each FLC semiannual meeting. Special training sessions on establishment of volunteer programs have been presented. Sessions have been held at FLC meetings to introduce such subjects as trade association interactions, patents, issues in militarily critical technology, the needs of the aging, university interactions, state and local economic development, and technology transfer between federal R&D organizations.

The FLC's network also provides valuable person-to-person advice both to assist new technology transfer professionals in their new programs and to assist each other with ideas, perspectives and problemsolving in specific technology transfers.

Mission benefits

Effective technology transfer professionals are aware of the technology, expertise and needs within their own laboratories. Through the FLC's forums and network, there are opportunities for laboratory-to-laboratory transfer and cooperation for direct mission purposes. In addition, in many technology transfer situations, particularly with industry, there is a two-way transfer that enhances the laboratory's technology base for mission work.

Other support activities

FLC/Agency Liaison Group—In 1983, the FLC organized an Agency Liaison Group. This group has become a regular interagency forum on technology transfer issues, policies and methods. It also provides the FLC with input from its member laboratories' parent agencies on improving its services.

Federal Laboratory Directory 1982—FLC cooperated with National Bureau of standards' ORTA, in the preparation of the directory, NBS Special Publication 646 issued in 1983. It contains various summary data and an information sheet on each laboratory. NBS has disseminated 3,000 copies. Recipients were all federal laboratories, 700 industrial organizations, policymakers in the Agencies and Congress, and repository libraries. An updated edition is in progress.

RESPONSE TO THE SUBCOMMITTEE'S ISSUES

Effect of the Stevenson-Wydler Act

The Stevenson-Wydler Act has engendered a significant increase in the number of laboratories active in the FLC, approximately doubling since its passage, and increasing the interest of industry and state and local governments in technology transfer.

Programs and review

Each federal laboratory should be free to develop its own results-centered program because: (a) its own requirements, mission, institutional culture and areas of technology will be unique; and (b) the authority to develop its program will make it accountable for the results as well as providing institutional pride in those results. Umbrella policy guidance from the agencies is needed to motivate and guide the laboratories' programs; after-the-fact oversight of these programs' methodologies and results can facilitate this process while permitting any necessary corrective action. Reviews by some group of all the agencies' programs can provide constructive comparison and feedback. Uniform regulations would have to be so broad (to cover the wide range of laboratory situations) that they would be at best ineffective, and very possibly counterproductive.

The Stevenson-Wydler Act

Several changes in the Stevenson-Wydler Act would significantly strengthen it. It could be viewed today as a permissive Act, rather than one that mandates effective technology transfer. The Act's permission to waive the requirement for full-time professionals in major laboratories should be removed. Only a person with full-time responsibility can ensure that the process works—if this is only a part-time duty, the individual often feels more comfortable with his other assigned duties rather than working tenaciously to instill effective technology transfer into the organization's culture and mission.

The specific requirement for application assessments should be relaxed. The general goal of reviewing laboratory programs for present and future transfer potential and communicating the results can be valuable, but the specified methods of review and communication have not been uniformly effective.

Each laboratory with an annual in-house budget exceeding $20 million per year should be required to assign at least one professional full-time to technology transfer; agencies with smaller facilities should dedicate full-time staff on a regional or national basis.

State/local governments

Section 11 (c)(4) implies that the laboratories may passively await requests for assistance from state and local government. The experience of many laboratories is that active efforts by the laboratories to establish working partnerships will lead to many more opportunities for valuable assistance. This section of the Act might be modified to encourage such active efforts.

CUFT role

The present actual role of the Center for the Utilization of Federal Technology (CUFT) is that of compiling and distributing written reports and summary lists of contacts and technologies in the federal laboratories and other organizations. This valuable support function is consistent with its location in the NTIS. Because several of its Stevenson-Wydler functions, viz. sections 11(d) (2) and (4), are being implemented by the FLC instead of by CUFT, they should be removed as CUFT responsibilities. This change would remove some confusion among technology users and even some federal laboratories as to the actual present roles of CUFT and the Federal Laboratory Consortium.

Industry cofunding

Co-funding of federal laboratories by industry has already begun in the Department of Energy's government-owned contractor-operated laboratories. This mechanism has proven to be of immense value in both technology transfer and in strengthening these laboratories' technology bases. This mechanism should be extended to other laboratories, subject to their agencies' policy guidelines and analysis of potential impact on the laboratories' mission work. Donation of equipment and facilities on government property for future government use, as part of this cooperation, should be permitted.

Measurement of effectiveness

Short-term and long-term systematic followup contacts with users will provide the most accurate measures of technology transfer. Some organizations such as PENN-TAP have an institutional procedure for such evaluation. Most federal laboratory transfer programs have insufficient resources to perform evaluations. Perhaps evaluations of some selected laboratories' programs would provide the needed guidance for other laboratories. It should be emphasized that major transfers can take 5–10 years to come to fruition, so that a long-term approach should be taken to benefit-cost analyses. In the near term, because the technology transfer process is a form of innovation analogous to research, evaluation could be performed by peer review groups drawn from the users of federal technology.

Extension

The Stevenson-Wydler Act already includes several unrelated functions. Extensions to non-federal-laboratory technology should be considered separately.

Problems

The problems in effective technology transfer are found on both the supply and demand sides. Effective transfer programs at the laboratories require: (a) management commitment that can be instituted by the Administration, the Congress and the Agencies with clear mandates and accountability for results; (b) dedication of full-time transfer personnel with the qualifications and program commitment needed to develop transfer methods and outside contacts; and (c) interlaboratory networking to increase the effectiveness and efficiency of each laboratory's program. Demand-pull by potential users of federal technology is developed primarily by extensive outreach and personal contacts. Our experience, supported by the results of Sandia Laboratories' technology transfer survey, indicates clearly that active, person-to-person efforts are the most important approaches to initiate user interest.

Concomitant with the potential value of federal laboratory technology transfer are concerns for national security and for preserving for American industry the benefits of federal technology. Partly through active efforts of the FLC, the member laboratory representatives have been educated on the issues in critical technology export controls. Several laboratories have assigned to one office the responsibilities for both domestic technology transfer and export control analyses: This has proven

an effective combination that strengthens both efforts. More difficult is the issue of preserving for the US economy the best use of federal technology. Definitions of a US company and methods of analyzing the net effect of transfers on the US economy have been considered, but with no definitive guidelines. This is a subject that should command the attention of high-level policymakers. Relevant issues include the effects of transfers on US economic strength, on the balance of trade, on foreign investment in the US, on US international competitiveness and the company's R&D location (with resulting opportunities for local spinoff enterprises.

INITIATIVES

Special access for small businesses, universities and State and local governments

The technology, facilities and expertise at the Federal Laboratories have proven valuable to small business and have even formed the basis for many new businesses. The important contributions of small business to national productivity, innovation and employment are well recognized at all levels in the Government. Similarly, university research and education is the backbone of the nation's intellectual strength; and the effectiveness of state and local government services has a major impact on our standard of living; however, the bureaucracy can be reluctant to approve new interactions between these entities and the federal laboratories. This aversion to risk or change could be dramatically assuaged by clear direction from national leadership. An initiative to provide streamlined access to the laboratories could begin with a strong encouragement of each agency and laboratory to examine its policies, rules and procedures with respect to facilities access, equipment loan, technical assistance and other methods of cooperation; and to shift their emphasis to stress technology transfer results over restrictions.

Mandate effective technology transfer by each laboratory

Visible Congressional interest in technology transfer as an important part of each laboratory's mission, including requirements for submitting plans and results as part of the agencies' budgeting and appropriations process, would strengthen federal technology transfer.

Several agencies and laboratories have been very aggressive in creating new methods of technology transfer. One change in the approach to program/project/policy approval could encourage an entrepreneurial spirit in technology transfer within each laboratory: Couple the mandate for effective technology transfer with an approval process that audits the propriety of past activities rather than to require detailed prior bureaucratic approval of all unusual and even some routine transfers. (All prior reviews for security classification would, of course, be maintained).

As discussed earlier, an emphasis on technology transfer results from each federal laboratory and requirement for dedicated full-time staff will significantly strengthen this process.

The central role of each laboratory in the technology transfer process should be recognized, and stronger participation and networking through the Federal Laboratory Consortium for Technology Transfer should be encouraged.

Strengthen the Federal laboratory consortium

The FLC is a volunteer organization: Laboratories and centers belong by choice, and some of these organizations provide funds for outreach activities and general contractor support. All officials of the FLC serve at the direction of their federal facilities. The success of this present volunteer approach indicates the FLC's value to these facilities, but it also limits overall effectiveness. Encouraging additional financial support and laboratory participation can accelerate the strengthening of this network, developing stronger outreach mechanisms, utilizing electronic mail and providing effective resource directory capabilities.

Encourage effective use of intellectual property

In the past, there have been instances of valuable technologies not being transferred because exclusive licenses to the governing patents were not expeditiously available. Although patents and other intellectual property do not affect the majority of transfer cases, they can be crucial in some cases. Rapid, effective licensing procedures are being developed in some agencies. These procedures should be coupled with appropriate incentives to inventors to ensure recognition and reporting of important innovations. Because the government does not have industry's flexibility in rewarding employees, royalty-sharing may be an appropriate incentive within the government. Income from patent licenses should also be used to reward noncommer-

cial innovations and for other mission-strengthening purposes within the laboratories.

Make technology transfer a part of every Federal R&D Program

The vast majority of Federal R&D activities do not place emphasis on promoting technology transfer or technical assistance. A sensitivity to potential applications of new technology, active person-to-person efforts to link users with new technology, and to link those having technical needs with expert resources, will significantly enhance the movement of technology into productive public- and private-sector uses. The expectation that some of the technical staff on each program will devote some time to active technology transfer (depending on the nature of the technology) will foster this process, particularly if the laboratory or agency requires a report on transfer activities as part of program reporting. Congressional encouragement that agencies provide identified technology transfer funds in each program and laboratory would significantly strengthen the support for this activity by the technical staff and first-line managers. This support would be strengthened further if technology transfer were a personnel evaluation criterion for the professional staff and management.

Congressional recognition and encouragement of laboratory initiatives and results

Congressional interest can be an effective motivation. They could encourage and review the Laboratory's efforts and successes in technology transfer through congressional oversight and interest from cognizant committees and from the local representative whose district includes the Laboratory. They could recognize also the extension of each laboratory's efforts through the national networking of the Federal Laboratory Consortium.

Establish a national forum on technology transfer

Most public and private organizations belong to one or more common interest groups, such as the Society of Research Administrators, various industrial trade associations, small business groups, and public-interest organizations like the US Conference of Mayors. There have been many one-to-one contacts between these organizations to develop cooperation, but there is a significant need that remains unmet: to "network the networks" i.e., to make pragmatic technology transfer the basis for a major, ongoing forum among all these organizations' members. Much of technology transfer can be attributed to serendipity, but special efforts to broaden the network of contacts and interest will help us organize for serendipity.

A series of major regional and national conferences should be convened to introduce and link representatives of federal government, university, local and state government, large and small industry, and their various common-interest associations. These links should be valuable not only in technology transfer but also in technical collaboration, education and training and other potential areas of cooperation. These meetings would be the opening steps in a continuing dialog among these groups, focused primarily on forging new cooperative efforts.

I thank you for the opportunity to present these views and suggestions.

Senator GORTON. Thank you, Dr. Stark.

General Thompson.

STATEMENT OF GEN. RICHARD H. THOMPSON, COMMANDING GENERAL, U.S. ARMY MATERIEL COMMAND

General THOMPSON. Mr. Chairman, I have a statement that I would like to have inserted into the record.

Senator GORTON. Yes. I should have mentioned this.

Obviously, Mr. Stark, your entire written statement will be included in the record, and yours will, as well, General Thompson.

We would appreciate a summary of it.

General THOMPSON. Sir, I would like to summarize my statement, if I may.

I am Richard H. Thompson, the commanding general of the U.S. Army Materiel Command.

I am honored to speak to you this morning because I have a strong personal interest and support the sharing of the Army's

technology and expertise with State and local governments, industry, universities and the private citizen. We call this activity domestic technology transfer.

My comments will address the Army's program, its management and what we feel are some potential improvements.

The Army has had an active program in technology transfer for over 11 years. The public law, coming somewhat later, has enabled us to have a more cohesive approach to uniform policy development. It has, in fact, institutionalized the process in enabling us to refer to congressional interest and support.

Fulfillment of the provisions of public law is a successful, cooperative activity. We feel that not only do we meet the provisions, but, in fact, exceed them.

The Department of the Army's Deputy Chief of Staff for Research, Development, and Acquisition, is responsible for establishing and insuring the execution of policies for domestic technology transfer. As such, this office is also the proponent for the Army regulation entitled "Military-Civilian Technology Transfer," which was revised in May 1983, to specify provisions of the Stevenson-Wydler Act.

This document, in turn, delegates the responsibility for centralized coordination for all Army technology transfer activities to my command, the Army Materiel Command. It institutionalizes the efforts and provides uniform guidance.

Further, the Department of Defense has developed a regulation governing the domestic technology transfer program which is intended to achieve the maximum national benefit from the total DOD science and technical efforts.

We believe it extremely important to give headquarters support to this function. I have, therefore, issued a commander's guidance statement to comply with the public law and the Army regulation regarding very active participation on the Army's part in this effort.

Now, each laboratory is entitled and encouraged to develop its own program. Given the unique mission of each of our individual labs, we believe it essential that each have maximum flexibility and latitude consistent with good management.

Our approach is to evaluate results and implement improvements only when and where needed. Agency review is at my level and it is my responsibility, as a commanding general, to see that technology transfer is conscientiously pursued throughout the Army structure.

I coordinate the transfer activities of 35 Army laboratories. I do this by holding two Army-wide meetings per year with required representation and reporting from each and every lab.

I believe the DOD and Army regulations provide ample control and guidance and that further regulation and review by the Department of Commerce is not appropriate.

Review by the Department of Commerce Center for the Utilization of Technology should be limited to reporting of appropriate technolgies as is now mandated and is now practiced.

CUFT could serve yet another role, that of providing an outreach function and help agencies in formatting information, technical writing, announcement of resources, indexing and abstracting in

secondary reporting, translating—that is, going from the laboratory language to layman language—and act as a switching center to connect the private sector to the Government.

Coordination of activities to the Governmentwide level, as stated in the public law, should be accomplished by the Federal laboratory consortium.

The Stevenson-Wydler Act, as it pertains to State and local governments is adequate and appropriate, as written. Therefore, we do not recommend any changes in this regard.

We believe that the authority in the act is adequate.

However, historically most people think of technology as an entity originating in laboratories, and the public law specifically addresses laboratories.

Further, we only think of technology in terms of hardware, equipment, facilities, or products from such labs. We think that we must consider that technology embraces more than just the output of the laboratory, and include our depots, our service schools, and our defense contractors.

For example, our techniques of teaching, program learning, computer controlled video disc technology and live satellite relay broadcast training have much to offer in education and training needs of the public and industry.

The use of our R&D results from the Federal laboratories should include any government source of technology.

Further, the term "technology" should be understood to include know-how, methodology, and technical advice.

This program is not just a source of solutions looking for problems, but can also solve problems looking for solutions.

The Army does not have enough guidelines for decisionmaking at this time regarding cofunding of research in the Federal labs as recommended by the White House Science Council Review Panel on Federal Laboratories. There may, in fact, be regulatory obstacles that have to be resolved.

Technology transfer is difficult to measure. However, we applaud the concept of measuring quality rather than quantity.

The peer review process could be used to delineate cost benefit as well as quality and establish figures of merit.

Allow me a moment to present yet another dimension of the transfer of technology.

Such agencies as NASA, DOD, and DOE are prime producers of technology, while others may not have the scope and depth to pursue research and development. They are clearly beneficiaries of the R&D process.

If we decrement the budget of the techology producers, then we decrement the technical resource of those beneficiaries. In other words, both are losers.

This logic presents a strong argument for technology transfer laterally within the Government, and especially to the nontechnology producing agencies to optimize the budgets of both groups of agencies.

We, therefore, further recommend the updating of the public law to address cross-fertilizing among agencies.

An area of concern in technology transfer today is to achieve inter and intra communication access to all government sources of technology by automation and telecommunications.

This would enable equal access to all Office of Research and Technology applications and technology producing nodes. We are working toward that goal.

The whole Government should know, understand, and support this vital work.

We should begin to provide audit trails of our work to enable development of standards of performance, effectiveness measures, and payback of benefits from Government dollars. We need to tell America in terms of the man on the street can relate to, that a high percentage of everyone's tax dollar that goes for Government operations is markedly improving everyone's standard of living.

Thank you, sir.

[The statement follows:]

STATEMENT OF GEN. RICHARD H. THOMPSON, U.S. ARMY

Good morning ladies and gentlemen. I am General Richard H. Thompson, commanding general, United States Army Materiel Command. I am especially honored to speak to you this morning because I have such a strong personal interest and support for sharing the Army's technology and expertise with State and local government, industry, universities and the private citizen—the activity we call domestic technology transfer.

My comments will address the Army's activities in domestic technology transfer, our methods of conducting and managing these activities and potential improvements to the program.

The Army has had an active program in domestic technology transfer for over eleven years. The development of the Public Law 96–480 in 1980, has enabled a more cohesive approach to uniform policy development. Further, we believe that it has provided the impetus needed to institutionalize the process so that those who may have been reluctant or resistant to participate because of a perception of mission conflict, can now fully justify their activity. Those who seriously look for authoritative sanction for expending resources beyond basic mission objective now have and use the "congressional interest" support.

The Department of the Army Headquarters, Office of the Deputy Chief of Staff Research, Development and Acquisition is responsible for "establishing and insuring the execution of policies for domestic technology transfer."

This office is also the proponent for the Army Regulation AR 70–57 "Military-Civilian Technology Transfer". This regulation was originated 10 years ago but was revised in May 1983 to incorporate the provisions of the Stevenson-Wydler Act. This regulation delegates the responsibility for "centralized coordination" for all Army technology transfer activities to the Army Materiel Command.

It is a respected and fully implemented document because it institutionalizes the effort and provides uniform guidance to the large family of Army elements. Further, the Department of Defense (DOD) has recently developed a regulation governing the domestic technology transfer program, "to achieve the maximum national benefit from DOD scientific and technical efforts." We believe it is extremely important to give headquarters support to this function. I have therefore, highlighted my strong support by issuing a guidance statement to all supervisors and action officers to "comply with the public law and Army regulation regarding active participation in domestic technology transfer and to enthusiastically support this effort." I believe the DOD and Army regulations provide ample control and guidance and that further regulation or review by Department of Commerce is not appropriate. Copies of these Army and DOD regulations and commanders guidance statements are available for your use.

Each Army laboratory is entitled and encouraged to develop their own program in technology transfer. Much of the success of technology development and application stems from the freedom afforded the laboratories regarding autonomy of operations. The Army Materiel Command coordinates the domestic technology transfer activities of all 35 Army laboratories. An annual report of activity is prepared by each laboratory.

The level of agency review for the Army-wide program is at the comand level and my responsibility as the commanding general is to see that domestic technology transfer is conscientiously pursued in all of the Army structure.

We fully support your efforts to improve the Government coordination of the transfer process especially through support from the Department of Commerce. We believe that the responsibility and authority for review by the Department of Commerce should be limited to reporting of appropriate technologies for distribution through the Center for Utilization of Federal Technology (CUFT).

The Section II D(2) states the CUFT shall "coordinate the activities of the Office of Research and Technology Applications of the Federal laboratories." It is our opinion that "coordination of activities" at the Government-wide level should more appropriately be accomplished by the Federal Laboratory Consortium (FLC).

The coordination function addressed in the act has been a de facto accomplishment of the FLC for over 11 years and they have succeeded remarkably. Let's not change a good thing that is working. The role of CUFT, however, could be more clearly delineated. We see their role as an "outreach function." They could help agencies in the formatting of information, in activities of technical writing, in announcement of resources, indexing and abstracting of government resources, in secondary reporting, in translating (from laboratory language to layman language) and to act as a "switching center" to connect the private sector to the Government.

We further believe that the authority in the Stevenson-Wydler Act is adequate however, the act, as written, addresses laboratories as the "home of responsibility" for domestic technology transfer. Historically, we have been thinking of technology as an entity which originates in the laboratories. The 1980 version of the Public Law 96-480 specifically addresses laboratories. There is a subtle implication of thinking of technology only in terms of hardware, equipment, facilities or products which come from laboratories. We must consider that technology developed by the Federal Government embraces far more than just the output of the government laboratory. Consider for example, the depots, service schools and defense contractors of the Army. Army depots have a significant expertise in automating the process of rehabilitating military vehicles. This unique technology could be applied to fleet commercial transport vehicles. Further the Army probably has more schools and training functions than any other institutionalized organization in the world. Surely our technique of teaching, programmed learning, computer controlled videodisc technology and live satellite relay broadcast training have much to offer in education and training needs of the public and industry.

Also, there is an abundance of Government-sponsored technology residing in the annals of industry and other defense contractors which never become offered or exposed to potential use by others. We could and should unleash the "limited" Army use of this technology.

The use of R&D results and their benefits to the public and private sector from the Federal laboratories should thus be expanded to include "any government source of technology". Further, the term, "technology" should be understood to include know-how, methodology and technical advice. Industry and the public sector and even the private citizen should clearly realize from the wording of the bill, that the Federal Government supports a strong program in domestic technology transfer. This program is not just a source of "solutions looking for problems" but is also a conduit for these non-Government entities to contact the Government when confronted with "problems looking for solutions".

The Stevenson-Wydler Act as it pertains to State and local governments is adequate and appropriate as written. Therefore, we do not recommend any changes. We do actively encourage our laboratories to interface with counterpart representatives of the State and local governments.

The Army does not have enough guidelines for decisionmaking at this time regarding co-funding research in the Federal laboratories as recommended by the White House Science Council Review Panel on Federal Laboratories. There may be regulatory obstacles that must be confronted and resolved.

Technology transfer is an elusive activity to measure. We applaud the concept of measuring quality rather than quantity. We would suggest that the time domain of near-term, mid-term and long-term objectives be established. Observables could be noted relative to these objectives as a measure of quality. Further, the peer review process could be used to delineate quality and establish figure of merit. It may be that cost benefit analysis and information audit, in addition to peer review would reveal quality.

Allow me to present another dimension of the transfer of technology. There are some agencies of the Federal Government which are prime producers of technology. Notable among these are NASA, Department of Defense, and the Department of

Energy (DOE). There are other agencies whose mission do not have the scope and depth appropriate to pursue research and development, but they are clearly benefactors of the R&D produced by NASA, DOD and DOE. Notable among these are Treasury, FBI and Department of Transportation. It therefore follows that decrementing the budget of the technology producers is going to decrement the resource of the benefactors. In the long run both Lose. This logic presents a strong argument for concerted effort in technology transfer laterally within the government, to support transfer between all agencies and especially to the non-technology producing agencies. This would optimize the budgets of both groups of agencies.

This lateral use of technology is not "institutionalized" and therefore the efficiency of the agency to agency aspect of the process is questionable. We therefore recommend the updating of Public Law 96–480 to address "cross-fertilization" among the agencies.

An area of concern in the domestic technology transfer activity today is to achieve complete inter and intra communication access to all government sources of technology by automation and telecommunications. This is seriously needed to enable equal netted access to all office of research and technology applications and technology producing nodes. We are working toward that goal but we have a long way to go. Significant improvement in the technology transfer operation would accrue from the whole of the government knowing, understanding and supporting this vital work which is relatively new as a concerted professional endeavor. We should all know about and support it just like we do other "new" programs. We should make it abundantly clear that domestic technology transfer is as potentially beneficial to the public as new product R&D is to the public. We would also recommend that those responsible for limiting the release of technology (export control) have a very close working relationship with those responsible for domestic technology transfer to assure the "right hand" knows what the "left hand" is doing and why. We should all begin to provide audit trails of our work to enable development of standards of performance, effectiveness measures, success methodology, cost benefit analysis and payback of civilian benefits from government dollars.

We need to tell America (in terms the man-on-the-street can relate to) that a very high percentage of everyone's tax dollar that goes for the military (government) is markedly improving everyones standard of living.

Thank you.

Senator GORTON. Thank you, General Thompson.

Now, Mr. Gillam.

STATEMENT OF ISAAC T. GILLAM IV, ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. GILLAM. Mr. Chairman and members of the subcommittee, I wish to thank you for this opportunity to participate in these hearings on technology and industrial competitiveness. Moreover, I am pleased to join my colleagues from other Federal agencies to review the impact and the effects which the Stevenson-Wydler Technology Innovation Act has had on promoting secondary application and the use of Government-developed technologies in the private industrial sector of the economy.

Since 1962, NASA has actively and aggressively carried out its congressional mandate contained in the Space Act of 1958 to broadly disseminate and transfer aerospace technology to U.S. industry and other user constituencies through its Technology Utilization Program.

This program consists of and operates as a nationwide system, whereby industry can gain effective access to a wide range of technologies made available through that system. The opportunities for technology transfer in both the private and public sectors are many and varied. Thus, the system requires a high degree of flexibility, technical competence and credibility, as well as effective outreach efforts to industry and other users of technology.

In our view, the effective outreach to industry and other users of technology represents the most difficult and yet most challenging task of all Government laboratories and agencies. At NASA, we believe that our nationwide network of university-based industrial application centers established for this purpose promotes and stimulates industrial and corporate interest in available advanced technologies, identifies and accesses industrial client problems and technological interests, and then brokers available information and human resources to fulfill those needs.

We are developing linkages and working relationships with State sponsored institutions and universities across the United States to provide even greater industrial coverage than has been previously possible. Thus, an ever-expanding outreach infrastructure exists within NASA which we believe could readily be linked to other Government laboratories to markedly increase and accelerate the transfer and use of Government-generated technology, thus enhancing the commercialization of these technologies, improving industrial productivity, and creating a stronger industrial and competitive base nationwide.

It should be noted that, although NASA has sought an exemption to the organizational formula and funding set-aside provisions of section 11(b) of the Stevenson-Wydler Act in February of this year, NASA supports the intent of the Stevenson-Wydler Act in its present form, since it provides other agencies with clear authority to engage in technology transfer actions. The reason for this exemption that NASA requested is that NASA currently has an alternative nationwide Technology Transfer Program to achieve the objectives of the act.

The NASA Technology Utilization Program is designed to promote and encourage the effective use and commercial application of aerospace-derived technological advances throughout the U.S. economy. On the basis of our experience, NASA believes that the total agency coordination and the conduct of certain nationwide outreach activities outside of the laboratories assure that new technology is equitably available to all U.S. industry.

Moreover, the Governmentwide cooperation and interlaboratory activities would have the effect of limiting duplication and enhancing the possibility that the most appropriate technology available nationwide will be effectively considered in response to technology's needs, even though those needs may be identified by a laboratory which does not work in that area of technology. Thus, there is a need for coupling of overall cooperation among agencies, but with the flexibility to allow transfer agents to interact with technology users on a case by case basis.

At NASA, regulation is seldom, if ever, used beyond the necessary rules surrounding the patent protection and limitation of technology export. Even then, flexibility is desirable. In actual practice, NASA allows industry to cofund research in its laboratories, as recommended by the White House Science Council Review Panel on Federal Laboratories, the Packard Panel. On a noninterference basis with NASA's national mission objectives, industry and universities are able to use significant NASA facilities and equipment for research on a cost reimbursement basis. Where the results of the research will contribute directly to NASA's mission and the

achievements of NASA's authorized objective, other arrangements may be negotiated.

In conclusion, Mr. Chairman, I would like to comment on a few of the problems that NASA sees with the way technology transfer is accomplished today and to provide recommendations to improve the overall process.

First, Mr. Chairman, it is our opinion that the system for transfer of Government-developed technology is incomplete, but it is developing in what we believe to be the right direction. The role the States are playing is significant in our experience, and Federal action should not preempt their involvement.

Second, the system is heavily dependent on the importance attached to technolgy transfer by agency and laboratory heads. A part of NASA's relative success has been the clarity of the Space Act mandate and the Stevenson-Wydler Act has helped in the case of other agencies.

Third, there are too many proposals to correct the entire system by turning this or that knob in a certain way. With clear responsibility and mandate, but with flexibility in the use of resources to accomplish that mandate, we believe that the present system can continue to develop in a positive direction.

Finally, the ambiguity surrounding the Federal Laboratory Consortium and its role is another weakness. The Federal Laboratory Consortium, as an entity, needs clearer support. And yet, that clearer support for the FLC should not lessen the authority and responsibility of the individual agencies and their laboratories and should not be at the expense of other existing programs, such as NASA's. The guiding concept should be to encourage networking and cooperation among agencies to minimize duplication of efforts and yet provide industry with the most appropriate technologies that best fit their needs.

Mr. Chairman, it has been a pleasure to come before you to communicate with colleagues from other Federal agencies on this important issue.

In keeping with the spirit and the intent of the Stevenson-Wydler Technology Innovation Act, we believe that NASA has achieved a high degree of success in fostering and implementing the transfer of technology to industry, academia, and to the public nationwide.

NASA's experience and direct support in cooperation with all Federal agencies could materially enhance the achievement of technology transfer and utilization objectives throughout the Federal Government.

Thank you.

[The statement follows:]

STATEMENT OF ISAAC T. GILLAM IV, ASSISTANT ADMINISTRATOR, OFFICE OF COMMERCIAL PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Subcommittee: I wish to thank you for this opportunity to participate in these hearings on technology and industrial competitiveness. Moreover, I am pleased to join colleagues from other Federal agencies to review the impact and effects which the Stevenson-Wydler Technology Innovation Act has had on promoting the secondary application and use of government-developed technologies in the private industrial sector of the economy.

Since 1962, NASA has actively and aggressively carried out its Congressional mandate contained in the Space Act of 1958 to broadly disseminate and transfer aerospace technology to U.S. industry and other user constituencies through its Technology Utilization Program. This program, which has evolved experientially over the years, now consists of and operates as a nationwide system whereby industry can gain effective access to a wide range of technologies made available through that system. Publications and announcements of potentially useful technologies, computerized access to scientific and engineering reports, computer software availability, selective access to laboratory scientific and technical personnel, and applications projects now comprise the system within which NASA operates its technology transfer activities.

The opportunities for technology transfer in both the private and public sectors are many and varied; thus requiring a high degree of system flexibility. Moreover, technology transfer processes must maintain a high degree of technical competence and credibility in order to effect meaningful and tangible end uses of the technology. Additionally, it is important that effective outreach efforts be maintained so that industrial firms, both large and small, as well as other potential users be continually apprised of the opportunities which are available to access and utilize externally-generated technologies applicable to their needs.

In our view, it is this latter requirement—to maintain effective outreach to industry and other users of technology—that represents the most difficult and yet the most challenging task for all government laboratories and agencies. At NASA, we believe that our nationwide network of university-based Industrial Applications Centers (IAC's) established for this purpose is an effective means to continually promote and stimulate industrial and corporate interest in available advanced technologies—emanating not only from NASA centers but from other government laboratories as well. The NASA-sponsored IACs have been working for years, cultivating strong ties with business and industry—identifying and accessing industrial client problems and technological interests and then brokering available information and human resources to fulfill those needs. The NASA Industrial Applications Centers are, moreover, presently expanding their outreach initiatives by developing linkages and working relationships with State-sponsored institutions and universities across the U.S. to provide even greater industrial coverage than has been possible.

Thus, an ever-expanding outreach infrastructure exists which, we believe, could be readily linked to other government laboratories, thereby providing U.S. industry broader and more direct access to all government technologies and laboratories on a problem-need basis. Such efforts would markedly increase and accelerate the transfer and use of government-generated technology, thus enhancing commercialization of these technologies, improving industrial productivity and creating a stronger industrial competitive base nationwide.

Mr. Chairman in your letter of April 11, 1985, to NASA, you specifically requested our views on several subjects which we now specifically turn our attention to.

With regard to the first—Why NASA sought an exemption to Stevenson-Wydler? How technology transfer is accomplished at NASA? It should be noted that, although NASA filed a waiver to the organizational formula and the funding set aside provision of Section 11(b) of the Stevenson-Wydler Act inFebruary 1985, as we have every year since the Act was passed in 1980, NASA still supports the Stevenson-Wydler Act in its present form since it provides other agencies with clear authority to engage in technology transfer activities. The reason for the exemption is that NASA currently has an alternate nationwide technology transfer/utilization program to achieve the objectives of the Act, and this program is designed to promote and encourage the effective use and commercial application of aerospace derived technological advances throughout the U.S. economy. The NASA program was found last year, in a review by the General Accounting Office, to "more than satisfy" the requirements and intent of the Stevenson-Wydler Act, both in the scope of its organization and in the funds used. Without the exemption, NASA's response to the specific requirements of the Act could result in duplication and unnecessary confusion of NASA field center roles in technology innovation and could disrupt our existing network. The NASA Technology Utilization Program operates under the leadership of a small staff at NASA Headquarters as an Agencywide "Office of Research and Technology Applications (ORTA)" and includes:

a Technology Utilization Office at each NASA laboratory (or field center);

the preparation of new technology reports (NTR) on each invention, discovery, innovation, or improvement resulting from NASA-supported R&D conducted by NASA laboratories or contractors;

the evaluation of each NTR for commercial significance by a team of technical experts;

the preparation and issuance of NASA Tech Briefs, a quarterly journal highlighting those inventions and innovations having the greatest commercial potential;

the availability of more detailed technical information in support of the announcements in NASA Tech Briefs;

the support of a nationwide network of Industrial Applications Centers (IAC's) which provide for governmental, commercial and industrial access to NASA's technology;

support of a Computer Software Management and Information Center (COSMIC) which makes government-developed computer programs available to industry, government and academic institutions;

an Applications Team which cooperates with public and private sector institutions in applying aerospace technology to meet public sector needs;

the support of technology applications projects in cooperation with the public and private sectors, to accelerate the availability of aerospace technology for non-aerospace uses having high public priorities;

promotion of conferences and seminars for U.S. industry on current and proposed NASA research and development, and on its significant results; and

the conduct of patent licensing and waiver activities.

The NASA technology transfer utilization organization works to assure that all NASA new technology is reasonably accessible to all industry in all areas of the Nation, regardless to whether the technology originates within NASA or its contractors.

With respect to the second subject—To what extent should each federal laboratory be permitted to develop its own technology transfer program? What level of Agency review is appropriate? Are uniform regulations a help or a hindrance? NASA cannot speak for other agencies. However, within NASA, it is not a question of "levels of agency review," but one of total agency coordination and the conduct of certain nationwide outreach activities outside the laboratories to assure that all of NASA's new technology is equitably available to all U.S. industry. This has the effect of overcoming the regional geographic limitations associated with purely laboratory-based activities—limitations that especially hinder small businesses the most. Agency-wide and inter-laboratory activities also have the effect of limiting duplication, and enhancing the possibility that the most appropriate technology available nationwide will be effectively considered in response to technology needs in both industry and the public sector, even though those needs may be identified by a laboratory which does not do work in the area of that technology. Any agency or interagency activity which encourages such networking and synergism tends to be useful. Regulation is a concept which NASA seldom if ever uses beyond the necessary rules surrounding patent protection and limitation of technology export. Even then, flexibility is desirable; uniformity merely for uniformity's sake can be detrimental. Technology transfer may not necessarily benefit by the establishment of uniform practices or formula guidance. The need is for a coupling of overall coordination with the flexibility to allow transfer agents to interact with technology users on a case-by-case basis.

Regarding the third subject—Does NASA have any recommendation on the role of the Center for the Utilization of Federal Technology? The Center for the Utilization of Federal Technology (CUFT) currently helps in the networking of technology transfer through production of two government-wide publications: The Guide to Federal Technology Resources, and the Directory of Federal Technology Transfer Personnel. Both of these help facilitate interagency cooperation and outside user access. As a clearinghouse or networking center for information on government-wide technology transfer activities, it plays a useful support function. Any consideration of a broader role should be needs-responsive and not prescriptively established.

With respect to the fourth subject—Would NASA favor allowing industry to cofund research in the Federal laboratories as recommended by the White House Science Council Review Panel on the Federal Labs (Packard Panel)? On a non-interference basis with NASA's national mission objectives, industry and universities are now able to use significant NASA facilities and equipment for research on a cost-reimbursement basis. Where the results of the research will contribute directly to NASA's mission accomplishment and achievement of its authorized objectives other arrangements may be negotiated.

In reference to the fifth subject—How can quality rather than quantity of technology transfer be measured? We believe that the most effective measures of the quality of technology transfer are those which are provided in objective terms by the user-recipient of the technology and which include hard evidence of use and tangible value: e.g., the existence of an identifiable new or improved product or process, the existence of a "bottom line" benefit of that innovation in economic and societal

terms (including the specific end effects of that product or process not only on the user organization, but also on its customers, clients, or constituencies). Periodic follow-up with user organizations to acquire such information is a continuing part of NASA's Technology Utilization Program. This has been and is largely responsible for NASA's ability to communicate the results of its transfer activities to the Congress and the public. However, even this approach is not able to comprehensively identify the full extent of aerospace technology diffusion and use by industry and other user organizations.

The last and final subject on which NASA's views were requested—What problems does NASA see with the way technology transfer is accomplished today? What recommendations would NASA make to improve technology transfer? This is an extremely complex topic, and one on which NASA is working diligently to provide the right focus and effect problem solutions and corrective actions.

First, Mr. Chairman, it is our opinion that the system for the transfer of government-developed technology is incomplete—but it is developing in the right direction. The role the states are playing is significant in our experience, and Federal action should not preempt their involvement.

Second, the system is heavily dependent on the importance attached to technology transfer by agency and laboratory heads. A part of NASA's relative success has been the clarity of the Space Act mandate, and the Stevenson-Wydler Act has helped in the case of other agencies.

Third, there are too many proposals to correct the entire system by turning this or that knob in a certain way. With clear responsibility and mandate, but with flexibility in the use of resources to accomplish that mandate, we believe that the present system can continue to develop in positive directions.

And finally, the ambiguity surrounding the Federal Laboratory Consortium and its role is another weakness. The FLC, as an entity, needs clearer support—and yet that clearer support for the FLC should not lessen the authority and responsibility of the agencies and their laboratories, and should not be at the expense of other existing programs, such as NASA's. The guiding concept should be to encourage networking and cooperation among agencies to minimize duplication of efforts, and yet provide U.S. industry with the most appropriate technologies that best fit their needs.

Mr. Chairman, it has been a pleasure to come before you to communicate with colleagues from other Federal agencies on this important issue. In keeping with the spirit and intent of the Stevenson-Wydler Technology Innovation Act, we believe that NASA has achieved a high degree of success in fostering and implementing the transfer of its technology to industry, academia and the public nationwide. NASA experience and direct support in cooperation with all Federal agencies could materially enhance the achievement of technology transfer and utilization objectives throughout the Federal government.

Senator GORTON. Thank you, Mr. Gillam.

All three of the members of the panel have agreed that there should be clearer support for the Federal Laboratory Consortium.

I would like each of you to comment, if you will, on whether you feel that the consortium should be given statutory authority to coordinate the technology transfer activities mandated in Stevenson-Wydler. If it is to be given such responsibilities, should all Federal laboratories be required to join the consortium?

General THOMPSON. Well, I think as I said in my remarks, sir, I would certainly think that that is appropriate.

Senator GORTON. In both cases?

General THOMPSON. Yes, sir.

Senator GORTON. All right.

Mr. Stark.

Mr. STARK. I would agree with that as chairman of the Federal Laboratory Consortium; yes.

Mr. GILLAM. I believe NASA also agrees, sir.

Senator GORTON. My, we are doing very well to start with.

Considering that Congress and the administration will probably keep most departments and agencies at fiscal year 1985 funding

levels, is there a way to generate increased technology transfer from the Federal Government to the private sector and the State and local governments without increasing budgets?

Again, any or all of you can comment on that.

General THOMPSON. Well, sir, I think that the answer here lies in more attention to the outreach function that I mentioned. I just don't know that you have to have more resources to do that.

Maybe what is needed is a redirection of the resources that are already allocated to making certain that we do a better job of reaching our people.

Mr. GILLAM. There are a couple of keys.

I would agree with the general that the outreach function is one that holds a great deal of promise, probably the most promise. However, within our buget levels, within NASA, as you know, we have a budget line item for our Technology Utilization Program, and we have initiated a new budget line item for commercial use of space. The commercial use of space also supports the transfer of technology to the private sector as well as joint research efforts with the private sector, as well as the centers for commercial development of space that we have talked about in terms of that area. These are patterned very closely after the centers of industrial technology that are outlined in the Stevenson-Wydler Act.

So, in many ways, NASA is within its authorization and within its current appropriation and is taking steps to implement the various aspects of the act.

Mr. STARK. In general, sir, I believe that, since technology transfer is so important and does not necessarily require a large fraction of any agency or laboratory resources, it can be handled within the present budgetary constraints.

Basically, what is needed is to instill within the laboratories a culture and a mandate to recognize potential commercial applications of technology and to perform the outreaching functions that have already been described here today. In addition to this, many laboratories find that cooperation with other laboratories and with other users of technology ultimately provide direct mission-related benefits, that is, technology coming back into the laboratory. This combination of mandate and mission value of technology transfer should certainly make it clear to the laboratories that at very small expenditure, their existing resources could make technology transfer work well.

Senator GORTON. Thank you.

Let me go back to follow up my first question.

If the consortium is given a legislative basis, where should its program management be located, and what should be its relationship with the Department of Commerce's Center for the Utilization of Federal Technology?

Mr. STARK. I will start on that one.

My personal feeling is that the National Science Foundation, in part because it has provided an informal home for the FLC for more than 10 years, is the appropriate place for the management to be housed. The relationship with the Center for Utilization of Federal Technology, in fact, is very good. We continue to cooperate, and have cooperated from the time that the CUFT was first estab-

lished several years ago. We would intend to continue cooperating on at least an informal basis.

General THOMPSON. Sir, I think what I would say is, don't give it to the Army.

Senator GORTON. Mr. Gillam.

Mr. GILLAM. Sir, I might say the same thing about NASA. However, I don't believe the agency has a position on where it should be located. Our position is that the way it is working with the Department of Commerce, under the current arrangement, it seem to be satisfactory. I believe we would not recommend any substantial change from that.

Senator GORTON. Would any of you favor the use of bonuses or royalty sharing for federally employed inventors or federally employed technology transfer officials, or some other kind of incentives or awards?

Mr. GILLAM. We have a fairly established position on that.

We do not, within NASA, favor a specific bonus for specific technology transfer actions because this leads to problems in other areas. People who are working on our regular mission work could be somewhat exluded from opportunities to participate in this kind of activity. So, we have integrated the bonuses and awards into a process that recognizes both technology transfer and mission accomplishment. We believe that is more equitable than special bonuses for a particular area because you do put people who are working on routine—though it is really not routine—agency work at somewhat of a disadvantage in that they may be working on something that may not have an application or a transfer process.

So we prefer to have the awards for technology transfer as an integral part of a larger system of awards and bonuses.

General THOMPSON. Sir, that is exactly the position that we came to.

We have asked ourselves that very question.

Senator GORTON. Mr. Stark.

Mr. STARK. I would agree generally with what both gentlemen have said.

Basically, the Federal Government does not have the same flexibility in rewarding its employees that private industry has, and, therefore, it is important to look at potential incentives not only for effective technology transfer and valuable patents, but also for important mission-related work.

Therefore, to the extent to which there is money available for bonuses, it should reward both technology transfer and related commercialization activity as well as the mission-related results of the agencies and laboratories.

Senator GORTON. General Thompson, how does the Department of Defense increase the private sector's interest in working with the Federal laboratories in the transfer of technology?

What peculiar or unique problems to the Department of Defense are there with these relationships with the private sector?

General THOMPSON. Sir, one of our problems is, how does that relate to our primary mission, and how do we get people to understand the benefits that will accrue from our participating in such a program?

One of the things that we are trying to do is to get a greater appreciation within our own structure of what it is that we are able to accomplish in a domestic technology transfer program. We do not do that very well, but we are working at it.

Senator GORTON. Thank you.

Mr. Stark and Mr. Gillam, each of you in your testimony has pointed out that industry-funded research and development projects can be accepted by the National Bureau of Standards, by NASA, by the Department of Defense, and the Department of Energy.

The Office of Science and Technology Policy's progress report on implementing the recommendations of the White House Science Council's Federal Laboratory Review Panel recommends that the authority of Federal laboratories to enter into cooperative research projects with industry, universities and nonprofit organizations be formalized.

Bills have been introduced into this Congress which would authorize Government-operated laboratories to enter into such cooperative research and development agreements.

If some of the laboratories are now performing industry-funded research and development, do you view it as necessary to have additional legislation to permit these cooperative agreements?

Mr. GILLAM. In the case of NASA, we do not require additional legislation because we have that authority under the 1958 Space Act. Sections 203 (c)(5) and (c)(6) allows NASA to enter into cooperative agreements with both international entities and with State, local, and other Federal entities. So, NASA does not require legislation in order to enter into those agreements. I am not quite familiar enough with the enabling legislation and the legislation associated with other agencies to do that. But it is a distinct advantage to have legislation that authorizes you to do that.

Senator GORTON. Thank you.

Dr. Stark.

Mr. STARK. I am similarly unaware of the legislative permission for other agencies to enter into coperative arrangements.

Legislation allowing cooperative arrangements would send a good signal to the agencies and to outside private industry that Congress is interested in seeing cooperative arrangements take place. Therefore, that would be one potential value to the legislation. Certainly, in our own case, within a laboratory of the Department of Energy, it is very important that we have that legislative authority.

Senator GORTON. Thank you.

Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman.

Mr. Stark, recently the President's Commission on Competitiveness discussed the importance of technology to the Nation's industrial future. It particularly emphasized the need for better manufacturing technology.

Yet we lag behind the Japanese in using new manufacturing technology. At the same time, the United States does not lack large research and development programs.

Along with the support to universities, the Federal Government has some 700 laboratories of its own.

Would I be correct in saying that there is a great deal of technology and expertise in those Federal laboratories that could help American business, including manufacturing, if we only knew how to tap into it?

Mr. STARK. I think that is exactly right, sir.

I think we know how to tap into it. The issue is getting the laboratories and the agencies to provide clear mandate and interest in seeing technology transferred, and outside industry clearly interested in cooperating with the laboratories in what can be a tedious process of knowhow and technology transfer.

Senator RIEGLE. Have you seen any examples where we have managed to make the transfer and gotten real dividends out in the private sector?

Mr. STARK. There have been many such examples at a number of Federal laboratories.

Senator RIEGLE. Give me some, please.

Mr. STARK. The clean room technology developed at Sandia Laboratories is basically the standard for semiconductor processing facilities worldwide. Without that technology, we simply would not have the speed or size of semiconductor components that we have today.

My impression is that the manufacturing technology program of the Department of Defense has had a significant impact in upgrading the ability of the defense industry to satisfy the needs of the Department of Defense. We are beginning to see important spillovers of this technology ultimately into commercial and industrial production.

Those are two brief examples.

Senator RIEGLE. What has been the relationship of any of you to, say, the President's Science Advisor, Dr. Keyworth? Do you meet with him on this issue from time to time, or have you at some time?

What is the nature of the involvement at that level on this issue?

Mr. STARK. I had the pleasure of explaining technology transfer to him about 2 weeks before he was appointed as the President's Science Adviser through a completely fortuitous circumstance.

We have had participation by members of the Office of Science and Technology Policy in meetings of our Federal laboratory consortium so that we can understand where they are coming from and also provide input to their deliberations. Jim Ling, in particular, has attended some of our meetings. We do not meet with them on a regular basis, however.

Senator RIEGLE. Have you seen Dr. Keyworth or spoken to him since he became the Science Advisor?

Mr. STARK. Just a couple of times since then. He has remained very supportive, as long as we are very careful not in any way to impact national security.

Senator RIEGLE. What about the other two witnesses?

Mr. GILLAM. We have had continuing contact with his office and members of his office. We have a meeting scheduled for the 29th of this month to brief him on where we are with our new activities and new efforts.

Senator RIEGLE. Along the lines of technology transfer?

Mr. GILLAM. Yes, technology transfer and commercial development—both.

Senator RIEGLE. General Thompson.

General THOMPSON. We have had no direct relationship. Most of it has been through the consortium.

Senator RIEGLE. How often do you fellows meet?

Mr. STARK. This is the first time the three of us have met. The FLC has established an agency liaison group involving technology transfer officials from the agencies that have Federal laboratories. They have met on about a quarterly basis for the last 2 years.

Senator RIEGLE. It seems to me that, if we are going to move at some rate of speed here, we need some better connecting links and some sense of urgency.

I serve on the Banking Committee, and Senator Gorton and I serve on the Budget Committee. We are wrestling with all of the difficulties of the financial stresses and strains that face us. If you try to put together the trade deficit and the trend lines in the trade deficit, together with the fiscal deficit and the trend lines in the fiscal deficit, plus probably 10 other major ways of measuring structural stress on the financial system and the economic system worldwide these days, and then bring it back to where the United States stands, one sees that we really need to move more quickly. We need a more efficient conduct of our own economy and private sector than we have managed to accomplish so far.

I would certainly welcome any other advice you have along that line on ways that this subcommittee or members of it might be helpful in ensuring that we connect things, get the right connecting links in place, and start to move things along faster.

I do not think we can afford to have a single dollar of research results that have private sector application sitting on a shelf somewhere gathering dust, not when the country is falling backward in so many different categories, such as trade, and our relative competitive position in a number of areas is declining.

It seems to me that we have to find a way to mainline that technology right on through into our private economic system.

I think it ought to be given a top priority. The President's Science Advisor ought to be meeting with you, and you fellows ought to be meeting with each other. I am all for working groups at the staff level, because that is where an awful lot of the work has to be done. But, it seems to me that this somehow has to come up on the list of priorities here, simply because the country has an urgent need to find a way to get some mileage out of the money that we are spending for this research.

I don't think most people in the country realize that we have 700 Government research laboratories. To me that is a rather breathtaking fact. I assume that they are justified for one means or another. But we have to find a way to get that yield out and through the economy a lot faster than we have.

I appreciate the example of the clean room illustration and the value that it has had and so forth. But that is a while ago. The question is what are we doing today. What are today's new finds, if you will?

General Thompson, you are sitting there and smiling. Did you have a comment?

General THOMPSON. I have two pages.

Senator RIEGLE. Of other new finds?

General THOMPSON. Yes, sir.

Senator RIEGLE. Let me hear some of them.

General THOMPSON. They are the very kind of things you are talking about.

Kevlar, the lightweight body armor is one. We saved 312 lives in just 1984 in making that available to law enforcement officials. Just in dollar costs, sir, that is $100 million in pensions that would have had to have been paid out.

The bonded shoe is not very glamorous, but for the past 15 years, that whole technology has been built on Army efforts.

The flexible food pouch is another. Why 35 percent of the groceries you now buy have been improved by some Army Technology such as flexible food pouches which were developed by your Army.

Irridated food is an Army development.

The synthetic valve respirator, which is part of the artificial heart came from Army research.

No-lead paint and coatings, and preservatives for antifreeze—all of those are Army.

You are absolutely right, sir. We have not gotten that message out.

Senator RIEGLE. I think that is a key list.

I guess what I am saying is that we are now at a point where, despite all of that, U.S. industry is sliding backward. So now I am asking myself questions about our investment in technology.

We all serve the same master, namely the public interest in this country. The question is how do we find a way to serve it better. The rate at which we have been moving in technology has still left us sliding backward in our overall international competitiveness. So we have to find a way to move faster than we have been moving.

It seems to me that one of the components that is available to us here, which we are now paying for, and properly so, is the research effort that is going on in a variety of governmental activities. We have to find a way to really facilitate an application of this at maybe 5, 6, 10, or 12 times the rate that we have done it in the past.

I guess what I am saying is that I would like to help you do that. But it seems to me that you fellows are in a more direct position than we to really see how we can shorten the lags here and how we can somehow put together some new connecting links that can make this happen at a faster rate.

I must tell you that I am sufficiently alarmed about our overall condition that we cannot afford to miss a single bet. If we do, we may pay an enormous price in damage spread across the econmy.

I think you have a great contribution to make here and we would like to help you make it.

Mr. GILLAM. Sir, I think in all of our presentations, we have all mentioned the word "outreach." I think we generally agree that that is the area where we may be the weakest, in the sense that the companies or the potential beneficiaries of the technology that we are talking about are not aware that that technology is avail-

able, and they are not aware of where to go to get access to that technology.

Senator RIEGLE. Well, why don't we start having some meetings? Why don't we start having some symposia, or why don't we start having regional meetings? Why don't we get the principal players, like yourselves and your top technical people, together. Let's have one on the Western side of the United States, or let's have one in the southern regional conference. Let's invite in the leading companies that would have an interest in technology. Let's spend a day and talk about the different things that are going on.

We can't just go on in the traditional manner because the traditional manner is putting us into a position where we are sliding back down the hill. We have to start moving up the hill.

I just ask you for some additional creative ideas and efforts. As I have said, I think you will find that we are prepared to try to help you get some of these things done.

Senator GORTON. We thank all of you for your helpful and constructive advice.

The second panel consists of Dr. Nam Suh of the National Science Foundation and Dr. Dale Corson from the National Academy of Sciences.

Dr. Suh, welcome back to the subcommittee.

You may proceed.

STATEMENT OF DR. NAM P. SUH, ASSISTANT DIRECTOR FOR ENGINEERING, NATIONAL SCIENCE FOUNDATION

Dr. SUH. Mr. Chairman and members of the committee, I am happy to have this opportunity to discuss some of our ideas for strengthening our Nation's industrial competitiveness over the long term and to make a number of observations relative to the Stevenson-Wydler Act.

Senator RIEGLE. Excuse me, Dr. Suh. Would you pull the microphone up a little bit closer so that everyone can hear you better.

Dr. SUH. Certainly.

On January 25 of this year, we reoganized the entire NSF engineering directorate into five new divisions and one new office and established a completely new program structure.

We took these actions to strengthen the engineering science base, to increase opportunities for industry/university interaction, and to implement programs that will help ensure that the United States continues to produce the world's best engineers.

I know that the committee is concerned about international competitiveness. My message is that NSF and other Federal agencies that have significant research budgets are aware of the problem and many actions are being taken to help strengthen the Nation's technological capabilities.

At present, we believe there is ample authorization to permit NSF and other Federal agencies to move ahead on efforts that should help to strengthen the competitiveness of the United States in the long term.

On April 3, 1985, we announced the establishment of six engineering research centers. These are part of a long-range program which should see other centers established at universities in the

United States over the next several years. The initial six centers include a telecommunications center at Columbia University; a microelectronics center at the University of California at Santa Barbara; a biotechnology center at MIT; an intelligence manufacturing systems center at Purdue University; a systems engineering center at the University of Maryland in collaboration with Harvard University; and a composite manufcturing center at the University of Delaware in collaboration with Rutgers University.

The engineering research centers were established in response to a wide range of inputs from the National Academy of Engineering, the President's Science Advisor, the National Science Board, and scientists and engineers in industry and other Federal agencies.

The centers are aimed specifically at developing new knowledge in areas that can help U.S. industry maintain its international competitiveness for markets at home and abroad.

Significant industry/university collaboration is central to each center. The panels which considered the 142 engineering research center proposals submitted to the foundation included significant industry representation.

In addition, each engineering research center has an important engineering education mission. The centers are committed to provide more hands-on and engineering systems type experience, as well as a firm theoretical foundation for engineering students at both the graduate and undergraduate levels.

We believe the engineering research centers will be a major contributor to national efforts to improve U.S. industrial competitiveness—a view shared by both universities and industry.

In addition, we have shifted 20 existing industry/university cooperative research centers, which are heavily oriented to engineering-based problems, from our scientific, technological, and international affairs directorate to the newly reorganized engineering directorate. These centers are focused on such major areas of technology as welding, robotics, ceramics, materials handling, optical circuitry, and computer graphics.

The industry/university cooperative research centers are smaller and are more sharply focused on industrially relevant research than the engineering research centers, which have a much broader mission. The industry/university cooperative research centers start with shared funding provided by NSF and industry. A requirement for each of these centers is that it become fully self-supporting with no NSF funding provided after 5 years. These centers have proven to be extremely effective in establishing strong industr/university ties.

I believe they provide a model for technology transfer.

Another key program contributing to industry/university collaboration and the transfer of knowledge that can stimulate advances in techology is our industry/university cooperative research projects program.

This program, which is also heavily oriented towad engineering, was made a part of the engineering directorate in the recent reorganization It is a catalyst for expanding industry/university collaborative research.

Research proposals that are determined to be industrially relevant can become a pat of the competition for funds from this program.

Substantial industrial cost-sharing is required for a research proposal to be considered for support under the program. We are currently supporting research on materials, computer engineerig, chemical process engineering, and a range of other industrially relevant projects.

The industry/university cooperative research projects program has been effective in stimulating industry/university collaborative research and technology transfer.

State and local governments are also a key factor in mounting efforts to enhance U.S. industrial competitiveness. High technology firms can create jobs and help in building strong economies. NSF has a small program called the experimental program to stimulate competitive research or EPSCOR.

It has proven extremely effective in bringing academic and industrial leaders together to design and execute research improvement plans. The objective is to enhance the research capacity of academic institutions in particular States that have been relatively less successful in competing for research funds.

Mr. Chairman, as you know, the National Science Foundation has a broad legislative mandate to maintain the health of science and engineering. We are frequently referred to as the balance wheel in Federal support for science and engineering. We are expected to evaluate the status of other science and engineering support needs in light of other agency programs, reports, and studies. Consequently, as I move through the remainder of my statement, in addition to highlighting NSF efforts, I will mention some of the actions taken by other agencies that have helped shape our views.

A key concern is the education of our young scientists and engineers. NSF's graduate research fellowships activities total $27.3 million in the fiscal year 1986 budget. Adding to this support, the Navy has initiated a graduate fellowships program, and I understand that the other two services are in the process of developing programs that will increase the science and engineering pool of graduates.

Several agencies, including NSF, have significantly expanded research on biotechnology. Within its budget request, NSF plans to allocate about $80 million in fiscal year 1986 for biotechnology research, including funds for the newly established biotechnology center at MIT, which I mentioned earlier.

I believe that the biotechnology area provides a good example of how Federal agencies can move in a positive way in their field to build the fundamental knowledge base needed to underpin future industrial efforts. Industry participation is a requirements in our engineering research centers program, and I believe that industry-university interaction is being given greater emphasis in the mission agency programs as well, not just in biotechnology, but also in other areas.

To meet the competition from Japan and other industrialized nations, we must first insure that we are developing the best engineerings and scientists in our institutions of higher learning. The

President's budget for 1986 provides important increased funding for NSF's science and engineering programs.

Small business and especially small, high technology firms, are one of America's great strengths. Today there re literally thousands of small, high technology firms that are pursuing daring high risk ventures.

NSF is supporting about 200 small high technology firms through its small business innovation research program. The projects range over many fields of science and engineering.

We have also increased our computer science programs, and we have started a special program to give researchers in all fields of science and engineering access to and time on supercomputers.

I think it is important to note that there are already in place mechanisms for moving university researchers in and out of Federal agency laboratories. For example, the Department of Energy supports programs that bring university researchers into its 11 national laboratories. DOD also has programs that permit university researchers to get experience in DOD laboratories.

We believe that such efforts as these negate the need for a formal Federal Laboratory Consortium for Technology Transfer within NSF.

NASA has a technology utilization organization which works to insure that new technologies developed through NASA programs are equitably available to all U.S. industry. And, I believe NASA has one of the best records of working cooperatively and successfully with industry to achieve high technology goals.

The point I want to make, Mr. Chairman, is that we agree with the intent of the Stevenson-Wydler Act. We need to develop and implement more mechanisms for enhancing industry/university interactions. But as I have noted, much is being done already.

We believe that there are already in existence programs and sufficient legislation to permit the National Science Foundation, and I believe other agencies as well, to continue efforts to strengthen U.S. science and engineering and to move research results from the laboratory to applications.

I believe that five things are essential at this time if we are to meet the competitive challenge over the long term. They are:

First, give our engineering and science students the best education.

Second, encourage U.S. firms, large and small, to increase their investment in research and high technology areas and to take risks.

Third, invest in research in science and engineering at levels that wil insure a strong and expanding base of knowledge that will fuel research applications efforts.

Fourth, stimulate industry-university collaborative research.

Finally, make wise use of the full research potential of universities, industry, and government laboratories to move America ahead.

We are making progress in all of these. We believe that there is adequte authorization for such efforts.

At NSF, we have the authority to advance science and engineering through support for fundamental research and the training of future scientists and engineers. We have more than 30 years of ex-

perience in fulfilling this role, and we are expanding our efforts to meet current and projected needs.

Thank you, Mr. Chairman, for this opportunity to discuss these points with you.

Senator GORTON. Thank you.

Dr. Corson, as with the others, your entire statement will be included in the record. We will appreciate your summarizing your statement for us.

STATEMENT OF DALE R. CORSON, CHAIRMAN, GOVERNMENT-UNIVERSITY-INDUSTRY RESEARCH ROUNDTABLE, NATIONAL ACADEMY OF SCIENCES/NATIONAL ACADEMY OF ENGINEERING

Mr. CORSON. Mr. Chairman, Senator Riegle, my name is Dale Corson. I am the chairman of a new body, called the Government-University-Industry Research Roundtable, which is sponsored by the National Academies of Sciences and Engineering.

The research roundtable is an experiment designed to address issues important to American science and technology.

After describing the roundtable briefly, I will review the roundtable's plans for examining university-industry linkages.

The research roundtable was created to provide a forum for scientists, engineers, administrators, and policymakers from Government, universities, and industry to come together, on an ongoing basis, to explore ways to improve the productivity of the Nation's research enterprise.

Our object is to understand the issues and to inject imaginative thought into the system.

The roundtable council, which guides the effort, includes senior officials from Federal agencies, universities, industry and working scientists.

Our operations are based on the premise that the health of our science and engineering enterprise is determined by our ability to create new knowledge and by our ability to utilize this knowledge for the benefit of society.

The roundtable is organized into four working groups. Group 1 focuses on the identification, recruitment, and retention of talent for science and engineering careers. Group 2 addresses the physical and organizational infrastructure for academic research. Group 3 focuses on the alliances among universities, industry, and Federal and State governments which are designed to promote the sharing and utilization of knowledge and technology. The work of this group is of most interest to this subcommittee. Group 4 addresses major issues underlying the entire scientific and engineering research enterprise.

When the issues surrounding a particular problem have been analyzed and when options for dealing with them have been developed, a forum with all the interested constituents invited will be convened. Three of these forums are now scheduled.

Group 3, called New Alliances and Partnerships: Enhancing the Utilization of Scientific and Engineering Advances, has initiated a project to examine what can be learned from new arrangements

between universities and small and large companies, the financial community, and the Federal and State governments.

Our method of approaching the task is through case studies of a group of 10 to 15 new alliances. The group will consider several different types of alliances, including, among others, arrangements between a single company and a single university, and State government programs, such as targeted technology centers and small business development programs.

Four general questions will guide the review:

One, how effective are the new alliances in contributing to the increased utilization of scientific and engineering advances?

Two, what are the effects of the alliances on the conduct of science and engineering research?

Three, what are the effects of the alliances on the roles, responsibilities, and characteristics of the institutions in each sector?

Four, how are the public's interests preserved in the operation of the alliances?

At this stage in our exploration of new alliances, we have more questions than answers to share with the subcommittee. Let me give you, however, some observations.

First, knowledge utilization and technical innovation are complex processes. They include many interactions between the people and organizations involved. They involve complex patterns of information flow and decisionmaking, and they vary considerably from one sector of society to another, and even within a given sector.

We hope the roundtable's explorations will provide useful insights into these processes.

Second, all is not new.

For example, in agriculture, there are longstanding linkages among land-grant universities, USDA research laboratories, agricultural extension services, commodity groups, equipment manufacturers, agricultural processing firms, and chemical product producers.

In medicine, there are linkages among the pharmaceutical industry, medical practitioners, and university medical centers.

Third, each party brings its own expectations to these arrangements. The universities usually search for additional financial support. However, with a few exceptions, they are not likely to gain large amounts of additional resources from the new alliances. Perhaps a more productive motivation is the opportunity to enrich academic intellectual environments and to expand university capacity to contribute to national, regional, and State needs.

The loss of competitiveness by American industry in world markets stems from a relative decline in productivity and quality of product. Industry enters the new alliances with the hope that an infusion of new people, educated in new ways, will help turn the situation around.

The motivation for State governments is industrial development and the creation of new business and new jobs.

The Federal Government seeks to see its some 700 Federal laboratories and its large investments in civilian R&D more effectively used to promote international economic competitiveness and social well-being.

In conclusion, the United States is going through a period of rapid, exciting, and, in some respects, troublesome, changes in its economic, social, scientific, and technological institutions and practices. Our understanding of how best to achieve our objectives in the midst of this change is limited. The challenge is to design effective experiments and new arrangements without destroying the principles, the policies, and the values that have made our institutions, our universities, our industries, and our governments the strong bodies that they are.

Thank you.

[The statements follow:]

STATEMENT OF DALE R. CORSON, NATIONAL ACADEMY OF SCIENCES

My name is Dale Corson. I am Chairman of the Government-University-Industry Research Roundtable, a new entity sponsored by the National Academy of Sciences and the National Academy of Engineering. I am pleased to be here this morning to describe the Research Roundtable—an experiment with a new type of institution to address issues important to American science and technology—and to review the Roundtable's plans for examining the contributions of university-industry linkages to more effective utilization of scientific and engineering advances.

Government-University-Industry Research Roundtable

The Government-University-Industry Research Roundtable has been created to provide a forum for scientists, engineers, administrators, and policymakers from government, universities, and industry, to come together on an ongoing basis to explore ways to improve the productivity of the nation's research enterprise. The object is to try to understand issues, to inject imaginative thought into the system, and to provide a setting for the seeking of common ground.

The Roundtable has two unique features. First, it was created on the assumption that all sectors—government, university and industry—share the responsibility for the stewardship of the scientific and engineering enterprise and for ensuring its continuing contribution to the national well-being. The make-up of the Roundtable Council, the guiding body for the organization, illustrates this feature. The Council includes senior federal R&D officials, senior officials from university and industry, and working scientists. In my experience, this is the first time that these parties have sat down together in an organized manner and on a continuing basis to examine the critical problems and opportunities facing American science and engineering. And let me add, Mr. Chairman, that although we do not now have a current or former member of Congress on this Council, we are working hard to recruit such a person and hope to have that search completed soon.

The second unique feature of the Roundtable is its ongoing nature. It is not a group convened to study an issue, write a report, disband and go home. The Roundtable is a means for addressing the important issues within a structure that provides for continuity and follow-up.

The operations of the Roundtable are based on the premise that the health of science and engineering is determined by the capabilities for creating new knowledge, by the effectiveness with which the general public and future scientists and engineers are educated, and by the extent to which these resources—knowledge and people—are utilized for the benefit of society. Today, there is increasing evidence that tension and weaknesses within the science and technology enterprise are threatening the nation's ability to sustain its position as a leader in the production and utilization of new knowledge and technology.

With respect to education and the practice of science and engineering, deficiencies have been noted in the status of academic equipment and facilities and the quantity and quality of academic and industrial personnel. Additionally, there are questions about the continued suitability of current funding practices and organizational arrangements for pursuit of the most promising and exciting scientific and engineering frontiers.

With respect to the utilization of knowledge and technology, the weakening of alliances between the individuals and organizations that create new knowledge, and those who use it is considered to be one of the factors contributing to our nation's deficiencies in translating scientific advances into applications. We hear much concern about the need to enhance industrial innovation by shortening the timespan from discovery and invention to application and by solidifying the connections

through which the academic scientific community keeps informed about technical problems and opportunities in industry.

The Roundtable is organized into four working groups to address these issues. Working Group One focuses on the identification, recruitment, and retention of talent for science and engineering careers. Working Group Two addresses the physical and organizational infrastructure for academic research. Working Group Three focuses on the ability of universities, industry, and federal and state governments, separately and cooperatively, to enhance organizational and institutional arrangements for promoting the sharing and utilization of knowledge and technology. The activities of this Group are most relevant to the interests of the Subcommittee in this hearing, and I will come back to describe its activities in more detail, shortly. Working Group Four addresses major issues underlying the entire research and engineering enterprise

The purpose of these groups is to elucidate issues in the areas under their jurisdiction, to identify problems and opportunities, and to consider options for dealing with them. Both near- and long-term goals are pursued. As progress in understanding an issue is made, the results will be brought before the Roundtable Council for its deliberation. When an area of concern is believed ready for public discussion, a forum, with all the interested constituents invited, will be convened.

Let me illustrate the nature of the Roundtable activities by describing briefly two events planned for the summer of 1985.

On June 5, the Roundtable will sponsor a hearing in which all relevant constituencies will participate in establishing the guidelines and priorities of an ongoing effort directed toward improving the efficiency and effectiveness of the sponsored research system. The objective is to identify specific suggestions for modifying or removing unnecessary administrative, management, and financial procedures in government and university sponsored research systems.

The second event is a working conference in July to find ways to meet the needs for academic research facilities. The conference will bring together representatives from the scientific and engineering communities, the Federal Government, both executive agencies and the Congress, state governments, academic institutions, industry, and the financial community, to explore ways to regularize the federal funding of academic research facilities and to explore ways to leverage the federal investment with additional approaches using all the resources available in our society. The Office of Science and Technology Policy, the National Science Board, and the National Academies of Sciences and Engineering will sponsor the conference. The Research Roundtable is the operating agent for the academies, and will be the convenor of the conference. I will be the conference Chairman.

Further explanation of the Roundtable's activities and lists of Council and Working Group members are provided in a Roundtable Status Report appended to this statement. I respectfully request that it be entered into the hearing record along with my written statement.

Working Group Three, New alliances and Partnerships: Enhancing the Utilization of Scientific and Engineering Advances

Roundtable Working Group Three, called "New Alliances and Partnerships: Enhancing the Utilization of Scientific and Engineering Advances," is just initiating a project to examine what can be learned from the new alliances and partnerships between universities and small and large companies, the financial community, and federal and state governments. In recent years, there have been many conferences, symposia, and workshops on university-industry interactions. In general, these sessions have focused on the generic types of partnerships and on broad policy issues, such as patents, licensing, royalties, and publication. Now that the collaborative programs have been in operation for a few years, the Roundtable is seeking to shift the focus of the discussion to the effectiveness of the programs, and to their impacts on knowledge and technology transfer between universities and industry, on graduate education and research, on industrial science and engineering, and on the operation and structures of the cooperating institutions.

We approach this task on the assumptions 1) that programs, their sponsors, and government and industry policy makers all want to know how well the new alliances are working, and 2) that it will be beneficial to exchange information and ideas about the criteria to be used in judging their effectiveness. Therefore, the Roundtable Working Group sees itself as a facilitator of a cooperative effort to examine program impacts, and not as a detached group of analysts collecting data and issuing a report. The project is intended to help the participants examine the operation and evaluation of their own programs and to provide a framework for ongoing

local, regional, and national level discussions. Also, the project results should be of interest to institutions and organizations interested in setting up new alliances.

Our method of approaching the task is through examination of a group of ten to fifteen types of new alliances. Four general questions will guide this review.

1. How effective are the new alliances in contributing to the increased utilization of scientific and engineering advances?

2. What are the effects of the alliances on the conduct of science and engineering research?

3. What are the effects of the alliances on the roles, responsibilities, and characteristics of the institutions in each sector?

4. How are the public's interests preserved in the operation of the alliances?

The basis for responding to these four questions will be information, discussion, and observations related to a more detailed set of questions. The more detailed questions include:

1. What were the expectations of each party in entering into the alliance, and who were the key persons involved in establishing the arrangement? What kind of R&D does industry see as amenable to carry out through these alliances, and likewise, what kinds of boundaries do universities place on the research appropriate for such arrangements?

2. Who is responsible in each participating organization for managing the arrangement on an ongoing basis? What are the funding arrangements? What disciplines and departments are involved, and to what extent? Were new organizational arrangements created in the participating universities or industry in order to maintain the arrangement?

3. What is the technical nature of the scientific program? What types of technical and scientific personnel are involved? What are the procedures for deciding on the particular research programs conducted within the partnership?

4. What are the mechanisms and procedures for communication, cooperation, and collaboration among the participating scientists and engineers from each institution? What procedures are being used to link the units responsible for carrying out the research with those units responsible for incorporating the research results into the development of new products and processes? What patenting, licensing, and other proprietary arrangements have developed?

5. What is the effect of the relationship on the university culture, for example, on student-faculty relationships, faculty-administration relationships, the nature of graduate education, the recruitment of faculty, and the nature of research problems pursued by university researchers? Likewise, what is the effect of the relationship on the industrial culture?

6. What are the indicators of the effectiveness and the impacts of these new arrangements? What do the universities and the industries gain from participation in these new alliances? Are these new arrangements indeed shortening the time span in which new knowledge and technology are translated into applications, and are they providing a route through which the academic scientific community may stay better informed about technical problems and opportunities in industry?

In pursuing these questions, the Working Group will work with several different types of arrangements, including:

1. industrial associations or cooperatives, where companies within a given industrial sector pool their resources to support research and education at several universities;

2. arrangements between a single company and a single university;

3. university research centers with multiple sponsors, which might include industry, state government, and federal government;

4. state government programs—both statewide strategies that include, for example, targeted technology centers, general research support, and small business development programs, and single generic technology centers initiated through state government action; and

5. small business development and entrepreneurial activities of universities and individual faculty; included here are university initiated or affiliated incubator centers for small businesses, university financing and otherwise nurturing and supporting new technology businesses based on faculty research, and small technology-based entrepreneurial businesses with extensive links to universities

As you can see, Mr. Chairman, the Working Group is embarking on an ambitious work plan. At this stage in our exploration of new alliances, we have more questions than answers to share with the Committee. I will conclude, however, with a few observations that have been made in Roundtable Council and Working Group discussions on this subject. We have found these observations useful and hope that they may also be of help to the Subcommittee in its deliberations.

Complexity.—The first observation regards the complexity of the processes of knowledge utilization and technical innovation. The translation of knowledge into applications is not the linear process from basic research through applied research, development, demonstration, to product, that is often characterized in simple diagrams. Rather, much research by persons from a broad range of disciplines has shown that knowledge utilization and technical innovation are complex processes. They include many interactions between the people and organizations involved; they involve complex patterns of information flow and decisionmaking; and they vary considerably from one sector of society to another, and even within a given sector. The linear model, together with its descriptor, technology transfer, in the past has led to simplistic and often inappropriate strategies for promoting enhanced knowledge utilization. In contrast, the new and emerging alliances, with all their variability and opportunity for give-and-take between knowledge producers and knowledge users, collectively may be an effective approach to improving the utilization and technical innovation processes. We hope that the Roundtable's exploration of these new alliances will provide useful insights. Nonetheless, it must be recognized that many factors beyond these new alliances also must be involved in any approaches to improving industrial innovation.

All is not new.—The second observation is that all is not new. While many new types of alliances and partnerships are being developed, there is as well a long tradition of government-university-industry interactions. This history of interaction is most notable in agriculture, medicine, and the defense/space area. Some observations about these areas are informative.

Myriad organizational entities and institutional arrangements have evolved in agriculture and biomedicine through which the government-university-industry interactions operate. For example, in agriculture, there are linkages among land-grant universities, USDA research laboratories, agricultural extension services, commodity groups, equipment manufacturers, agricultural processing firms, and pesticide producers. In medicine, there are linkages among the pharmaceutical industry, practitioners, and university medical centers, which include their teaching and research hospitals. Parallel linkages are common between schools of engineering and elements of the defense and space industries. In addition, in each of these areas there is a focus on practical problems, and the units within universities that are involved—schools of agriculture, schools of medicine, and schools of engineering—have a tradition of interest in the applications of science and technology which provide a basis for fertile university-industry interactions.

In the core arts and sciences departments in universities, interests center around basic science and theoretical problems. Therefore, the nature of university-industry interactions in these areas is different and likely to include more tension, at least initially. Whether interactions in these new areas can or should draw on the models of engineering, agriculture and medicine is at the heart of the current experimentation with new partnerships.

Expectations.—My third and final set of observations has to do with the expectations of each of the parties in getting involved in these new arrangements. For universities, the list of expectations usually begins with the search for additional sources of financial support. These sources are attractive because of the limitations on federal funding for research and the flexibility provided by diversified income. Within the Roundtable, however, discussions have tended to center around the point that the primary responsibility for support of basic research continues to lie with the Federal Government, and that, with few exceptions, universities are not likely to obtain large amounts of additional resources from new alliances.

Additional, and perhaps more productive motivations for universities entering into these new alliances is to enrich their intellectual environments and to enhance their capacity to contribute to national, regional and state needs. By providing a broadened base for scientific cooperation and communication between academic and industrial scientists, and by providing a mechanism for the sharing of equipment, facilities, techniques and materials, these alliances can create new and valuable perspectives on undergraduate and graduate education, open up additional challenges for academic science and engineering and tie educational and research programs of universities closer to national and local needs. The extent to which the alliances bring industrial perspectives to graduate education and research becomes especially important if one assumes, as some predict, that for the next couple of decades, increasing numbers of scientists and engineers will be taking jobs in industry. Moreover, the ability of university faculty to work with industry and become involved in entrepreneurial activity may help retain some of the best scientists and engineers within the university. As desirable as these motivations are, they can lead to structural and operational changes in the university that deserve close watching.

Industry has realized that the loss of United States competitiveness in world markets stems from a relative decline in productivity and quality. Industry enters these new alliances with the hope that an infusion of new people, educated in new ways, will help turn this situation around. Additionally, as product life cycles become shorter, industry needs a continuing flow of new ideas that may lead to new or improved products. The new partnerships provide industry with the ability to try out new research ideas, new research areas, and speculative alternatives to current products without large in-house investments in facilities and people. The alliances also may increase the vitality of the work environment in industrial laboratories.

Past involvement by state governments in academic science and engineering has been based on constitutional and statutory responsibilities for providing general support for colleges and universities. More recently, recognition by states that effective utilization of science and technology resources is essential to achieving their goals, has led states to expand their roles in science and technology. State strategies assume that the Federal Government must continue to be responsible for the primary support of basic research and for guiding national economic policy. The states, however, see their role as that of a catalyst fostering and supporting the partnerships between higher education, business and other sectors. Their principal motivation is industrial development, and the creation of new businesses and jobs within state borders.

The Federal Government approaches these alliances from several perspectives. First, it seeks to enhance the contributions of some 700 federal laboratories to industrial innovation by promoting university-industry-laboratory collaboration. Second, the rationale for the federal support of much civilian R&D is to contribute to international economic competitiveness and improved social well-being. Thus, there are several federal programs and policies that seek to encourage the application of federally-supported R&D in the civilian sector, including programs directed toward forming university-industry alliances and patent, tax, and antitrust policies. Finally, federal support for academic research and education helps to build the capacity in the universities that is of interest to industry.

CONCLUSION

In conclusion, the United States, and indeed the world, is now going through a period of rapid, exciting, and in some respects troublesome changes in its economic, social, scientific, and technological institutions and practices. The Government-University-Industry Research Roundtable, as a social policy experiment which seeks to involve in a meaningful way all sectors of society in the stewardship of the American scientific and engineering enterprise, is one response to these changes. Another is the wide range of new arrangements emerging between universities, small and large companies, the financial community, state governments, and the Federal Government, to meet individual institutional objectives as well as to enhance the linkages between the producers and users of new knowledge and technology. Our understanding of how best to achieve our social, economic, scientific, and technological objectives amidst this change is limited. Thus, such experimentation as I have described should be encouraged, and should be watched carefully, if we are to find the most effective means for meeting our national needs into the next century. The challenge is to design effective experimentation without destroying the principles, the policies, and the values that have made our institutions—our universities, our industries, and our governments—the strong, world-leading, entities that they are today.

Senator GORTON. Thank you, Mr. Corson.

Will Federal laboratories be represented in the Roundtable's Working Group Three, new alliances?

Mr. CORSON. Yes.

The director of Argonne National Laboratory is a member of that working group, and the role of the Federal laboratories in the new alliances with industry and with universities is part of the consideration of that group.

Senator GORTON. You mention that one of the deficiencies in translating scientific advances into commercial applications is the lack of interaction between creators of knowledge and those who use it.

The Federal Laboratory Consortium and the Stevenson-Wydler Act attempt to facilitate interaction between these two groups.

Is the roundtable going to look at the work of the consortium and the mechanisms set up by Stevenson-Wydler?

Mr. CORSON. Our first priority is looking at the university/industry relationship, and we are only beginning to think about the Federal laboratory ties to the other sectors of our society. So at this stage, that part of the effort is not well developed.

Senator GORTON. Dr. Suh, you state in your testimony that if Stevenson-Wydler is not reauthorized, there will still be in existence sufficient legislation to encourage moving research results from Federal laboratories to private sector applications.

Would you tell me what legislation that is?

Dr. SUH. Well, sir, I think within the NSF Act, we are given, I think, enough authority to carry out all of the university/industry cooperative research programs. In fact, I testified a few years back, when the Stevenson-Wydler Innovation Act was enacted in support of the act. In fact, at the time the act was enacted, one of the models they used in enacting the act was one of the programs NSF had in the form of the industry/university center program.

In fact, I was running one of the centers at MIT, and in drafting the legislation, they used the way we are doing it as a model. Much of that component was in there.

So, NSF has been doing much of these things.

I think the difference between what has happened between that time and now is the fact that the climate, the culture in the country, that indeed this kind of university/industry cooperation is an acceptable thing and is indeed something that should be encouraged, is a major change from the kind of cultural climate we used to operate in 5 or 6 years ago.

In fact, when I started that kind of cooperative research effort at MIT 10 or 12 years ago, there were a large number of people opposed to the entire concept. Since then, that concept has been used in a large number of universities, and we have now over 30-some centers doing that kind of collaborative research.

Senator GORTON. It would seem to me that what you have described is the success of the act. That would be a good reason to reauthorize and strengthen it. There is substantial difference between an agency being allowed to do something and its being encouraged or directed to engage in an activity.

Dr. SUH. Sir, the NSF has been doing this, even prior to the enactment of the act. Since then, with your support and the support of other Members of the Senate and the House, we have started a general research center program. That will further strengthen our support of industry/university interaction, and I think it will give us sufficient emphasis to the whole concept. Therefore, we feel that we do have sufficient authorization for the legislation to deal with this university/industry collaboration.

Senator GORTON. What harm would be imposed by the reauthorization of the act?

Dr. SUH. Well, personally, I don't know of any harm that can be done by it.

Senator GORTON. What you are really saying is that you could go on doing the same thing and you might do it if the act is not reauthorized; but we sort of would have to take that on faith.

Reauthorizing the act certainly is not going to hurt the program.

Dr. SUH. You are right.

Senator GORTON. Stevenson-Wydler established the Department of Commerce's Center for the Utilization of Federal Technology. It compiles and distributes written reports and summary sheets of contacts and technologies in Federal laboratories and other organizations.

If we do not reauthorize that center, who will pick up that clearinghouse function?

Dr. SUH. I cannot answer that question because I do not really know all of the authorities that the Department of Commerce has. But it seems to me, at least within the National Science Foundation, that we are looking into the idea of disseminating information to the user community, and we are taking active steps to implement that.

So, from the NSF's point of view, we can, indeed, accomplish all of those goals stated in terms of information dissemination.

In fact, I am getting together with our colleagues from the National Bureau of Standards to talk about this.

Senator GORTON. You have spoken of what NSF will do, even if the act is not reauthorized. Are you totally confident that, if we do not reauthorize Stevenson-Wydler, Federal laboratories, all of them, will still regard technology transfer as a part of their mission requirement?

Dr. SUH. Well, since coming down to Washington, I have talked with most of my counterparts in other agencies. I think they are very sensitive about this whole issue. The reason they are sensitive about this issue is because, as I stated earlier, the cultural climate has changed dramatically during the past 5 or 6 years. That cultural climate might have changed because of a number of factors. Maybe the Stevenson-Wydler Act had a role to play.

But the fact that now the university communities are anxious to collaborate with industry, the fact that we can now talk about information dissemination as being part of the function of the National Science Foundation, indicate that we can carry out all of the programs without having any new legislation.

Senator GORTON. Both the Intergovernmental Science and Technology Program and the Industrial Program of the National Science Foundation are scheduled to be terminated in fiscal year 1986.

What does NSF propose to do in lieu of these programs to promote the intent of Stevenson-Wydler? Or, is their cancellation a part of your recommendation that we not reauthorize?

Dr. SUH. As I stated in my testimony, we do have a number of programs whereby we do try to increase collaboration between the dawn of technology and the acceptance of technology through the industry/university collaboration, and we are looking into the possibility of further enabling our university researchers to have access to national laboratories. Also, we do have collaborative efforts being made with other Government agencies to co-fund some of these engineering research centers. So we have been studying

how other agencies and NSF can collaborate in some of these new undertakings, such as engineering research centers.

So, we are doing all of those things that you just spoke about in a very vigorous way, in fact. And, in fact, a substantial part of my time has been spent in collaborating with other agencies in implementing some of the technology transfer issues. Therefore, it is my understanding, at least, that we do have sufficient legislation that would give us the authority to carry out all these functions. And we have been doing that. In fact, we are spending a great deal of effort and management time to deal with all of these issues.

Senator GORTON. I must tell you that I am totally dissatisfied with that recommendation. It is clear that the great majority of people who are interested in technology transfer want, at the very least, the reauthorization of Stevenson-Wydler and in many cases its strengthening. That certainly reflects the views of the chairman of this subcommittee.

I do recognize that some of the testimony you have given may have been required by organizations outside of the National Science Foundation. But the message you should take back is that that testimony is not persuasive.

Mr. CORSON. May I just make one comment along the line of the NSF program?

Senator GORTON. Yes.

Mr. CORSON. I come from Cornell University, and we have a microelectronics development center there, a so-called submicron center, looking to the next generation of microelectronics technology, which came to our university as the result of an NSF national competition in the beginning of 1977, involving all universities that were interested.

It was won by Cornell and came there. It is organized with industrial participation, both as observers and as boards of advisers and users that are fully integrated into all the new developments that are going into the new generation of both software concepts and hardware technology involved.

NSF took the lead in that all the way back in 1977.

Senator GORTON. Thank you.

Thank you both.

Our final panel will consist of Mr. Paul Houck, of the Pennsylvania State University; Dr. Timothy Janis, of the Indianapolis Center for Advanced Research; Ms. Linda Cooper, of the Ohio Technology Transfer Organization; Mr. Larry Palur, of the Ohio Technology Transfer Organization; and Mr. Larry Crockett, of the University of Michigan.

Mr. Houck, we will start with you.

Again, I will state to each of you that your entire written statements will be included in the record. We would like you to summarize them, if you will, in not more than 5 minutes.

STATEMENT OF PAUL W. HOUCK, INFORMATION COORDINATOR, TECHNICAL ASSISTANCE PROGRAM, PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PA

Mr. HOUCK. Thank you.

The Pennsylvania Technical Assistance Program is better known as Penntap. It operates as a statewide service in Pennsylvania, as a unit of the Pennsylvania State University in partnership with the Commonwealth's Department of Commerce and has been doing so for the past 20 years.

To summarize my prepared observations in regard to the Stevenson-Wydler Act and the status of technology transfer, I want to emphasize the role of technology transfer, its function, and most of all, its potential—factors which tend to become lost or at least subdued in much of the legislation or in many of the programs that are intended as technology transfer thrusts. When enacted or performed, these intentions come out with blunted guidelines or efforts that bounce off the target without leaving impressions or results.

I have given you our thoughts on the need. I observed that what the United States has done with utilizing the results from billions of dollars of research could be illustrated if everyone in this room were to purchase a 1985 automobile and then park it in their garages at home on their blocks, or buy a new home and then board up the doors and windows. They made the investment, drove the car home, moved furniture into the house, and then never used them afterward.

The Government, for its part, has invested in research and development, probably applied the results to one particular project, and then parked the information without much effort to determine if it could be used in the public marketplace.

That scenario has changed somewhat in the last few years, particularly since some of the Federal labs and agencies, on a vountary basis, started to get involved in technology transfer.

There are now many Federal employees who are dedicated to transferring technology to the private sector and to the State and local governments.

Stevenson-Wydler, of course, was intended to bring the Federal effort together, but, from our viewpoint, the impact has been slight.

Penntap already had access to much of the vast informational base within the Federal structure. The act did draw attention to the need for Federal dissemination, and it did originally mandate manpower and budget provisions for technology transfer, although those mandates were watered down.

The act did create the Center for Utilization of Federal Technology, or CUFT, but its inadequate staff renders its effort below potential.

Generally, Stevenson-Wydler appears to be a conglomerate of ideas assembled for a mission whose goals have gone astray.

In our opinion, it confronts the forest of technology and technology utilization rather than the trees.

An important, but missing, factor seems to be a practical understanding of where and how the most effective technology transfer takes place—at the grassroots level, among all kinds and all sizes of companies and institutions—and that the transfer function must have an agent, a technical person as a middleman, a matchmaker between the grassroots need and the best available resources of technical information, whether it is the Federal Government's vast

system, the hundreds of research universities, special libraries, State governments, computer networks, or private sources.

We have suggested, Mr. Chairman, that this committee should look carefully at what we call the missing link in this Nation's approach to full utilization of all of its technical resources, a missing link that prevents us from realizing the tremendous potential impact technology transfer can have on our economic growth.

The missing link is a decentralized, but structured network of technology transfer centers, disciplined in science and engineering only, and geared by the same operational principles for producing results.

To illustrate briefly the potential of these centers, I will tell you how Penntap works—not necessarily as a model, although others have called Penntap a model system and many States and a number of foreign countries have used us as a model—but more to emphasize potential.

We have a small staff of engineering, scientific type specialists, who work full time responding to between 1,200 and 1,300 cases every year. Since 1972, when we hired our first full-time specialist, we have had a followup evaluation system to measure results, the actions taken, the improvements made, the dollars and time saved, and so forth.

Since then, our users have told us they have achieved economic benefits valued at just under $80 million. In 1984, the benefits totaled more than $10 million.

These figures do not include residual benefits, new or saved job impact, capital investments, or new products. Significantly, our cost-benefit ratio is also a plus at 17.2 to 1—$17.20 in benefits coming back into the economy for every $1 invested by the university and by State and Federal Governments in our program.

Technology transfer can be cost effective.

My concluding comment is this, Mr. Chairman. The Federal Government has created a strange paradox in regard to technologies. It rightfully, and legitimately, spends billions to create and to extend our technology base. But it allows, by comparison, a pittance to distribute valuable parts of that information to places where it can be used to create or expand our economic growth. Yet, the administration and Congress are struggling with a deficit problem which many experts claim could be eased considerably by economic growth.

Properly managed technology transfer can have a significant impact on economic growth. Our suggestion for the way to take advantage of this potential, in reality, is for the Federal Government to join with the States and appropriate universities to establish a network or chain of technology service stations, to not only market proven technologies, but also be easily accessible, at the grassroots level.

Think of them as stations with, one, a self-service pump for the companies and institutions with manpower and knowledge to deal directly with Federal or university or other resources; and, two, with full-service pumps, manned by technical specialists who can help define needs and problems and potential applications, find solutions and otherwise fill the need for technology assistance. We

have plenty of fuel, an abundance of technologies, and the brain power to sustain our position in the technoogy revolution.

If the Stevenson-Wydler Act can be redressed to accommodate this practical approach, yet retain the strong emphasis on mandate with the Federal laboratories, our effort would reap virtually unlimited benefits to our economy.

Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF PAUL W. HOUCK, INFORMATION COORDINATOR, PENNTAP

Mr. Chairman: My name is Paul W. Houck. I am the Information Coordinator for the Pennsylvania Technical Assistance Program which is operated as a partnership by The Pennsylvania State University and the Pennsylvania Department of Commerce. For the purpose of reference, we are considered as primarily a University function and we operate from University facilities. We do take on special projects for state or federal agencies; currently, for example, as part of the U.S. Department of Commerce's Economic Development Administration (EDA), we operate Pennsylvania's University Center with a special task to assist small businesses in the area of advanced technologies. Our technology transfer services are limited to engineering and scientific areas. In Pennsylvania and in technology transfer circles around the country, we are well known by the acronym PENNTAP.

I thank you for this opportunity to offer this committee observations based on PENNTAP's experiences over the past 20 years, and to comment on our working relationship with federal laboratories and agencies, as well as the Stevenson-Wylder Act.

For purposes of illustration, Mr. Chairman, I would observe that I cannot imagine anyone in this room who would surrender to such extravagances or indignities as purchasing a 1985 automobile and then parking it in their garage at home on blocks, never using it . . . or buying a new home and then boarding up the doors and windows, never using it . . . or, on their wedding day, telling their bride or groom as the wedding reception ended, that they were going out to play cards with friends all night . . .

Yet, that kind of scenario has existed for years in the field of research and development. As you well know, we have been spending billions of dollars for research every year in this country, but there have been no significant provisions for the mechanisms needed for practical transfer of research results to the marketplace.

In far too many cases, the fruits of research have gathered dust in the warehouses of knowledge . . . government warehouses essentially . . . parked on blocks, boarded up, unused.

Fortunately, that scenario has been changing; not the amount of research nor the funding to support it . . . that is continuing at a generally high level—and that's as is should be. I don't want to be misunderstood, Mr. Chairman; my statement is not against the research effort. To the contrary, my only question about research and development is whether we are devoting enough of our resources in that direction.

What is changing is the attention we have been giving to find ways to use research results, to uncover the laboratory shelves, and to make our abundance of technology available where it can be used productively. The change has been much too slow in coming and access remains a problem in some areas, in spite of Congressional intentions in the Stevenson-Wydler Act. The major difficulty that persists is with the delivery mechanism. We simply do not have a national, coordinated, structured program that promotes and makes possible an easily accessible flow of technology from the research lab through transfer agents to companies, institutions or other organizations that need the technology or have a potential use for it.

The Federal Laboratory Consortium started to open the doors to federal resources a number of years ago . . . not completely since it was basically a voluntary initiative, but the effort has been there to link the private and public sectors with technologies developed under federal auspices . . . and I will address this effort in a moment. The Stevenson-Wydler Act has attracted more attention to the need for dissemination of federal technologies. Its mandate for technology transfer is an extremely important contribution because it forces the labs and agencies to participate. And this represents the only appreciable illumination the nation's private sector has of what is happening in federally-sponsored research. Yes, there are other means of access, but these are limited and generally oriented to the "professional" information searcher from this or other countries. Despite the weaknesses still

present in Public Law 96-480—its waivers of manpower and funding provisions—if the technology transfer efforts mandated for the labs and others are stunted, the setback to the growth of the economy would be serious.

The scope of seriousness can be seen if I present a perspective of technology transfer's potential by telling you about real, actual impact caused by our PENNTAP activities in Pennsylvania.

PENNTAP covers the entire state. Our office and our specialists are based on the main campus of the Pennsylvania State University, but we provide services to and respond to calls for assistance from all corners of the state. We are one of just a handful of statewide organizations whose mission is to link companies with the latest available technical information that is appropriate for their need . . . in other words, a technology transfer service that will find the right technology for the exact place it is needed in the marketplace.

We respond to between 1,200 and 1,300 cases each year and every case is handled by a professional technical specialist. On our staff, the specialists are engineer-scientist types, all with advanced degrees and experience in industry. They work full time for PENNTAP, do not conduct research, and are not permitted to do any consulting work on the side, in Pennsylvania.

PENNTAP hired its first specialist in late 1971. From that point through the end of 1984, we responded to more than 19,300 questions and problems. Over the years, business and industry have accounted for an average 55 percent of the cases; others have involved local governments, colleges/universities, health care units, school districts, county/state/federal government agencies, and consulting/engineering firms—all having direct or some significant impact on the economy.

After we have provided assistance, at a point when we believe the user can measure improvements or achievements, we ask for an evaluation—not of our service, but of what has happened as a result of our services. Now, not all cases involve answers and solutions which can be measured by dollars and cents, and not all users return the evaluations, but on the basis of an average 45-50 percent return of evaluations and the statements made by users, the known economic benefits credited to PENNTAP's assistance from 1972 through 1984 was just under $80 million. The benefits reported by users during 1984 totaled $10 million. These figures do not include other factors which have an impact on the economy, such as residual benefits, capital investments in equipment and buildings, or in new product development, or in jobs. In 1983 and 1984, our PENNTAP users indicated we helped with the development or improvement of 55 new products. In a five-year period ending with 1984, users told us we had a hand in creating or saving over 500 jobs.

Another significant statistic that's relevant to this discussion: This kind of effective technology transfer can be cost-effective. PENNTAP's operating benefit:cost ratio average is a rather impressive 17.2 to 1 . . . which means, of course, that known economic benefits—not counting the impact of new products or new jobs—have been returning $17.20 to the economy for every $1 invested in PENNTAP by the University, the State or the Federal government.

In relation to these figures, I remind the committee that our technical specialists or transfer agents are high caliber professionals, not part-time faculty or graduate students. Yet, at no time has PENNTAP's operating budget exceeded $500,000. When you know that approximately one-fourth of our cases involves travel for on-site visits and that we have very large postage and telephone bills, it is not difficult to realize that we must operate with a relatively small staff. And we do—seven to ten technical specialists depending on the projects we have under way.

I have cited these PENNTAP statistics for two reasons:

(1) If a relatively small technology transfer organization following disciplined procedures and philosophies and using professional specialists to perform one-to-one transfer functions can case economic benefits amounting to $10 million, or $8 million, or $12 million in one year and also be instrumental in creating new products and new jobs, what impact would a network of similarly structured organizations have on the national economy?

(2) PENNTAP, or any information transfer system, is only as effective as its personnel and its base of information. I've mentioned the attention PENNTAP gives to choosing qualified personnel. However, with the perpetual turnover of knowledge and the near avalanche of new technologies in recent years, no one organization or person can be expected to be 100 percent current—the total expert possessing all answers. Therefore, the key to successful and practical transfer is access to and linking of the best available resources. To PENNTAP, the best available resource is any person, organization or association that can supply a possible solution to an existing problem . . . or produce a technology that appears to have potential for application and economic impact in Pennsylvania. In countless cases during the past seven or

eight years, the "best possible" resource utilized by PENNTAP has been a federal facility. I am sorry I cannot give you a dollar figure on the extent of the impact federally-based information has had on our state's economy, via PENNTAP, but I can assure you that the $80 million total I mentioned earlier would be much lower if we had not been able to turn to federal sources.

Thus, Mr. Chairman, if this committee is looking for evidence or reassurance that the federal dollars spent for technology dissemination . . . that the federal effort in this regard is paying off, is helping to create or save jobs . . . you can find it in Pennsylvania. Obviously, if you ask if a cutback in the federal programs directly involved in technology transfer or in supporting technical assistance delivery would have a serious affect on the nation's economic growth, our reply again would be "yes, very serious."

I would like to provide you with more detail on PENNTAP's cooperative relationship with various federal resources, but first, and at the risk of sounding presumptuous, I believe it would be helpful to the committee to understand that my statements reflect not only my opinion but also the philosophy and position and the status of PENNTAP—helpful to the extent that you know where we're coming from . . . and it's not just as one of the oldest technology transfer organizations in the nation. PENNTAP's system has been identified as a model for technology transfer. Louis Rukeyser, the syndicated columnist and commentator, examined our program a number of years ago and called it the most sophisticated in the nation. A team of academic administrators assembled from around the country conducted an in-depth study a few years back and observed that PENNTAP is a model other states should emulate. In fact, during the past four years alone, 37 states and 14 foreign countries have come to PENNTAP for assistance in setting up or in refining technical assistance programs. Our director, Dr. H. LeRoy Marlow, has appeared before a number of Congressional committees. He is the immediate past president of the National Association of Management and Technical Assistance Centers (NAMTAC), an organization which includes among its members the University Centers sponsored by EDA, as well as other federally-endorsed assistance centers. He is incoming chairman of the National Productivity Network and is active in the national Technology Transfer, Society. Among others, PENNTAP designed a technical assistance program for Venezuela several years ago and we were recently invited to Great Britain to consult on arrangements for transfer units.

I call your attention to this PENNTAP background only to re-affirm our position and our understanding of the technology transfer needs and potential to our country.

One of the factors relative to our successes over the years—and revelant to the federal involvement—is our very active Advisory Council. This is a group of business and industry executives, appointed by the president of Penn State, who each year volunteer about eight days of their time in meetings, task forces and travel to help us stay on the cutting edge of business and industry trends. They help us determine policy, plan technology awareness events, support our efforts within the university, state government and elsewhere to keep our specialists and the organization updated and tooled to sustain our ability to respond to the Commonwealth's needs. To add to its own expertise and experience, the Council utilizes resource persons who have specialized backgrounds and serve continuously as part of the group. One of these resource persons who has participated in Council affairs since 1977 is Mr. Jerome Bortman, who is part of the Federal Laboratory Consortium, working out of the Naval Air Development Center at Warminster, Pennsylvania, as the technology transfer coordinator for the Mid-Atlantic region.

One of the reasons PENNTAP has had a successful track record in using federal resources is Mr. Bortman's resourcefulness in helping PENNTAP's specialists find and gain access to the information harbored in federal labs or other depositories. We are quite aware, certainly, that Mr. Bortman's office has many other calls for assistance from the private and public sector and that he has been not only helpful but very successful in bringing technologies out of the federal system into the marketplace.

There are other government personnel who demonstrate a dedication to technology transfer that ultimately shows a payback to the nation's economic well-being. One of these role models is Mr. James Wycoff at the National Bureau of Standards, a resource frequently used by PENNTAP. Mr. Wycoff, who is current Washington chapter chairman of the national Technology Transfer Society, has been most cooperative over the years, in an active way and in responding to our technical specialists.

It would help, I believe, if I relayed some examples of federal technology transfer involving PENNTAP.

One of the most successful came in the mid-1970's when we learned about a preventive maintenance program developed by the Naval Facilities Engineering Command (NAVFAC). As we scanned the numerous manuals and publications produced for the program, we realized its possibilities were enormous. We took a small group of potential users to the Naval Weapons Lab at Dahlgren, Virginia, for a demonstration, then had these same people participate in a pilot experiment on the program's non-military effectiveness. We believe many institutions and companies were simply unaware of how much money they were losing by the lack of proper preventive maintenance procedures. The pilot program was successful, proving our point. Since then we have passed that program to hundreds of companies, hospitals, school districts, colleges. You should see some of the evaluations from those users: " . . . saved $40,000 in one year . . . $200,000 . . . $60,000 . . . $25,000 . . . etc." Millions in savings from one transfer of technology from a federal resource.

PENNTAP's use of federal bases has been diverse and includes cooperation from a number of locations. A sampling:

DOE's Oak Ridge lab provided computer printouts of materials on the use of compressed air for energy storage.

Argonne National Laboratory supplied reports of research data on batteries for electric cars.

NASA assisted in getting together the developer of the spacecraft splash down float collar with an inventor in Pennsylvania.

Army Cold Regions Lab in New Hampshire provided ideas to assist in solving a problem with operations of a front end loader in cold temperatures.

Brookhaven National Laboratory provided data on the use of polymeric concrete being cured rapidly with radiation.

DOE's Livermore Lab helped us with a state-of-the-art report for solving the problem of removing frozen coal from railroad hopper cars.

National Bureau of Standards shared with us data on the use of used oil, a subject of numerous inquiries.

Department of Transportation assisted in developing a plan to cope with a hazardous material spill.

U.S. Fire Administration assembled information which PENNTAP in turn has used to assist nearly 200 communities in developing master plans for fire protection.

Department of Agriculture provided information related to silo fires and PENNTAP's fire and safety specialist and a Penn State colleague further sophisticated a silo fire-fighting system which has received nation-wide attention and use.

Naval Air Development Center assisted in developing a contract to provide helicopters for high rise fires and marine rescue.

The same facility linked PENNTAP with federal labs specializing in anti-static technologies when a company making polyurethane containers feared problems with flammable materials.

The exchange of such information depends heavily on the credibility involved; when it exists in the form of understanding and respect, the exchange is usually smoother and more frequent. Professional competence at both ends is important because the information can and should go in both directions—from the federal resource to the university and from the university to the federal sources.

PENNTAP's staff has provided assistance to federal personnel of this nature:

We have worked with the David R. Taylor Naval Research Lab and the Caderock Naval Lab on various occasions, including one instance when the Navy was concerned about heat and fire resistance qualities of computer and electronic equipment aboard ships. Among others, we have supplied information to DOE on such questions as extraction of uranium from sea water. Though it was an indirect return of technology to the federal government, I would like to mention a case in which PENNTAP worked with a small firm in the development of a new product which I will identify only as an infrared camera imaging system. The product was selected as winner of a Governor's Product of the Year Award in 1984. Because of it, a spin-off company was formed with sales projections of $1 million in its first year. We're told that the product is now incorporated into the space shuttle tracking system and is also being used for hydrogen testing tasks in the shuttle program.

I must also mention another federal resource which PENNTAP has referred to on numerous occasion, the National Technical Information Service. NTIS and CUFT, the Center for Utilization of Federal Technology which was created by Stevenson-Wydler, provide a valuable tap-in service, a quick catalog look at what's available in federal locations.

I have given you this background to demonstrate PENNTAP's experience with federal resources, and, more to the point, to support our belief that the federal labs and certain other requirements imposed by Stevenson-Wydler are legitimate areas

for federal involvement . . . that the access function is not one that can be downgraded and allowed to deteriorate in the hands of non-specialists . . . that an intensified federal linkage system, coupled with an expanded network of grass roots transfer organizations, such as PENNTAP, would have tremendous . . . unlimited potential for economic development opportunities.

I realize the Stevenson-Wydler Act was designed to address these potentials. Nevertheless, in its comprehensive approach to technological innovation . . . in its broad brush attempt to cover the problem and the need, the Act's performance record has not followed the design. After four or five years, it has not given us a technology innovation or transfer coverage; in reality, the only marks it has left have come from the federal labs and, to some extent, from CUFT . . . otherwise, it has not contributed effectively to technology development.

If you look at what it has accomplished and what it has not accomplished among its original goals, there is a rather clear indication that the mission went astray. The point is that 96-480 imposed upon itself tasks which generally confronted the "forest" rather than the "trees." Its generalities obscure the targets, and even if funding had come through to match the design, there is doubt that the Act's accomplishments would have improved.

I will be more specific when I respond to several questions posed by the Chairman, but, for the moment, I ask you to look carefully at not an opposing but another view of the state of technology development and application . . . specifically the need for utilization of existing and forthcoming technologies in the marketplace.

With one exception, we have everything in place to implement a viable technology application system, one that would tie all of our resources together on a national scale and create a channel in which technology could flow to meet the demand or to create a demand.

We have the technologies and the brainpower in government, universities and the private sector to sustain our position. We have the vast informational base within the federal government and, thanks to the federal lab initiatives and the Stevenson-Wydler mandates, the access to this valuable resource. We have the universities as another prime source for information and backup, needing only the motivation for public service outreach. We have state governments eager to stabilize existing economic bases, to diversify and to move with technology developments. Additionally, we have the experiences from several states which have taught us important lessons about technology transfer itself. One lesson is that technical information simply cannot be dumped, or broadcast, or even given in printed form in response to a particular need, if it is to be effective . . . if it is to produce the expected or best possible results.

With all of these positive factors in place, we have on the other side of the economic scene a ready market for business, industrial and institutional applications. We know that small business generates the power for our economy. We also know that small business is where the most help is needed to find and to apply technologies . . . where the entrepreneurial spirit is born and nursed. We don't need further studies, policy conjectures or theoretical economic exercises to verify all of this.

There is, however, one missing ingredient, a missing link that prevents the potential from really developing, and that is the mechanism for a practical national transfer and delivery system. A small number of states maintain their own systems devoted to pure technical missions. There are technical assistance programs in many states, but they are fragmented by types of services offered and expertise available.

What is suggested here is beyond the design of the Stevenson-Wydler largely because it represents a de-centralized approach. The operational pattern should fit a national model, geared with fundamental principles oriented toward producing results, but technology thrusts would have to vary according to state or network member need. It also would be beyond the scale of services that could be provided by federal labs, NTIS, CUFT, NASA, OPTI or other agencies since they are limited in how far they can reach . . . for, as a matter of fact, in how far they want to reach. As you know, it has been the resistance by some agencies, not necessarily those I've mentioned, which has been a deterrent to Stevenson-Wydler implementation.

Essentially, Mr. Chairman, the thought is that this committee's concerns about industrial competitiveness . . . about the status of Stevenson-Wydler and its potentials . . . about the impact of the federal labs, in regard to the general question of utilizing federal technology . . . could more appropriately include concern about the federal role in helping to provide the missing link, the stronger bridge between what the federal government is now doing and where the technology can be applied.

I would have to assume that the linkage, the mechanism was or is a "tree" somewhere in the Stevenson-Wydler "forest" but the fact is that it is missing.

It is no longer a question of determining what kind of bridge would work best—that has been proven. The fundamental question is whether the federal government is really serious about making available the results of its multi-billion dollar investments in research. If it is sincere, and it is ready to accept the fact that the necessary principles and guidelines for dissemination have already been tested, proven and demonstrated successfully, then there is a wide open opportunity for Congress to move into productive partnerships with state governments and universities . . . cooperative ventures as part of a national network of centers whose primary mission would be to transfer science-engineering technologies. The impetus to bring this economic enrichment force together must come from the federal government.

If Congress would pursue that course, it would surely wipe out the strange paradox that now exists—the unceasing but, nevertheless, vital expenditure of billions of dollars for scientific exploration in research and development but sporadic, inadequate and yet equally important funding of vehicles that can carry the research results to the marketplace for utilization.

Another perspective of this paradox is the budget dilemma and the deficit situation. We are told that economic growth will provide the national stability needed to make tax increases unnecessary in regard to deficit reduction. We are also told—and can be reasonably certain, based on recent evidence—that economic growth will depend heavily on our adaptability to the technology revolution. At the same time, the federal government is the central focus, the largest developer, the major clearinghouse for technology—spending enormous amounts for that purpose from one hand while allowing a comparative pittance in the other hand for distributing its technology to places where it can cause or be part of the economic growth.

By insuring the strength of its own technology transfer forces—through the federal labs, for example—and offering a joint effort with states for a grass roots transfer and application network effort, the federal government would be closer to and impact much sooner on economic growth and stability. A re-dressed Stevenson-Wydler could be part of that effort.

Mr. Chairman, your invitation to testify today included specific questions regarding the purpose of these hearings. While I have already touched on a number of these subjects, for the purpose of an orderly record and possible clarification, I will address your questions separately.

What effect has the Stevenson-Wydler Act had on the technology transfer efforts of our organization? It has been positive, though, in all honesty, not as significant as the Act may have been intended. We may not be a typical example because PENNTAP had already established numerous worthwhile contacts in federal labs and other appropriate agencies which were voluntarily active in technology transfer. However, we support the effort, where I have indicated.

Should federal labs be permitted to develop their own transfer program? The labs exist to specialize in assigned technical areas. They know the market for their expertise; they should continue or be allowed to continue dissemination by flexible methods best suited to their expertise and their "clients," but with certain uniform ground rules, such as mandatory personnel and budget set-asides.

Does Stevenson-Wydler authority for technology transfer need to be strengthened? Yes, as I indicated in the previous question, certain provisions should be reinstated. My understanding is that only ten to twenty (10 to 20) percent of the labs or agencies have full-time people assigned to technology transfer, largely because changes to the law have permitted manpower and budget sections to be weakened. The federal government has responsibility to return the technology to the tax base market. All departments and agencies which conduct research, including Defense, have plenty of technology that can be distributed without disrupting government work or security. Part-time effort will not accomplish the task.

Does the Act, as it pertains to state and local governments, need revision? How? Here again, our observation is that the law's generalities permit a passive attitude, rather than encouraging or mandating an active role.

Do we have recommendations regarding the CUFT role? The role and concept are fine, but it is under-staffed. About six months ago, the National Association of Management and Technical Assistance Centers (NAMTAC) initiated an effort to assist CUFT in developing a dissemination effort through its membership. Adequately funded and staffed, CUFT could pursue these kinds of opportunities in an active way.

Would you favor allowing industry to co-fund research in federal labs? PENNTAP does not conduct research activities, although it frequently links industries with private and government labs having appropriate capabilities. Cooperative research by

universities and industry is a feature of Pennsylvania's government-sponsored Ben Franklin Partnership program. The usual hitch in these kinds of arrangements is the question of ownership of results, but federal standards and Stevenson-Wydler specifications are clear. The National Bureau of Standards has a successful program whereby people from industry go into NBS to work on specific areas. I would see co-fund difficulties in government operated federal labs; some possibilities in contract-operated federal labs.

How can quality rather than quantity of technology transfer be measured? PENNTAP's entire philosophy, and operation, are geared to producing results with an absolute minimum of paper work, red tape. We do not count "eyeballs" or phone calls or hours spent on this or that type of service. In contrast, many government programs force universities and contract performers to play games with artificial activity statistics that are counterproductive, have little practical use, and contribute nothing to the goal of the project. Quality comes from the credibility of personnel and the information transferred, not activity. Of course you have to have activity to produce results, but you have to make certain your emphasis is properly placed. At PENNTAP, when the time is appropriate for an evaluation of a particular case, we don't do the evaluation; we ask the user to do it. We don't ask for an evaluation of our services; we ask for an evaluation of results, what happened, what was achieved in dollar and manpower savings, in productivity improvements, in energy conservation, product development, employment. The user is the only person who can measure quality.

Should Stevenson-Wydler be broadened to include transfer of technology not developed in federal labs? The implication here is that a means would be established for federal employees to reach out into the university and private labs to retrieve technologies that could then be transferred back into the public and private sectors. If this is the idea, my response is that the Act should not be broadened. Not to be forgotten is the fact that some agencies resisted the intent of the original guidelines. On the other hand, if this question implies that Stevenson-Wydler might become the "father" or "mother" vehicle for establishing what I have called the "missing link," a structured network that would enhance technology transfer from all of this country's research labs—federal, state, university and private—then my response would be "yes!" As I said earlier, the federal role in bringing together this national technology transfer network for science and engineering needs would be a legitimate role, and because the federal government is so heavily and rightfully involved in scientific and engineering exploration, it must provide the impetus. I might suggest, incidentally, that while the EDA is a budget-cutting target, its Technical Assistance Division, and more precisely its University Center program, offers a nucleus for a national network. But, no, I do not see how giving federal employees authority to reach out to other resources, under present Stevenson-Wydler circumstances and concepts, would greatly increase the availability of technology at the grass roots level.

What problems are there with the way technology transfer is accomplished today? How can it be improved? I believe I have covered this ground in my testimony; however, I will respond to this question by summarizing quickly the principle guidelines for governing a technology transfer program that will work:

It should have a university base, staffed by full-time professionals from technical fields with special communication talents;

The service must establish access to multi-university sources, special libraries, federal/state/university lab and agency resources;

It needs rapport with professional and trade and labor organizations;

It must be readily accessible to potential users and be prepared for prompt reaction to requests for assistance, and also initiate delivery of technological information to potential users;

Most important, it must be built around the fact that technology transfer is a human activity, involving a qualified specialist or agent as the middleman or matchmaker between resource and need because

. . . one-to-one exchange enhances credibility, reception and use of information and definition of problems;

. . . interpretation of technical data is essential if it is to be understood and properly applied by the user;

. . . availability of information is not enough; simply making reports, bulletins, etc., available does not ensure their use;

. . . possible solutions often require many resources before information can be assembled that fits the exact need;

. . . sustained contact, help and interest in a particular case, as well as follow-up, is often what inspires the user to continue action or development.

Before I close, I would like to touch briefly on two important areas of technology transfer which sometimes develop blemishes in federal programs.

The first is the traditional federal concept that projects must eventually become self-sustaining. PENNTAP has never charged for its services and here's why: If you have any public dollars in your budget, you can hardly justify any restriction on the type of clientele you serve. PENNTAP operates in a field that is about as sophisticated as you can serve, but we deal with all sizes and types of organizations. In a single day, a specialist on our staff might be in contact with a vice president of a major corporation, the owner of a small machine shop, the president of a research company, an entrepreneur asking for help in checking out a new product, and the maintenance engineer at a small college. At least half of our cases involve small companies.

You can't charge what your services are really worth; that would start you in business competing unfairly with private enterprise. How do you determine a fee amount? If you try a variable charge, then you have to find out sales volumes, employee totals, product values, etc. How do you charge an educational institution, a municipality, or a young entrepreneur about ready to launch his own business? But, even if you could arrive at a reasonable fee, you have to weigh potential income against the fixed costs of billing, bookkeeping and collecting. From our viewpoint, the profit margin would not be sufficient to make the ordeal worthwhile. A more important consideration: We know that large numbers of the people who call us for help would not do so if they had to pay for the service, regardless of the amount. The onus of a charge affects people in different ways, no matter how badly they need help. If the question of a fee is raised, our response is that the University and the State, or the University and the Federal Government are providing the service.

The second area is related. We do not believe that a service supported in part or entirely by tax dollars and using public facilities should compete with the private sector. I know that is not a common philosophy in many state and federal service programs, but it should be. Our staff will go only so far in helping to find solutions. If a solution requires some type of special calculation or design, a new formula, a new equipment layout, etc., we back off. We will provide names of three or four consultants who specialize in that area, but the user makes the choice and the contact. We will suggest equipment needs and specifications, but do not recommend particular products by brand name.

To help us stay in line, we asked the Consulting Engineers Council of Pennsylvania to name a representative to our Advisory Council and it has done so for a number of years. Many consultants, in fact, use PENNTAP as a resource for their clients.

Finally, Mr. Chairman, I can reassure you that technology transfer's time is here. If this country is going to maintain its position in the world's technology revolution, the federal government cannot back away from its leadership role; nor can it slight the fact that the revolution is, in reality, a technology evolution—an evolving turnover of knowledge, innovative expansion of known technologies, a borrowing frombuilding upon process that depends a great deal upon access to and transfer of existing technology.

To discourage, rather than expand that effort, could be a critical mistake.

Thank you, Mr. Chairman, and Senators.

Senator GORTON. Thank you, Mr. Houck.

Dr. Janis.

STATEMENT OF F. TIMOTHY JANIS, DIRECTOR, TECHNOLOGY TRANSFER/ARAC, INDIANAPOLIS CENTER FOR ADVANCED RESEARCH, INC., INDIANAPOLIS, IN

Mr. JANIS. Mr. Chairman, I appreciate the opportunity to appear here this morning to present some viewpoints on the obviously complex subject of technology transfer.

My name is Tim Janis, and I am the director of technology transfer at the Indianapolis Center for Advanced Research, a nonprofit R&D center whose business is to develop and transfer technology.

My remarks this morning will principally focus on our major activity which is the operation of the Aerospace Research Applica-

tions Center for NASA as part of its technology utilization program.

ARAC's mission is to provide solutions to industrial technological problems through the engineering applications of existing technology.

I would like to emphasize that, to us, technology transfer is a business and, as such, it means we must develop viable products that are salable to our customers.

With the invitation to appear here this morning, we were presented a sequence of questions to which to respond. I would call your attention to the testimony that is presented for full delineation of those responses, and I would like to summarize just a couple of those key points.

The impact Stevenson-Wydler has had on our activities has been modest. In a direct sense, it has provided us with focal points for access to Federal expertise and innovations which is essential for our program. Its indirect impact has been more profound as realized through the heightened awareness that technology transfer has gained by virtue of the act.

The provisions of the act have provided mechanisms for establishing technology transfer programs in the Federal laboratories. It is our belief that the success of any program is based upon the entrepreneurial abilities of the leadership; furthermore, for a program to be responsive, that the needs are better and more sharply defined at the local level than they are at the national level.

The programs that have been implemented are principally bureaucratic, and it is our belief that bureaucracy tends to diminish incentives, and personal goal setting that are necessary for personal achievement and concomitant program success.

There is a question regarding quality versus quantity, and I would like to only mention what I consider a semantics issue.

Transfer implies to take from one place to another place. So, in technology transfer, by use of that particular phrase, it would imply taking something from the developer to the user. It does not imply, however, implementation. Most often, our measurement is based upon quantitative issues that state how well the user has done the resultant technology. I believe that, if we are going to use that measurement, we must go beyond calling this technology transfer and include the word "implementation," or "infusion," or something of that nature.

In summary, problems that I would bring to your attention include, one, that I believe the funding for technology transfer has never received high priority. Second, I believe that the incentives necessary for achievement many times are absent in the system that is currently in place. Finally, I believe that what has been developed is a passive system as versus an active system.

My recommendations are the following:

One, we sincerely believe that technology transfer is a critical element to successful technological innovation. Therefore, I recommend that technology transfer be incorporated as early as possible into any major development program.

Programs, however, should be market driven. There should be user involvement from the front end to the back end. The current

system should be transformed from a passive one to an active one, and this principally involves effective outreach.

A national infrastructure should, in fact, be established. I agree with Senator Riegle in that regard. I am not advocating the formation of a new bureaucracy. I am suggesting that a linkage needs to be formed. A potential starting place would be something such as the NAS forum, or a national committee whose responsibility is to look at technology transfer policy.

I believe that, as in any subject area, some appropriation should be made for research and development into effective technology transfer methodology.

Finally, I would suggest that any new program should utilize existing programs to avoid duplication and reinvention.

I appreciate the opportunity to appear before you this morning and I would be happy to respond to any questions.

[The statement follows:]

STATEMENT OF F. TIMOTHY JANIS, DIRECTOR, TECHNOLOGY TRANSFER/ARAC, INDIANAPOLIS CENTER FOR ADVANCED RESEARCH, INC.

Mr. Chairman: I appreciate the opportunity to appear before the Subcommittee to present viewpoints on technology transfer. The topic is a complex mixture of technological and sociological methodologies. Modifying an anonymous quote, "it isn't what you know that counts, it's what you find in time."

The Indianapolis Center for Advanced Research (ICFAR) is a non-profit R&D center, the primary mission of which is to enhance the well being of society through the development and transfer of technology. ICFAR operates the Aerospace Research Applications Center (ARAC) as part of NASA's Technology Utilization program. ARAC is an Industrial Applications Center (IAC), the primary mission of which is to provide solutions to industrial technological problems through the value-added engineering application of existing technology.

Technology transfer

Gilmore, in 1969, defined technology transfer as "a purposive, conscious effort to move technical devices, materials, methods, and/or information from the point of discovery or development to new users." For a time, it was believed that documentation and publication of technological applications in the open literature was the effective mechanism for technology transfer. NASA, and more recently, others have recognized that "the best method to consistently achieve optimum technology utilization in the private sector is to constantly look at the technology as a firm in the private sector would—as a means to either make or save money."

Methods for effecting technology transfer are many and varied. They may, however, be classified into two general categories—passive and active. The passive mode consists of documenting, publishing, distributing and responding to inquiries. Although technology transfer has become synonymous with economic development, most reported technologies are never quite right for transfer into the marketplace. Success is solely dependent upon the right idea reaching the right individual at the right time. Even in our highly computerized environment, the odds for this occurring are quite low. The passive approach thus has only modest potential for success.

The active mode effectively couples the source of technology with the eventual user. Experts have stated that the most effective mechanism for accomplishing this task to date is the "linker mechanism." The linker facilitates transfer of the technology between the developer and the user. For example, in the ARAC approach, which is depicted in Figure 1, a technical sales representative identifies a client and helps define a problem statement. A proposal is prepared, and upon client acceptance, an ARAC engineer is assigned the project. The engineer identifies applicable technologies and resources by the interrogation of computerized data bases. After his discussion with experts and final analysis, a report detailing recommended approaches is prepared and transmitted to the client. The linker in this model is a complex combination of active outreach and engineering.

Many other models have been developed that have attempted to exploit both the passive and active modes. Most of the presentors who have appeared before this

Subcommittee have developed and/or implemented some approach to technology transfer.

An additional clarification is necessary to keep the subject in perspective. Technology transfer is a dissemination process, and does not include technology implementation. This point is generally lost when measurement of technology transfer success is made. The time frame for implementation may be short, or as long as the time required for product development. Thus, measurement of results can be quite misleading.

This background information constitutes the base for the remarks about the Stevenson-Wydler Act. The recommendations to be presented for enhancing technology transfer are built upon this base, published information and, most importantly, the 22 years of experience of ARAC.

Stevenson-Wydler

The purpose of the Stevenson-Wydler Technology Innovation Act of 1980 is to improve the economic, environmental and social well-being of the nation through technological innovation. Section 11 of the Act sets forth a policy to ensure full use of the results of federal research and development. It includes provisions for staff in federal agencies and laboratories whose responsibility is to transfer federal research and development results to state and local governments, and to the private sector.

Each year, the Department of Commerce prepares a report on activities of the Act. Recently, the GAO provided an independent statement (GAO/RCED-84-60) of the status of the agencies' efforts to implement Section 11 of the Act. Quoting their findings, "GAO found that most of the agencies and their laboratories have taken actions to implement the requirements of the Act. GAO also found that patent policies and lack of resources to perform technical assistance may hamper technology transfer efforts." Historically technology transfer activities have been underfunded. The GAO's detailed findings may be found in the document, and will not be repeated here.

Included with the invitation to appear before this Subcommittee was the invitation to respond to a series of questions regarding Stevenson-Wydler. Following are experiential responses to these questions.

Impact.—The Act has had modest impact upon our activities. Directly, it has provided easier access to federal expertise through the Office of Research and Technology Applications (ORTA), and documents from the National Technical Information Service (NTIS). Indirectly, the heightened awareness of the utility of technology transfer has had some impact.

Local Laboratory Development.—To be successful, programs must respond to user needs. In general, those needs are more sharply defined at the local level than at the national level. Some regulations are necessary to avoid duplication and re-invention. The development of quality local programs is dependent upon the entrepreneurial capabilities of the leadership and their ability to exercise them. In most instances bureaucracies tend to diminish the freedom and incentives needed for maximum achievement.

Provisions.—As was so eloquently stated by members of this congress, "Technological innovation is a wellspring for economic growth." In 1982, manufacturing's share of the GNP dropped to under 23%, the lowest it has been since World War II. The development, transfer and implementation of technological innovation is critical to revitalization. The Act has provided for important mechanisms to carry out much of this activity. Bureaucratic approaches have been utilized which quite often have not included factors such as incentives, prestige and competition that are essential for success.

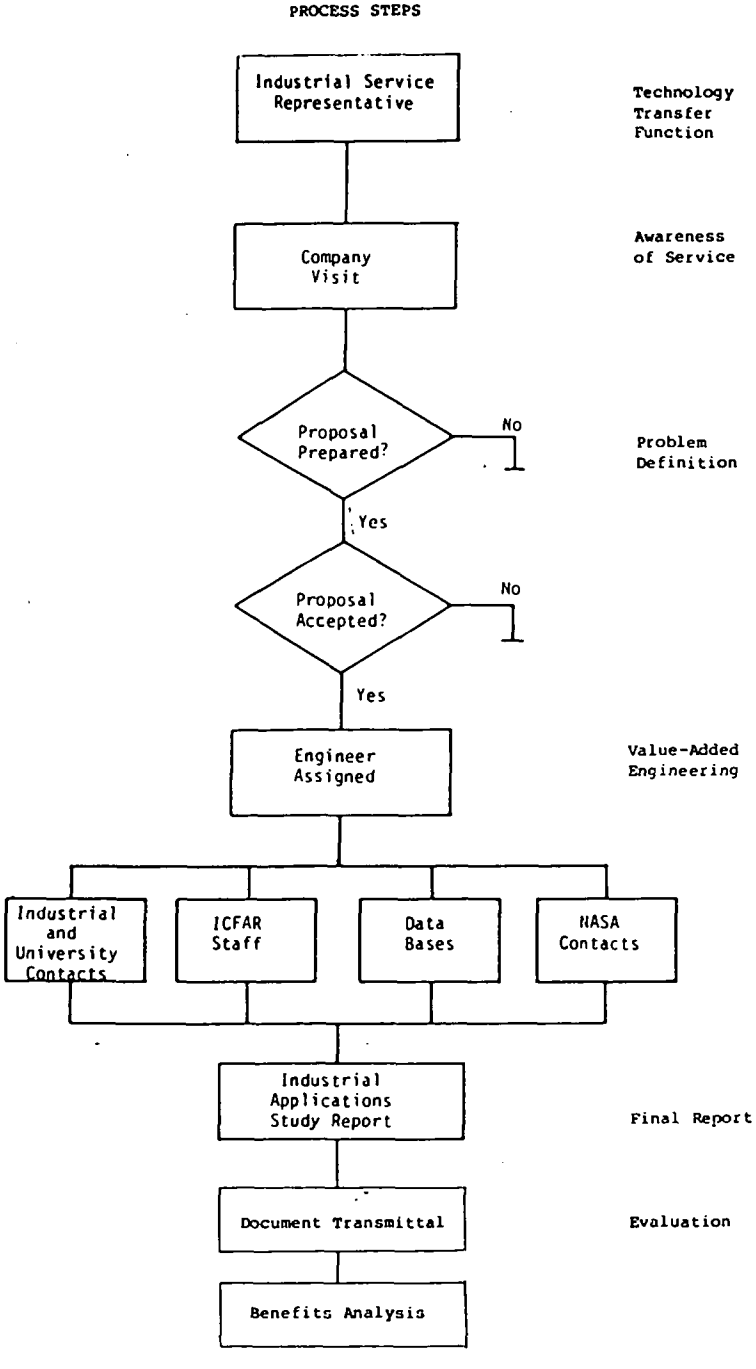


Figure 1. Industrial Applications Study Profile.

State and Local Government.—As enacted, the Act requires that technical assistance be provided upon request. Universities and local economic development groups have been putting together programs to fill this need. The federal laboratories should continue to be a resource to these groups.

CUFT.—The Center for the Utilization of Federal Technology was formed to produce and provide access to a computerized data base of federal technologies. A comprehensive, up-to-date data base of available technologies is essential for technology transfer activities. However, other agencies also have produced data bases and documents and duplication should be avoided.

Industry Funding.—The federal laboratories represent a major public investment and are reservoirs of talent. The application of these resources to private sector needs should be maximized. Jointly funded programs between industry and government laboratories should focus the latter's development activities while still not sacrificing quality research.

Quality vs. Quantity.—As was stated earlier, one of the misconceptions about technology transfer is that it implies technology implementation. Thus, measurements made strictly on the basis of dollar savings or dollars generated are inadequate. At ARAC, a thorough customer benefits system has been developed and implemented. It seeks to ascertain both the qualitative and quantitative impact of the project. The client is the only meaningful judge of the results. Based upon experience, if technology transfer is the sole process being evaluated, the amount transferred should be the key element.

Non-Federal Technology.—At the present time, the federal government maintains the patent data base and all the data bases containing federally developed technologies. This puts in its possession the majority of all U.S. innovations. It is not recommended that the federal laboratories' mission be broadened to include the few remaining innovations. Many private sector firms have produced data bases, and offer transfer services for these novel technologies.

Major Problems.—

(1) Although technology transfer has become an important component of economic development, the priority of funds for the process is not very high.

(2) Patent policies that do not include meaningful returns to the inventor and the laboratory tend to de-motivate innovators rather than motivate them.

(3) The generally passive nature of the technology transfer system.

(4) The disparity of the programs among the laboratories.

(5) The difficulties in obtaining cooperative programs.

SUMMATION

The transfer and subsequent implementation of technologies, both "soft" and "hard", is at best an inexact science. Considerable legislation has been enacted that has produced programs to enhance technological innovation. Based upon experience obtained at ARAC, the following recommendations are offered for consideration:

Technology transfer should be a critical component of any technology innovation legislation.

Existing programs should always be reviewed and enhanced rather than new ones being created.

An effective national technology transfer infrastructure should be developed.

Greater private sector involvement should be emphasized as a means to instill entrepreneurial drive.

Technology transfer programs should be responsive to market needs.

A national task force comprised of federal and private sector experts should be constituted to develop and review technology transfer policies.

The passive approach should be transformed into an active approach by effective marketing and engineering through cooperative arrangements with existing organizations.

Licensing and royalty dis-incentives should be removed from the patent policies.

A technology transfer focal point should be manufacturing technologies.

Future major terrestrial or extra-terrestrial technology development programs should incorporate technology transfer activities as early as is feasible.

Resources should be appropriated to enable technology transfer to become technology infusion (transfer and implementation).

Resources should be appropriated for additional research and development into technology transfer methodology.

Thomas Edison, our most prolific innovator, said "Genius is 2 percent inspiration and 98 percent perspiration." Technology transfer has undoubtedly received its 2

percent of inspiration through legislation. What is still required is market driven perspiration to achieve success.

Senator GORTON. Doctor, thank you for that textimony.

Ms. Cooper or Mr. Palur, you are next.

STATEMENT OF LARRY PALUR, DIRECTOR, OHIO TECHNOLOGY TRANSFER ORGANIZATION, THE OHIO DEPARTMENT OF DEVELOPMENT, COLUMBUS, OH

Mr. PALUR. I would like to preface our comments on behalf of the Ohio Technology Transfer Organization, or OTTO, on our definition of technology transfer.

We do not necessarily feel that symposia, workshops, and dissemination of technological information constitutes technology transfer. We do believe that it is a transfer of information from a source to a user. We at OTTO have addressed the quality issue in measuring what a technology transfer is worth and whether it has to be implemented or not. We choose to evaluate ourselves on the process of transferring the technology versus the implementation.

We have, with the help of the Stevenson-Wydler Act, in the State of Ohio, established a domestic technology transfer initiative with Wright-Patterson Labs in Dayton, OH.

A year ago, Governor Celeste and General McMullen, the commanding officer at Wright-Patterson ASD, signed a domestic technology transfer initiative establishing a full-time person at the Wright-Patterson Office of Research and Technology Application.

Thanks to Stevenson-Wydler, we have had the necessary support behind the initiative, and this initiative has been very effective in working with our State on behalf of the technology transfer issue.

OTTO is a network of 32 people working on an existing infrastructure. We believe that the initiative for that network should come from the State and should be State supported.

However, we do believe that enhancement of support provided by Stevenson-Wydler supplied an initial host of resources for our network within the State, in getting technology from sources, such as the Federal labs, to the users.

We believe that technology transfer is a people business. It is people talking to people. It is information going from one person to another. Our relationship with the Federal labs has been on the humanist side. We have worked one-on-one with a host of Federal laboratories nationally. We have involved ourselves in the Federal laboratory consortia meetings and appreciate their expertise and their willingness to share expertise with the State of Ohio.

One issue that has presented itself to our initiative is the issue of reverse technology transfer—getting information from the private sector, ideas, concepts, and developments, into the Federal labs, to be incorporated into Federal R&D projects. This is an issue that we are just beginning to look at in the State of Ohio.

In reference to cofunding the research, we define cofunding as an issue where the Federal labs would be providing research for the private sector under contract. We do not percieve it as an issue where they would be sharing facilities and, therefore they would utilize the existing facility's equipment, perhaps exotic equipment, and facilities that might not be available in the commercial sector.

I would like to conclude with the fact that we are a grassroots network. We are working one-on-one with business and industry, with State and local government, and we are hybrid. We cross commerce, government, and we work with academia.

Thank you.

[The statement follows:]

STATEMENT OF THE OHIO TECHNOLOGY TRANSFER ORGANIZATION

The key points that we would like to make relative to the Stevenson-Wydler Act (96–480) are:

The Stevenson-Wydler Act has provided extensive resources for the Ohio Technology Transfer Organization. Any changes to this act should enhance the existing commitment to federal technology transfer.

Federal labs should work in concert with state technology transfer initiatives. 96–480 should provide incentives to federal labs to support this activity.

The Center for Utilization of Federal Technology should concentrate on the linking of human expertise available in the lab with the private sector.

For valuable technology transfer to occur, a dialog must be maintained between the producers and end users of technology.

The following sections are our response to specific questions directed to us by your committee in the order these questions were listed on the correspondence of April 1, 1985:

96–480 in concert with Ohio's uniquely established network of technology transfer agents, with the commitment of Wright-Patterson/ASD, has provided an effective technology transfer system. The memorandum of understanding of June 1984, (see attachment) has made the technological resources of the ASD/AFWAL labs available to all Ohio's businesses, academicians and state/local governments.

Federal Labs should be encouraged to establish technology transfer programs in a joint effort with the state. There would be a commitment to develope and maintain an outreach network. Reviews of programs should be minimal, with oversight and direction provided as needed. We do not feel uniform regulations would be effective. What is necessary is for labs to work with already existing state initiatives in developing a method that is appropriate for the locale. There should be incentives in the act that encourage lab officials to work with state officials on developing a state technology transfer plan. A state outreach network that works as a filter between lab personnel and the private sector is very effective in Ohio.

There does need to be strengthening in the legislation so that labs do more than publish technical briefs. A staff should be funded to work with lab researchers, private sector and educational institutions as a facilitator for the transfer of federal technology. This staff would help determine the commercialization of the technology and target that technology to a particular constituency. This staff would filter a request for information from outside the lab and link the requestor with the appropriate expert in the lab making available the human expertise in the federal labs to the private sector. Presently, Stevenson-Wydler provides for the labs to deliver technological outreach at the lab through the establishment of CUFTS and ORTAS. It is economically infeasible for the federal labs to establish the type of outreach network necessary for effective technology transfer; therefore, the labs should be encouraged to coordinate their efforts with state level (and supported) technology transfer endeavors.

As stated previously, the transfer of federal technology to state and local governments or to the private sector is only as effective as the outreach mechanism linking the technology users with the technology generators/resources.

The present view of the CUFT from the OTTO perspective is that the prime focus of the CUFTs is targeted on the publication of federal lab generated technology. This method often falls short from projecting the technology for spin-off applications. This approach should be continued to maintain an awareness of the technology being developed at the labs, but should not be the sole focus. The CUFT should concentrate on human resource networking. Our experience at OTTO has taught us that a human expert is the most valuable source of information. Not only does an end user have the added benefit of "brainstorming" with the expert, but the human expert is the synthesis of a professional lifetime of experience, something very difficult to duplicate in a document. By having a staff responsible for building a human resource network (computerized is preferable) as well as concentrating on translating technical briefs in ways that will make spin-offs appear obvious to end users, the CUFT would become more effective.

Our interpretation of "co-fund" is one where private sector dollars could be received by the federal labs to perform "contract research." This would encourage the optimum use of established facilities and equipment. At times it is evident that exotic equipment/facilities are not available through commercial channels. "Co-funding," by our definition, would reimburse the labs and their staff for time, equipment and facility use, scheduled around priority government research.

It is very difficult for a technology transfer agent to know an end user's need precisely enough to evaluate whether or not to proceed in a certain direction. For this reason a transfer agent's time spent with a client is counted as having a positive value when the client expresses the opinion that the assistance saved him time, and therefore money (Creighton and Early, 1983).

Technological developments are not exclusively generated at the federal labs. In many instances private sector developments may: 1. Save federal research dollars. 2. Provide new innovation to the labs. 3. Offer the expanded "federal product" market to the private sector.

Currently, the procurement system is the main channel available to the private sector if they have a product or process that could be used by the federal government. This process curtails the potential of fledgling developments that could enhance government research. Opportunities should be made available for the lab to avail itself of research results from the private sector.

For an effective technology transfer system to function between various communities (federal labs and the private sector), efforts to create common cross-institutional goals must occur. The ability to network and communicate within and between these different communities is needed. To do this, there must be high level administrative commitment to the process of technology transfer on the part of the federal labs. What end users of technological research need are clear answers to their concerns, needs and problems.

TECHNOLOGY TRANSFER INITIATIVE—MEMORANDUM OF UNDERSTANDING

The State of Ohio and the Aeronautical Systems Division (ASD) at Wright-Patterson Air Force Base agree to pursue a Technology Transfer Initiative. Ohio's state and local governments, educational institutions, and business community will have access via the Ohio Technology Transfer Organization (OTTO) to the Aeronautical Systems Division Office of Research and Technology Applications (ORTA) for the purpose of utilizing technology developed at ASD and at other organizations accessible through the Federal Laboratory Consortium.

This linkage will serve as the initial model of cooperation utilizing Ohio's unique network of Technology Transfer Agents as an outreach mechanism for the application of available federally developed technology. This understanding will reinforce the implementation of the Stevenson-Wydler Technology Innovation Act of 1980 (PL 96-480).

We the undersigned agree to the Aeronautical Systems Division—State of Ohio/ Local Governments Technology Transfer Initiative.

GOV. RICHARD F. CELESTE,
State of Ohio.

THOMAS H. MCMULLEN,
Lieutenant General, USAF,
Commander, Aeronautical Systems Division.

Senator GORTON. Thank you.

Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman.

I am delighted to have the opportunity to introduce to the subcommittee Mr. Larry Crockett of the University of Michigan. I am delighted that he is here as a witness today. He is the director of the special projects division of the University of Michigan's Institute of Science and Technology, and he heads up within that organization three programs which provide information and technical assistance to industry. One is the State Technical Services Program, originally funded by the Federal-State Technical Services Act, which has, of course, not been in existence for a decade. Michigan has kept the program going with university money.

The second function is the EDA University Center, begun with an EDA grant. We have worked with that part of the organization, particularly in the case of McClough Steel, where we were able, through timely work, to do an impact study in such a way that we were able not only to save that economic entity and the jobs that went with it, but to avoid a rather catastrophic set of circumstances in one major industrial area within our State.

Finally, there is the Trade Adjustment Assistance Center, which provides technical assistance to firms that qualify for trade adjustment assistance. That center, which is in Ann Arbor, also serves Ohio and Indiana, as well as the State of Michigan.

So, this is a fairly broad reach.

The one thing that I would hope you would do today, Mr. Crockett, in light of the discussion that has been ongoing—and you have had a chance to be here in the audience and to hear it—is to talk about where we need to go from here.

I read your statement and that will be made a part of the record. You will want to refer, perhaps, to parts of it. But I think the essential thing that we are driving for here is to try to look ahead, to try to decide what the future should look like and what we need to do now to change some of the trend lines that are occurring here. These trend lines are adverse to us or not as positive as they should be. Then we must try to figure out how we change things or how we put emphasis in different places and in one way or another aim ourselves in a strategic sense better than we have managed to do thus far, so that we can make more progress, faster, by a better use of our assets and resources.

I am delighted that you are here and am anxious to hear from you.

Senator GORTON. Mr. Crockett, with that fine introduction, we would be happy to hear from you.

STATEMENT OF LAWRENCE RICHARDS CROCKETT, DIRECTOR, SPECIAL PROJECTS DIVISION, INSTITUTE OF SCIENCE & TECHNOLOGY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MI

Mr. CROCKETT. Thank you, Senator Gorton and Senator Riegle.

With that introduction, you have given the highlights of my testimony, so I will proceed directly to proposals for the future.

You mentioned the State Technical Service Act of 1965. I believe that could be a model, appropriately amended, for a national technology transfer program, working through our colleges and universities.

I also would strongly recommend the expansion of the Trade Adjustment Assistance Centers so that we have a university-based center in each of the major industrial States.

I believe the research results of the Federal laboratories should be directly utilized as a information source for this university-based technology transfer activity.

When I speak of technology transfer, I speak of it in the broad sense, in the applied sense, as my colleagues have said. I also mean it in the broad sense so that if a business person approaches us with a small technical problem but a major financial problem, we will not say, that is not a technical issue, so we will not address it.

We deal with a broad scope of problems because we are looking at how we can improve the economic health of our region and our country.

Working with the Institute of Science & Technology at the University of Michigan, I have been involved in technology transfer for some 17 years. The tragedy as I see it, is that we spend in the range of $50 billion annually on research, and provide the research results to other nations. These nations then use that technology against us to make products that compete against our own business firms.

I encourage the expansion and reactivation of the Stevenson-Wydler Act.

I believe the focus on small business and the joint university-industry efforts of the act are excellent. We find that even without this focus, 80 percent of our clients of the EDA university center programs and the Trade Adjustment Center programs, are small business firms. In the years I have been out working with industry in the State of Michigan, I have found it tragic to go out and see business firms working with technologies that are 30 and 40 years old. The only way these firms stay in business is to work themselves to death.

I encourage this committee to do take every possible action to improve the technology transfer efforts of our country.

Thank you.

[The statement follows:]

STATEMENT OF LAWRENCE RICHARDS CROCKETT, DIRECTOR, SPECIAL PROJECTS DIVISION, INSTITUTE OF SCIENCE & TECHNOLOGY, THE UNIVERSITY OF MICHIGAN

I am honored and gratified by the invitation to testify before this subcommittee on Science, Technology, and Space.

I would like to give you a brief history of our University, the Institute of Science and Technology, and then comment on the E.D.A. University Center and Trade Adjustment Assistance Center networks. Both of these federal programs promote technology transfer and have a direct bearing on this hearing which is focused on the report of the President's Commission on Industrial Competitiveness and the status of the Stevenson-Wydler Technology Innovation Act.

The University of Michigan was established in 1817 and located in the frontier town of Detroit. In 1837, the University reorganized and moved to its present site in Ann Arbor. It has a current enrollment of 46,699 students, a full-time staff of over 15,000 and a research budget volume of over $133 million.

We are very proud of the academic ranking achieved by our university. National surveys have consistently ranked the University's professional schools among the top ten. A 1974 survey of professional school deans conducted at Columbia University, for example, ranked Michigan as one of the nation's leading universities in the quality of its graduate professional schools. In 13 out of the 18 areas surveyed, The University of Michigan rated in the top 10. This was the best overall record.

The University's Institute of Science and Technology was created by an act of the State Legislature in July, 1959. This was Michigan's response to the Russians' launch of Sputnik, and its challenge to our technological leadership. This year the Institute is celebrating its 25th anniversary. In a concurrent resolution passed by the Michigan Legislature, the Institute was commended for increasing diversification of the Michigan economy by fostering the growth of technology-based industries, and for assisting business by researching problems and identifying new growth opportunities. The Institute was organized to serve two basic functions:

1. To serve as a center where industry, education, government, professional, and civic organizations within the state can discuss advances in research and ways in which they may be used for the maximum benefit of the region; and

2. To conduct studies to determine the needs of regional industry, especially those needs which can be fulfilled, at least partially, by gains in science and technology.

A brief organizational chart attached to this statement identifies the responsibility and direction of our management and technology transfer program within The University of Michigan.

State Technical Services Program (STSP)

In 1965, the U.S. Congress created the first federal program for technology transfer: the State Technical Services Program. Its purpose was to accelerate the industrial and economic growth of the states and the nation through the improved application of technical and scientific knowledge. Colleges and universities in all of the states became the vehicles to expedite the application of new management and technical information to business and industry. I was selected to be the Director of the STSP at The University of Michigan. The program was designed to achieve three objectives:

1. To strengthen the nation's economy by upgrading industries through the utilization of advanced technology, thereby expanding the industrial base;
2. To increase employment by facilitating industrial use of technology resulting in the manufacturing of new products; and
3. To enhance the competitive position of U.S. products in world markets.

During its short life, the program was very successfully implemented by a formal network of ten four-year colleges and universities in the State of Michigan. A close-knit network was organized allowing the technology transfer operation of any university to draw upon the capabilities of the entire group. This linking capacity brought the state universities together in a way that had never occurred before. Those associated with the State Technical Services Program were enthusiastic about its ability to provide assistance to industry and the accompanying benefits to the participating universities.

The program extended to hundreds of colleges and universities in each of the states. The U.S. Department of Commerce in Washington, D.C., acted as the coordinating agency for the entire program.

In 1969, at the request of Congress, the Arthur D. Little firm was selected to perform the evaluation of the State Technical Services Program. The following is a quotation from their report:

"Our evaluation of the State Technical Services Program shows it is providing a useful and economic service in transferring technology which substantially benefits the nation. The program can be made more effective and costs reduced by concentrating the federal and state universities on efforts and services which yield the most returns. We recommend that the State Technological Services Program receive continued federal and state support with increasing emphasis on direct service to industry."

The states surveyed in this Arthur D. Little report were Arkansas, Georgia, Illinois, Oregon, South Carolina, Utah, Vermont, Wisconsin, and Michigan. A recent report of the General Accounting Office entitled "The Federal Role in Fostering University-Industry Cooperation", dated May 25, 1983, makes note of the findings of the previous Arthur D. Little study of 1969.

This pioneering technology transfer program (STSP) was the creation of Professors J. Herbert Holloman and Myron Tribus of the Massachusetts Institute of Technology. It was the first time that university-based programs were used as a vehicle for transferring the benefits of technological innovations to business and industry.

The total federal expenditure of $20 million over three years, dispersed among 50 states and hundreds of colleges and universities, was not adequate to realize the potential of this technology transfer effort. Despite the positive evaluation, the program surprisingly was not funded beyond the third year.

The University of Michigan, through university funds, continued limited technological transfer activities without federal funding. In the United States, only a few universities continued a technology transfer activity without the necessary federal funds.

EDA University Center Program

In 1978, the Institute of Science and Technology received a grant from the U.S. Department of Commerce, Economic Development Administration, to implement a University Center Program to provide management and technical assistance through the application of university skills to the Michigan industrial community. I was selected to direct this new EDA University Center. We now have a unique on-line computer software package, SCRIPT, to identify university faculty and researchers for specific industry problems or opportunities. The computer program maintains a profile of over 3,000 faculty members and researchers, and identifies each individual's research interests, objectives, and recent publications. Profiles can

be searched across 7,000 research areas or by individual key words. Thus, business and industry problems can be matched immediately with the university faculty and staff who have the expertise to solve them.

At the start of 1981, we were asked to evaluate the economic impact of the EDA University Center Program. In response, a letter was prepared by University President Harold T. Shapiro to Congressman John D. Dingell which stated:

"The economic impact this program has achieved in our state is impressive. Since its inception at our University in 1978, the Center has assisted in the creation of 1,141 jobs and the retention of 1,235 jobs in private industry. Federal funds provided during this period were $325,000, and matching funds of $173,024 were contributed by the University. The cost per job created by our University Center has been $218; the cost per job retained, $202. This is clearly a very cost-effective program that creates jobs, improves productivity, and helps slow the rate of inflation."

During the first three years of the program, over 600 inquiries for assistance were lodged with the Center. Many of those involved company searches for financing sources. A total of 260 Michigan firms and organizations were provided with technical assistance in nearly half of all the state counties.

In recent years, the Center has initiated dozens of new cases. A significant effort was undertaken at the request of the staff of Senator Donald W. Riegle, Jr. to help save 3,000 jobs at the McLouth Steel Corporation. Center staff provided a public task force chaired by Senator Riegle with an economic impact study of the potential closing of the facility. The study was instrumental in staving off creditors until a new buyer could be found. McLouth Steel has been purchased by a new owner and an overwhelming majority of the jobs have been saved.

The application of new technologies to the manufacturing process has become a major area of concern and opportunity for industry, labor, and the education community. The implications of flexible automation for the U.S. and, in particular, for the Michigan economy, are dramatic. Sometime after 1990, robot capabilities could be such as to make over seven million manufacturing jobs replaceable.

Dramatic as these implications are for the population at large, they will be even more dramatic for the minority community. Minority workers face the prospect of bearing a disproportionate burden of the job losses resulting from the implementation of new technologies. Concurrently, as flexible automation production increases, minority enterprises may find themselves shut out of the benefits.

In July, 1982, the EDA University Center efforts to address these developments resulted in the formation of the Minority Technology Council of Michigan, Inc. The Council includes representatives of private minority businesses, several universities and colleges, the greater Detroit Chamber of Commerce, and several nonprofit minority corporations.

Senator Donald W. Riegle, Jr., in the Congressional Record of October 4, 1983, took note of this effort and stated:

"Governor James Blanchard commissioned the State of Michigan Minority Technology Council. This joint venture between The University of Michigan and the Michigan Department of Commerce is designed to assist minority-owned businesses move into technologically intensive fields. It is a program I would recommend the Federal Government and the other 49 States adopt.

"Mr. President, minority-owned businesses have a wealth of knowledge and expertise to offer this country. We should take advantage of these resources while at the same time expanding opportunities for these entrepreneurs."

The EDA University Center Program, like the previous State Technical Services Program, has received a very positive evaluation. The U.S. Department of Commerce selected the consulting firm of Bentley, Clark Associates, Inc. to assess the performance of the EDA University Center Program. In part, the evaluation states:

"Client verification of jobs created, jobs saved, jobs created and saved, and capital investment generated shows the University Center Program to be an efficient economic development program."

This program evaluation was submitted to Malcolm Baldridge, Secretary of Commerce, in September, 1981.

Although the EDA Centers now cover some 50 universities, it is a very limited program with a national budget of $5 million. For example, The University of Michigan Center receives $100,000 in EDA funds, with a responsibility to provide management and technical assistance to over 14,000 industrial firms in Michigan.

Trade Adjustment Assistance Program for Firms

The United States Congress, in order to provide assistance which would let our firms compete on a more even basis with their international competition, established a trade adjustment assistance program through the U.S. Department of Com-

merce in 1974. This program was established through the enactment of Public Law 93-618, known as "the Trade Act of 1974."

Today, the U.S. Department of Commerce, International Trade Administration, provides technical, management, and limited financial assistance to firms hurt by imports through a network of technology transfer centers called Trade Adjustment Assistance Centers (TAACs). Located principally at universities and covering every state in the union, these centers provide eligible firms with in-depth assistance to improve their operations and become competitive. The assistance provided is on a cost-shared basis, i.e., the company must contribute at least 25 percent of the cost of the assistance.

Nationally, the program has assisted over 2,300 firms and has developed over 1,000 business adjustment plans for successfully meeting international competition.

In discussing this program, I would like to focus on our experience with the Great Lakes Trade Adjustment Assistance Center at The University of Michigan in Ann Arbor. Keep in mind that we are only one of thirteen such centers, and our successes have been multiplied many times over across the nation.

The Great Lakes TAAC, part of The University of Michigan's Institute of Science and Technology Special Projects Division, provides technical, management, and financial services to firms damaged by imports in Indiana, Michigan, and Ohio.

This tri-state region is the most heavily industrialized, economically distressed, and import damaged area in the U.S. There are over 37,000 manufacturing establishments and 2.6 million manufacturing workers, which make up 14 percent of all U.S. manufacturing employment. The three states have over 42 percent of all U.S. workers certified as having lost their jobs due to foreign competition. Michigan and Ohio rank first and second in the nation in trade-impacted workers.

Although the Great Lakes TAAC is the most recently created Center, established in early 1983, the experience we have had demonstrates that a decentralized technology transfer network, linked to a strong research university, can have a significant impact on the well-being of our region.

Since its inception in 1983, the Great Lakes TAAC has responded to over 350 business inquiries and has assisted over 30 companies in establishing eligibility for technical and management assistance under the program. Of these, nearly 20 have signed agreements with the TAAC to receive in-depth assistance in developing and implementing a successful business strategy which will permit them to be competitive once again in world markets.

The firms receiving this assistance account for over 5,500 industrial jobs and over $360 million in annual sales. They represent a wide variety of industries including: apparel, agricultural implements, compressors, computer controls, electric motors, forgings, furniture, glass, industrial knives, material handling equipment, steel.

The size of TAAC client firms ranges from less than $500,000 in annual sales and 10 employees, to over $100 million in sales and 1,000 employees. The typical firm has 75-100 employees and $6-$10 million in annual sales. The program focuses on the small-and medium-sized manufacturer.

The staff of the Great Lakes TAAC is made up of industry experts with an average of over 25 years experience in the private sector. They understand business problems and people, and are able to respond to company needs in a way that has effectively enabled these clients to meet the challenge of foreign competition. Through the previously mentioned computer program, SCRIPT, this staff has immediate access to the faculty and research staff of The University of Michigan. Senior faculty representing engineering, economics, and marketing act as advisors to the Center.

I would like to give you just a sample of responses we have received from firms receiving assistance from the Great Lakes TAAC.

Equipment Manufacturing, Inc., a $10 million a year material handling company in Michigan wrote:

"The Great Lakes Trade Adjustment Assistance Center in Ann Arbor, Michigan, has been a large reason for our staying in business. It identified three potential large volume product lines for which we had the technical knowledge, and equipment to produce. GLTAAC helped us outline a marketing strategy and has put us in contact with its resources, the resources of The University of Michigan and commercial consultants."

Bobbie Brooks, a large Cleveland apparel manufacturer, expressed it this way:

"The TAAC program has represented significantly more than just an infusion of capital, although that too is appreciated. It has provided us with a level of expertise, a feeling of hope when our economic conditions seemed bleak, a sense of purpose and direction to combat the unfair competition of off-shore production and most of

all, the opportunity to once again bring Bobbie Brooks to the state of excellence and self-sufficiency we once enjoyed."

Continental Steel of Indiana wrote us:

"On behalf of Continental Steel, I would like to thank you . . . for the assistance we have received from the Great Lakes Trade Adjustment Assistance Center. You have provided much valuable assistance to our company in the development of a project feasibility study including both a market study and engineering/cost study of modernization of the 10-inch mill at our Joliet, Illinois, Bar Division."

Looking beyond these responses of individual companies to the assistance they have received, how cost effective is the Trade Adjustment Assistance Program in our three-state area? During the past two years, the Great Lakes TAAC has provided assistance which was instrumental in retaining or creating over 2,480 direct jobs to companies in the three states. In addition, there are another 3070 indirect jobs that are dependent on the direct jobs. The two-year budget for the Great Lakes TAAC totals $2,062,000 government monies. The cost measured over direct and indirect jobs is only $371 per worker.

When one considers the tax revenues derived from the continued employment of these workers and the economic impact on our region, the money spent on trade adjustment assistance is money well spent.

One of the strengths of the Great Lakes Trade Adjustment Assistance Center is its association with The University of Michigan and the synergism resulting from the presence of several technology transfer programs under one umbrella.

The Great Lakes TAAC makes use of faculty, graduate students, and research resources at the university. By having access to these, we can multiply our limited resources in providing the technical assistance to our client firms. This has been demonstrated in several instances including the Michigan manufacturer who wrote:

"We appreciate the help we have received from Professor Walton Hancock of The University of Michigan's engineering faculty, in cooperation with the Great Lakes Trade Adjustment Assistance Center. We believe it is a fine exchange of how the academic and business folks can work together in solving a very real problem."

The association of GLTAAC with the Institute of Science and Technology provides an added advantage. Within IST, the EDA University Center, sponsored by the U.S. Department of Commerce, provides a means of responding to firms which may not be eligible for the TAAC assistance, but have business problems that can be solved by the University Center. Often this synergism between the programs can prove to be instrumental in resolving a company's problems and helping a firm remain in operation.

An example of this is Saylor-Beall, a compressor manufacturer that employs 60 workers in a small Michigan community. The company was severely impacted by foreign competition and was certified as being eligible for assistance through the TAAC. The owner was not interested in assistance and, through inaction, was leaving the market open to foreign competition and the loss of 60 jobs. However, he was agreeable to selling the business. Management and workers at the firm were desperate to find a solution which would save the business and their jobs. Great Lakes TAAC staff informed the EDA University Center staff of the situation, who in turn identified a successful Michigan businessman who acquired the compressor company, provided $750,000 in new equity, and has worked with the TAAC in developing and implementing an adjustment strategy. In the process, 60 industrial jobs were retained for the community, with a strong possibility of future growth and additional jobs.

The Trade Adjustment Assistance Program was instituted to assist industry already trade impacted. It is a reactive program which can provide assistance only after imports have damaged a firm's ability to compete. As a result of foreign competition, many sectors of our economy are already crippled. The foreign challenge, however, is not static. The targets are changing and no sector is safe. This is particularly true of our high technology sectors.

The President's Commission on Industrial Competitiveness has reported that the "United States has lost world market share in 7 out of 10 [high technology] sectors." The Commission's findings go on to say, however, that "the use of technology cannot be limited to 'high tech' industries. Mature industries can and should make better use of advanced technologies as part of their own renewal processes."

If our nation is to maintain its leadership role in the world, if we are to provide a rising standard of living for all our citizens, we must ensure that those sectors of our industrial base which represent the high technology industries remain competitive and dominant in the world. At the same time, following the findings of the President's Commission we must facilitate the application of new technologies to our mature industries as well.

The International Trade Administration is cognizant of these trends. Recently it has, through the Office of Trade Adjustment Assistance, provided funding to The University of Michigan to organize a high level forum to discuss how we as a nation can prepare our industries, particularly the high technology sectors, to withstand the foreign targeting which they face.

The forum participants will be:

Mr. Frederick Dent, President of Mayfair Mills, Member of the President's Commission on Industrial Competitiveness.

Dr. Sidney Jones, Under Secretary for Economic Affairs, U.S. Department of Commerce.

Dr. Frank Stafford, Professor of Economics, The University of Michigan.

Mr. Murray Finley, General President, The Amalgamated Clothing Workers of America.

Mr. W. Paul Frech, President, Lockheed-Georgia Company.

Mr. Milton Stewart, Editor-at-Large, Inc. Magazine.

Dr. Marina v.N. Whitman, Vice President and Chief Economist, General Motors Corporation.

The sessions, moderated by Mr. Thomas Burnham, Esq. (managing partner of Rose, Scmidt, Chapman, Duff & Hasley), will discuss Perspectives on U.S. Industrial Competitiveness and the alternatives available to improving competitiveness of our industry before and not after it has been severely damaged by imports. The conference will be held April 23, 1985.

Recommendations

Based on our Institute's 25 years of experience in technology transfer, we believe that the limited federal programs expended on the State Technical Services Program, EDA University Center Program, and Trade Adjustment Assistance Center Program amply demonstrate that management and technical assistance to industry through colleges and universities is a cost-effective technique for improving the competitive position of industry in the United States. We believe an appropriate amendment to the State Technical Service Act of 1965 could be the model for a national technology transfer program.

These university-based centers would provide both the technical and management assistance to facilitate the growth of firms in the "high tech" industries as well as work with our mature industries to ensure that they have the technological tools to remain competitive in the world economy.

In addition to recommendations of an expanded State Technical Service Program, we believe the severe impact of foreign competition on industry requires the support and expansion of the Trade Adjustment Assistance Center's effort in the United States.

In the event it is not possible to implement a new amended State Technical Service Program, we would strongly recommend an expansion of the successful EDA University Center Program.

We commend the President for the establishment of the Commission on Industrial Competitiveness, chaired by John A. Young. As the Committee's report points out, $18 billion worth of government R&D is conducted in more than 700 federal laboratories, employing one-sixth of the nation's scientists and engineers. This huge resource could be utilized as another resource base for the university-based technology transfer program operating under a new State Technical Services program and expanded TAAC program.

We believe that an expanded University technology transfer system connected with federal laboratories and other sources of management and technical expertise could provide the following:

1. An increase in the capacity of technologically backward or financially constrained businesses or industries to take advantage of scientific and technical developments. Of special concern are the small and minority-owned firms in the United States;

2. An increase in the rate of establishing new businesses that make use of scientific and technological developments and improving their ability to survive;

3. An increase in the quality of graduate training of industrial scientists and engineers.

Federal resources must be found to provide the funding for a national technology transfer system. I completely concur with the President's Commission on Industrial Competitiveness when it states:

"Universities are under stress. University revenues do not cover the rising cost of research and engineering faculty salaries do not compete with those of private industry. As a result, fully one-tenth of the nation's engineering faculty positions are

currently vacant. In critical fields like electrical engineering and computer science, some universities report half of their positions are unfilled."

Also, in the same report it reiterates: "Universities are strapped. The shortage of engineering faculty discussed earlier calls into question our ability to train the number of skilled people our industries require in the future."

We agree with the report's finding that: "Funds for engineering research should be augmented: the Administration's 22 percent increase in National Science Foundation (NSF) funding for engineering research in fiscal 1985 is a good beginning. In addition, NSF's new program of cross-disciplinary engineering research centers at universities should be expanded in future years to include up to 25 centers nationwide."

Since the Stevenson-Wydler Act was not given the resources to carry out the mission of Congress, it is difficult to evaluate the Act. However, we do support the Stevenson-Wydler Act as one method to apply the results of the billions expanded on research and development by transfering management and technical assistance to business and industry. We believe the focus on small businesses and the encouragement of joint university-industry efforts by the Stevenson-Wydler Act is excellent.

Senator GORTON. Thank you.

I am sorry, Ms. Cooper, but I did not realize that you also had a statement to make, along with Mr. Palur. We would be happy to hear from you now.

STATEMENT OF LINDA COOPER, RESEARCH ASSOCIATE, OHIO TECHNOLOGY TRANSFER ORGANIZATION, THE OHIO STATE UNIVERSITY, COLUMBUS, OH

Ms. COOPER. Thank you.

One of the reasons both of us are speaking is that, in the Ohio Technology Transfer Organization, we are a partnership of various types of institutions. Larry Palur is the director of the organization out of the Ohio Department of Develpment and I manage the Research Resource Center for this field network of technology transfer agents. I am a research associate at Ohio State University.

We also have field agents who actually live and work in communities throughout Ohio, who are housed in 2-year technical and community colleges.

So I think the point really needs to be made that the OTTO Program is really rather unique nationally, in our partnership with various institutions, in our outreach mechanism and in it's grassroots nature.

What I would like to speak about is what I see from my unique position within OTTO, working in a university and also managing a research resource center for OTTO field agents.

I think our field agents need to be seen as out in the trenches. They go out and knock on businesses doors and say I am your neighborhood technology transfer agent, what are your problems and so on.

They are generalists. They are not necessarily engineers. They have to quickly grasp a wide range of issues. Human skills are extremely important at this end of the technology transfer process.

They get questions and then, once they get these questions, they need to find resources. That is why I say they are out in the trenches. They never know what they are going to get. And they do not locally necessarily have the resources that are available to help them. That is were Larry's office and my office come in to play. We work for our agents, as support staff to them, to help them when they are in these situations.

I might add that my experience in the 5 years I have worked with the OTTO Program with the Federal Laboratory Consortium has been excellent. They were the ones who taught me much of what I know now about technology transfer. The people who have worked in that consortium have a wide range of experience and knowledge in the human technology transfer process.

In our early days, before we were as established as we are now, we really counted on these people in this network, this informal network nationally, of getting on a telephone and calling up someone and saying I have somebody who has a problem with this process and need some information. A Cliff Lanham in a lab will say oh, I know who is doing work in that area, and he will connect you.

That was extremely crucial for the OTTO Program in the early days.

The Federal Laboratory Consortium meetings, that you were talking about, with informal gatherings and people talking, are just absolutely essential in this process.

Also, in the early days, we participated in an electronic information exchange system. Many people participated on this computer system. I would ask a question and we would have people who would say, I know somebody who is an expert, and they would mail it back to me via computer and modem.

That was a very interesting experiment. I think if there were resources that were made available to help develop this kinds of electronic network nationally, it would be really wonderful.

In working at the university, I see the types of resources the agents need. I must say that the emphasis from our agents seem to be on human expertise. I think that the Stevenson-Wydler Act has really encouraged the dissemination of publications. There has been a lot of dissemination of tech briefs. But in Ohio, especially in some of our more rural counties, where technology is not that sophisticated, these briefs really are not sufficient. That is where a human expert really is essential.

Our agents usually are wanting us to find experts, either at Ohio State University or in other places, where they can talk with someone, because an expert has a lifetime of experience, a professional lifetime of experience, which is really going to add value to that information, moreso than any written document. The type of brainstorming that can go on between the expert and the individual looking for a technology, or who has an idea, or who is having a problem, is just something that never can be duplicated in a library or in a document.

So I think any kind of national technology transfer initiative really has to pay serious attention to that human expertise, which I think is the real value in the Federal labs at this point.

The mission of an academic institution and its research at Ohio State University is extremely different from the mission of a small business person or an entrepreneur out in the community who is looking for a technology to market. So the type of research and the end product are really often very incompatible.

I know that the function that our office attempts to play on campus is to act in trying to find a common link between those different institutions, so that even though their missions are different, somewhere there is a bridge where they can come together.

One of the most difficult aspects of that is that there are very little incentives for university faculty—and I suspect this is true in Federal labs—to work with the business community, unless it is on large-scale research projects. Tenure is not given to somebody, and they really do not get much credit or receive much incentive for talking with individuals. So I think it is very important that we look at the kinds of incentives individuals are given within the institution to facilitate the transfer of that technology.

The last aspect that I think is really important is that translation is extremely necessary. The spinoff applications are not very obvious. Not only that, but the actual marketability and commercialization of the product is going to be very esential to someone in the community.

So I think there is a need for people who are working full-time at analyzing and looking at the possibilities and potentialities for the commercialization of the products.

Thank you.

Senator GORTON. Ms. Cooper and anyone else on the panel, what advantages do State programs have over Federal programs in encouraging private sector use of federally developed technology.

Anyone may respond.

Mr. PALUR. It becomes an issue of cost-effective. We utilize the existing infrastructure financially. We are provided office space, secretarial support, copiers, and so forth, that we have at a local level, to recreate those services and those offices from a Federal level to the magnitude that we, at least in the State of Ohio, and I am familiar with Pennsylvania and what a few other States have done—it is just not cost-effective. Management is held at both a local level, regionally, on that regional campus, and it is also held at the State level.

So we are controlling fiscal dollars, activities, and accountability, and we are providing that local service in that ultimate linkage, whereas we are not creating extra levels of bureaucracy through Federal funding and Federal support.

Senator GORTON. Would anybody else care to respond?

Ms. COOPER. I think another point is one of the strengths of the OTTO Program, though also one of the most aggravating aspects, is it is very different, depending on what locality within the State an OTTO agent is located. The needs of a community, such as Hocking, OH, are very different from the needs of a community like Cleveland, OH. I think when you have a more grassroots, State-funded program, what you have is perhaps a little more flexibility to the local circumstances.

I could see that fitting into a national network. But I think there has to be real attention paid to the necessity of flexibility on the local level.

Senator GORTON. Thank you.

Mr. CROCKETT. Senator Gorton, if I might comment, the EDA University Center Program has some 50 universities across the country. One of the effective aspects of the program is that it does not use a "cookie-cutter" approach to reaching industry in the United States. The U.S. Department of Commerce EDA Center contracts with the university in that community that knows best that local business climate and what its needs are.

The danger of a State-oriented activity—and I speak from 14 years experience in industry—is that industry does not look at State or national boundaries. It goes where it can receive the help required to solve the problem. So, a State constrained system, particularly if that system is looking at only State resources, could be dangerous and I think would not be as effective as a nationwide network.

Senator GORTON. Mr. Crockett, I have a question about your own State operation.

How do you choose among companies which would like to have assistance, or can you meet every request for assistance?

Mr. CROCKETT. We cannot at all. For example, with the EDA University Center Program, the University of Michigan is the only university in our State that has that grant. It is $100,000 and is matched by the university with $50,000. We serve 14,000 industrial firms. We only deal with industrial firms and we make a analysis of the firm as it comes to us. We have a proactive outreach activity. Before we work with a firm we assess whether our assistance will be able to help this firm, and whether they will be able to make use of that assistance to move forward. There are firms that we have to turn away, sometimes we refer them to other organizations, sometimes we must say that what we can provide them is not appropriate.

A screening process is necessary in our technology transfer activity.

Senator GORTON. How do you use the Federal Laboratory Consortium and the Center for Utilization of Federal Technology?

Mr. CROCKETT. We have had very little direct contact with them. Our State is not blessed with any strong Federal laboratories. In my 17 years' university technology transfer experience, I have not had personal experience with a Michigan industrial firm that has made direct use of information coming out of the Federal laboratories.

The Center for the Utilization of Federal Technology is so woefully undermanned that they are just scratching the surface of technology information. When we seek information, we go to our university library system or we make use of a university computer that links us to 140 data centers. Using the facilities of the University of Michigan, we have access to more information than they could possibly think about with that very small, underfunded Federal Technology Center in Washington.

Senator GORTON. Mr. Houck, Dr. Janis, have either of you had a different experience?

Mr. HOUCK. We make wide use of the Federal labs. As a matter of fact, one of the Federal lab representatives, Mr. Jerome Boatman, at the Naval Air Development Center in Warminster, PA, sits as a resource person regularly with our advisory council. He is considered as a member of the council. He meets with the council at all of our meetings.

He is a constant source to our advisory council and to all of our staff people.

We have contact with other members of the Federal lab. Another person with whom we deal regularly is Mr. James Wyckoff at the National Bureau of Standards. These two men probably have been

our most frequent contacts. But we have dealt with, on a give and take basis, a number of Federal labs. Their function is an essential one so far as we are concerned in relation to any viable technology transfer operation.

Mr. JANIS. I would just clarify an earlier remark.

Our activities require access to all types of innovators and innovations. The ORTA's provide a very nice focal point for that. It is very difficult to take a telephone directory and begin to try to ferret out that expertise. So, having the opportunity to begin at a focal point is a critical issue in at least defining the accessibility.

There are many spinoff kinds of things like that. You may find a list of names. As you are well aware in creating data bases, one has a problem of how well you can define the expertise of an individual and whether that individual will really respond when someone calls.

So, again, the focal point is very helpful—to say yes, although this person is an expert, you are not going to learn a great deal from him because of the nature of that particular individual. From that aspect we have found it very useful.

I would have to concur in terms of CUFT.

The important issue is how does one maintain the data base of research activity. How do you keep on the cutting edge and make that information available?

We know there is a proliferation of data bases available that we all have access to, and they are in differing states of develpment. Certainly there is need to establish and to look at how does one flow, as early as possible, information into the system and somehow then make it accessible.

Senator GORTON. Dr. Janis, you stated in your written testimony that Stevenson-Wydler is basically passive in its technology transfer mandate. How would you propose to us that we change the act to make it more active?

Mr. JANIS. Yes, but first let me try to explain what I mean by passive.

Publications are a very important element, as are seminars, et cetera. But, I think, as my colleagues here have indicated, you have to knock on doors.

Technology transfer is not an easy business. There are not people just waiting out there, breathlessly, for the next invention. You have to convince them that there is something of value to it. So, in fact, it then becomes incumbent upon you to go out there and to knock on their doors and to inform them of what is available.

I would suggest that one of the things that has happened within the NASA system is that they have allowed this entrepreneurial development to occur. It became apparent within the industrial application centers, after many years of frustrating activity, that people were just not going to come to you looking for you to do something. In particular, even if you were just giving something away, you had to put some value on it for clients in fact to decide that it would have some value to them.

So my suggestion is that you first look to existing outreach organizations that are out there—they are in the private sector—they are in the not for profit sector—and that those be utilized. I would not advocate that we form the National Federal Marketing Pro-

gram so that all of us could reach out, but that, in fact, we take advantage of the infrastructure that is there. But it first needs to be focused and then put into action.

I think we heard this morning from Mr. Gillam stating, for example, that NASA would encourage the interaction of its programs with other agencies.

Senator GORTON. Mr. Houck, you describe a successful advisory council in describing Penntap. Would you recommend that a similar group be made up of Federal, industry, small business, universities, State and local representatives and the like, as a part of Stevenson-Wydler's Federal effort?

Mr. HOUCK. By all means.

Every quasi Federal and State agency or unit has a tendency to get carried away with itself and needs something to keep its feet on the ground and in contact with the real world. We use our advisory council for that purpose.

That gives us a good relationship with what is going on in industry, what is needed, the trends, and also the technology trends. They talk a language that we do not hear on campus or in labs. We can be more practical and, therefore, a better technology transfer organization as a result of our advisory unit.

We respect our advisory council to the point that we have the president of Penn State appoint the members; they serve 3-year terms and then must leave for 1 year. If they have done a serviceable job, they are invited back at some point—maybe right away, maybe not for a couple of years. If they have taken the job lightly, they are not invited back. They volunteer the equivalent of probably 7 or 8 days a year—these are executives, high priced people—in travel time and meeting time, private meetings among themselves without the Penntap people, task force type of assignments, on the phone with our specialists or with our staff people. It is a dedicated, shirt-sleeved type of council.

Probably the first indication that it is a serious group—they don't have their name on our letterhead.

That is how we judge them.

Senator GORTON. Mr. Houck, you recommend the creation of a national network of technology application centers. Do you have any idea how we can establish that kind of thing here at the Federal Government level in a year of a freeze, when we don't have any more money to spend?

Mr. HOUCK. Well, there is money going to other purposes which probably could be funneled into this effort, what is referred to by Mr. Crockett and a few others as the "former State Technical Services Act." That is a very similar mode to what I am talking about.

That was a joint venture, State and Federally funded with the universities, a three-way funding, of technology transfer programs.

PENNTAP was started about that time the act of 1965, I think it was. It lasted unti 1970, when it got chopped apart through some disagreement and loyalties in the Commerce Department. But it was on its way to creating a good network.

A few States maintained their interest and continued the programs after the Federal Government pulled out.

Where do you get the money? That is not mine to answer.

Senator GORTON. Thank you.

Senator Gore, we are happy to have you here. I had just finished my questions.

Do you have a statement or do you have any questions you would like to ask?

Senator GORE. I was involved in a hearing before the Government Affairs Committee, Mr. Chairman, which is still going on on national security clearances. I have been deeply involved in that. But I have been frustrated at not being able to attend this hearing as well because I am very, very interested in this subject and have had hearings on the House side of the Capitol previously on this issue. I think it is absolutely critical.

I just wanted to say this much to indicate to you and the witnesses at the hearing that we have had today that I hope to continue to be active and involved in this area.

I want to commend you, Mr. Chairman, for organizing this hearing. But in light of the time and what has already passed, I will not have any questions.

Senator GORTON. I must say, just as Senator Gore has, that your experiences are of real importance to us and of real help to us in determining the course of action that we ought to take.

Each of you has given of his or her time, effort and thought in this process. This subcommittee appreciates that assistance.

Thank you all very, very much.

[Whereupon, at 11:42, a.m., the subcommittee adjourned, to reconvene upon the call of the Chair.]

EFFECT OF NEW TECHNOLOGIES ON ECONOMIC COMPETITIVENESS: TECHNOLOGY TRANSFER

THURSDAY, MAY 2, 1985

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:02 p.m. in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to the second of 2 days of hearings on our Nation's economic competitiveness and how it is affected by technology.

At the first hearing the subcommittee heard testimony about how well the research funded by the Federal Government is being transferred to the private sector. Today we will discuss the report of the President's Commission on Industrial Competitiveness, what the Government can or should be doing to promote the competitiveness of American industry.

In that context, we will discuss the existing programs authorized under the Stevenson-Wydler Technology Innovation Act, as well as other legislation affecting research and development at Federal laboratories, universities, and in private industry.

The report of the President's Commission on Industrial Competitiveness identifies technology as the single area in which the United States enjoys a strong competitive advantage and has the desire and ability to continue that competitive advantage. But maintaining that advantage will take work.

The report says we must create a solid foundation of science and technology which is relevant to commercial usage. We must apply advances in knowledge to commercial products and processes and we must protect intellectual property rights by strengthening patent, copyright, trademark and trade secret protection.

Senator Riegle do you have an opening statement?

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Mr. Chairman, I want to thank you for scheduling this hearing. I believe that our national competitiveness, particularly in technology, is the most critical issue facing the long-term economic security of this Nation.

I am particularly pleased that today we will have the opportunity to hear from a member of the President's Commission on Indus-

trial Competitiveness. I have read the Commission report and it is a lucid statement of the problems we are facing:

> Our ability to compete internationally faces unprecedented challenge from abroad. Our world leadership is at stake and so is our ability to provide for our people the standard of living and opportunities to which they aspire.
>
> Americans must take on the challenge of competitiveness as the economic agenda for the next decade.

We cannot continue to create jobs, compete in the world economy, and retain our standard of living without a technological advantage. To keep our edge we must do everything we can to foster innovation and the infrastructure in American manufacturing. This includes education, basic research, and technology transfer.

The need to act could not be clearer. Yet, I am disturbed to note that instead of moving ahead we are going back and forth in an effort to save the few programs already in existence.

Today's hearing focuses specifically on the Stevenson Wydler Innovation Act of 1980. Stevenson Wydler is the one program enacted over the past 5 years that addresses the problem. Yet the administration has virtually ignored the program.

We looked at the technology transfer side of the program 2 weeks ago. Today we will look at the need for industrial technology centers and the organization of R&D within the executive branch. Not one cent has been requested for the centers. The National Technology Board mandated by the act has still not been established. And now the administration is proposing to eliminate the Office of Productivity, Technology, and Innovation.

Other nations are engaging in concerted, coordinated efforts to buildup their national competitiveness. We cannot expect to compete unless we are willing to make critical investments in our own long-term competitive future.

Today's hearing should give us an opportunity to learn more about technological innovation and our ability to compete in world markets. I only hope that this is also the beginning of an effort by Congress and the administration to work together with industry, universities, and labor to ensure that our Nation remains on the cutting edge of technological change.

Senator GORTON. Thank you, Senator Riegle.

Senator Gore, do you have a statement at this time?

OPENING STATEMENT BY SENATOR GORE

Senator GORE. First of all, I want to congratulate the distinguished chairman of this subcommittee for holding this hearing on U.S. industrial competitiveness. This is an extremely important issue and one that will require a great deal of effort and foresight on the part of Congress to address. Senator Gorton is to be commended for his commitment.

During the last decade our Nation has faced increasing economic competition from other countries. While certainly part of our tremendous trade deficit is due to the strength of the dollar because of the budget deficit, the problem is much deeper than that. Indeed, in many areas, American industrial superiority is declining. In some areas we have even fallen behind.

As a Member of the House of Representatives, I chaired the Science and Technology Subcommittee on Investigations and Oversight. In that capacity, I held many hearings on different aspects of

this problem, ranging from job forecasting to research joint ventures to the problems and opportunities created by new technologies. Those hearings left me absolutely convinced that unless our Nation begins to take this problem seriously, we will find ourselves hopelessly disadvantaged vis-a-vis foreign competition. We must begin to take action now, or soon it will be too late.

Today we hopefully will hear some suggestions about how to correct our situation. We will explore possible courses of action available under the Stevenson-Wydler Act, and more importantly, we will consider the recommendations of the President's Commission on Industrial Competitiveness, known as the Young Commission.

I have been impressed with the range and depth of the Young Commission's recommendations, and I hope that after this hearing, the Congress will be able to consider them in detail. Some of them may be implemented; some may not. Regardless, they provide us with a good starting point to search for solutions.

I hope to explore the substance of the recommendations with our witnesses today. There is one recommendation that I would like to highlight here, however. That is the recommendation presenting the need for increased Federal involvement in educational computer software.

Two years ago I held a series of hearings on the role of computers in education. The purpose of those hearings was to examine the ways in which computer technology can enhance the educational process and to better prepare our children for the world and workplace of the future. One issue that was raised at those hearings was that the current state of educational computer software is abysmal. One witness testified, in fact, that only 3 percent of all educational software can be considered high quality. The rest amounts to little more than electronic page-turning.

To help remedy this problem I introduced legislation during the last Congress to create the National Educational Software Corporation to facilitate the development of high-quality, interactive educational software by private companies. As the Young Commission pointed out, the development of such software is essential if our children are to take maximum advantage of computer technology. I will introduce my legislation again this year, and I hope that my new colleagues in the Senate will support it.

Senator Hollings has asked me to have his opening statement included in the record.

[The statement follows:]

OPENING STATEMENT BY SENATOR HOLLINGS

Mr. President, in 1984 America suffered a trade deficit of $130 billion. This year, we are well on our way to a $150 billion shortfall. The trade imbalance is converting America into a debtor nation, in hock to the rest of the world. It threatens our businesses, our jobs, our standard of living–even our national security is at stake.

Studies have shown that every billion dollars in the trade imbalance means 25,000 jobs lost. Figure it out. Last year's trade deficit translates into more than 3 million lost job opportunities.

America's industrial competitiveness is fading. Competition on the international market is tough, and our nation's industries are getting whipped.

In my view, the President's Commission on Industrial Competitiveness offers one of the best analyses yet of why our nation's industries are falling behind in this global competition, as well as what we in Congress must do to help reverse the trend.

To begin with, we must put our trade programs in order. We have the laws–what we need is the will and the organization to carry them out. We must also reduce the bloated federal deficit. Accomplishing this, reports the Commission, will not only bring down the overvalued American dollar, but it will also reduce the cost of capital to American companies.

Then there are technology and human capital. The Commission's report is right on target when it says that advanced technology and a skilled workforce are America's two primary advantages on the world marketplace. We must work hard to maintain and expand those advantages.

I look forward to hearing today's testimony about the role of technology in boosting industrial competitiveness. This Committee has long had a vital interest in how to better utilize the government's huge investment in research and development. Now we must look for ways to parlay this commitment into improved competitiveness and the fulfillment of other national needs. I, for one, want to use this opportunity today to look closely at the Commission's findings about technology, especially its conclusions that (1) not enough federal R&D is devoted to improving industrial competitiveness, and (2) manufacturing deserves more emphasis. In addition, I look forward to hearing the views of our witnesses regarding the Stevenson-Wydler Act, the National Science Foundation, and the government's other science and technology programs.

Thank you, Mr. Chairman.

Senator GORTON. I expect the witnesses today to elaborate on these themes, discuss the role of the Federal Government in promoting industrial competitiveness, and to give the subcommittee insights into the needs of private industry.

Our witnesses today include Lionel Olmer, the Under Secretary for International Trade in the Department of Commerce, to whom we are grateful for finding time amidst his travels to appear; Dr. John McTague, representing the Office of Science and Technology Policy; and Egils Milsbergs from the Commerce Department's Office of Productivity, Technology and Innovation; also, the Executive Director of the President's Commission.

We are honored also to have Dr. Ian Ross, the President of Bell Laboratories and cochair of the Committee on Research and Development in Manufacturing of the President's Commission on Industrial Competitiveness and Dr. Lewis Branscomb, vice president and chief scientist of IBM Corp.; and Mr. Brett Berlin with the National Coalition for Science & Technology.

Our first witness will be Mr. Olmer, who I understand will testify without written testimony, as he needs to make some changes in what was presented to him in the course of the last couple days. For that we are particularly grateful and honored to have you with us.

STATEMENTS OF LIONEL H. OLMER, UNDER SECRETARY FOR INTERNATIONAL TRADE, DEPARTMENT OF COMMERCE; JOHN P. McTAGUE, DEPUTY DIRECTOR FOR SCIENCE, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, OFFICE OF THE PRESIDENT; AND EGILS MILBERGS, EXECUTIVE DIRECTOR, PRESIDENT'S COMMISSION, AND DEPUTY ASSISTANT SECRETARY, OFFICE OF PRODUCTIVITY, TECHNOLOGY AND INNOVATION, DEPARTMENT OF COMMERCE

Mr. OLMER. And I very much appreciate your understanding and I have taken a lot of guff about my foreign travels, and let me tell you that shuttle service to Tokyo is not going to be commercially feasible, nor is it desirable certainly over the long term for either

Government officials or private sector folks who are looking to retain their sanity, much less to make a dollar.

I would like to talk to you about my perceptions in this area, which I will tell you have been on my mind for at least the last 4 years and perhaps I might add for the last 10 years, stretching back into my own service in the private sector on behalf of a multinational, high-technology corporation.

In the first instance, when I came to government in 1981, I was convinced that America's competitiveness in high technology industries was declining. It was my judgment that we were losing market share to a number of other countries in the world and that we were losing it for reasons which did not relate to what would normally be thought of as characteristic of high technology competitiveness.

That is perhaps a combination of Government overregulation or Government intervention in the way of industrial targeting. And I caused a study effort to be undertaken for perhaps a 6-month period that ultimately produced a document which is now available through the Government Printing Office and I think had something to do with the creation of the Commission that Mr. Milbergs will be talking about shortly.

That report confirmed the belief that I had that we were losing market share in almost every high technology sector. The answer given to me by a number of people who chose not to see this as a problem was that we were looking only at international trade, and that international trade merely measured capital flows and was therefore a marginal consideration in the calculation of competitiveness, and the report should be summarily dismissed.

I chose to take a different view, and my boss, the Secretary of Commerce, did likewise, and that report was presented orally and its written form to the President and Cabinet members in 1982.

I have recently taken another look at it. I have given it to friends in the industry and I stand by its basic conclusions. I believe that we now more than ever are facing a continuing decline, and the numbers in our trade accounts certainly reflect it. Our imports of high technology goods increased four times as much as our exports in that area have increased. If that kind of trend line were to continue for any considerable period of time, we would find America being evacuated by high technology manufacturing in the search for both markets and other places in which to locate their manufacturing.

Indeed, it does seem that a number of companies have in recent years, perhaps the last 18 months, been looking for places to locate their facilities offshore. Some have attributed it largely to the high value of the dollar. Others have attributed it to perhaps a conjunction of events, macroeconomic issues as well as performance requirements of foreign governments which say if you want to sell here, you have got to locate here. And what I want to see produced in my country is not basic manufacturing, but I want to be part of this technological revolution.

Not many months ago I spent a couple of hours in something that approximated a debate with a senior official of the Brazilian Government in an effort on my part to convince him that Brazil's information law ought not to be passed, and that any intentions

that it had to require companies to transfer the technology that the Brazilians thought was necessary should be eliminated or Brazil would run the risk that American companies present would disinvest, would leave, or that companies that had an intention on paper or in their minds of locating in Brazil because of the enormous market potential would change their minds.

He maintained that it was essential for the Brazilian Government itself to determine the kind of technology which was necessary for Brazil's future. I maintained that it was impossible for a Government official to do that. We parted good acquaintances but without a meeting of the minds. We understood each other's position, but there was not alteration of Brazil's policy, and indeed, efforts on the part of the U.S. Government to intervene at a high level and assert what we believe was wrong failed. The Brazilians are pursuing what they believe is their national interest by declaring what kinds of technology and under what conditions products can be manufactured based on that technology, and where even they might go. It has caused a number of leading American corporations to rethink, and it has caused, I believe, some American companies to actually alter their plans on locating.

That is not an unusual phenomenon. I believe that it is part and parcel of the recognition worldwide of the importance of high technology to growth, to employment, productivity, to innovation, to indeed, a nation's ultimate well-being, not merely in an economic sense but in a national security sense as well.

Well, what are we doing in the United States? In my view, we do have leadership in most areas of high technology. We continue to produce inventions, we continue to produce new processes and products based on that technology that is the envy of the world. We do create far more jobs as a consequence of our high-technology efforts than any other society on Earth, including the Japanese.

We have a number of problems, and those problems are not going to go away by themselves. The report by the President's Industrial Commission that you will hear about shortly I believe is a landmark effort to describe how or what the problem is and what might be done about it.

I might say a word about Japan in particular. As you have remarked, I have been traveling a lot, and most of those travels have been to Japan. There was a time when I lived in Japan as a younger man, at a time when Senator Rockefeller was a student in Tokyo, as a matter of fact, and I believe that I have seen just fantastic change take place in the course of the last 25 years.

And the Japanese in so many respects are the envy of the rest of the world, sometimes for the wrong reasons. In my view they have a very inefficient economy, but in some areas which are centrally important they do the right thing. And one of those areas happens to be high technology and research and development.

One of the things that they do is right—a couple of things that they do that is absolutely right, in my judgment, is their emphasis is on the commercialization of technology, less on its intrinsic value, and the second is once that commercialization has been identified, they will spare no effort to see that evolution take place.

I remarked at a talk that I gave at the noon hour to a group of exporting companies several years ago in private life I visited west

Africa on business, and I was immensely impressed with a Japanese major trading company that had set up shop in a hotel on the Ivory Coast, in Abidjan. And what impressed me most was that the Japanese company, this is a trading company, was present there for however long it took to conclude a variety of deals stretching from basic industries, through technology, and it had the authority to commit resources in terms of engineering, in terms of maintenance and service, in terms of sale and marketing, in terms of financing, and in terms of whatever legal help might be necessary.

In my mind, that argued for the Export Trading Act which you became somewhat obsessed with in the early days of the first Reagan administration, and I think properly so, because for an American company to penetrate the Japanese market, it has to be prepared to make the commitment long term, and that requires a lot of time, money, and effort. Not many companies, looking at the aggregate, not many companies are prepared to do that. Many of them need help, and I thought one way to do it would be to model the Japanese trading company. It has not yet worked to the degree that I had hoped and many others had hoped, but the tally sheet is not yet complete. It still is a significant possibility.

Senator, I would like to close with perhaps one more anecdote. You asked a couple of questions specifically about fine ceramics. In connection with a report that I mentioned to you that I submitted to the Secretary a couple of years ago, I visited Japan and spent about 5 days touring a variety of high technology companies in Japan, including what was then called Kyoto Ceramics, now known as the Kyosorac Corp., and I was enormously impressed with the fact that they had produced two automobiles with ceramic engines.

And I asked permission to drive one of them, and they did not know how to turn me down. They were very, very chary of letting anyone outside the company get behind the steering wheel because the problem of brittleness had not yet been solved, and I am sure they had visions of one of the two only models they had being cracked up against a parking lot wall.

I did manage to drive it 25 miles an hour. It worked, is still working, and I found that the government subsidies as we know them were marginal to nonexistence, and compared with the amount of money that the U.S. Government had put into a similar kind of venture, not identical but somewhat similar, it was nothing. And yet the Japanese had quickly brought—perhaps that is a publicity gimmick, but maybe not entirely so—quickly brought not to market but to visible presence a living example of what might be done with fine ceramics.

A report of the Commerce Department on competitiveness in fine ceramics says that the score is not yet in as to whether the Japanese are ahead or we are ahead. It is evident, however, that the Japanese have locked up the market for fine ceramics in electronic components, and that to me has immense national security implications. Increasingly, semiconductors need to be packaged in ceramics because of the smaller and smaller volume and the potential for the generation of heat which is not desirable. Plastic is not a suitable alternative, and therefore ceramic packaging is used to a greater degree.

The last time I looked at it, the Japanese, and this one company, had something in the neighborhood of 90 percent, 85 percent of the world's market, and there are virtually no merchant market manufacturers of ceramics in the United States. Virtually everyone is dependent on importation from Japan.

Now, I am not suggesting it is wrong to be dependent on imports from an important ally with whom we share so many objectives and will continue. I do think that it is a sign of maybe misdirection in some areas that does need to be altered, and I hope that you will from your other witnesses get testimony as to what can be done and how it can be done.

You have also asked for some comment on our R&D project in the apparel area, and it is one that I have been very proud of finding money in the Commerce Department in a period when money was evaporating faster than water on a hot rock to pour into this project because it represented a project that was involving both labor, and management, and academia, and the government. And I thought, who could ask for anything more? And progress has been made. But time has marched.

The project was begun in 1980. The Commerce Department, I believe, has paid in perhaps $5 million, roughly 50 percent. It could be a little less than that. It could be $3½ million, $5 million, $7 million, maybe. That is not the point I wanted to make. The point I wanted to make was that by the time this product gets produced, there are three prototypes. Its commercial value in the United States is questionable. It will be costly. The apparel industry has been in decline. It will not be available readily to companies that are small and medium size. Larger American apparel companies have been so devastated by imports from abroad that increasingly they are going out of the business or locating offshore or just importing to fill out product lines.

What we may find is that this somewhat wonderful invention that automatically cuts sleeves of men's suits primarily, or at least that was its original intention, automatically, without any manual intervention, may wind up as a commercially viable product in and of itself for sale abroad, to increase, in other words, the competitiveness of our competition in the apparel industry. And that would not be a sweet irony if it transpires.

Thank you again for being so understanding, and I would be happy to remain for any questions that you or Senator Rockefeller have.

Senator GORTON. We understand that you have asked that we question you now so that you can leave, and we will do so.

But first, Senator Rockefeller, do you have an opening statement?

Senator ROCKEFELLER. No.

Senator GORTON. You have had immense experience in trade negotiations. I guess as much as anything else that is what has had you on that shuttle to Tokyo.

A couple of questions with respect to that. In your view, is international trade of benefit to the United States only on the basis of its being balanced, or are we better off having open markets here even in these high technology goods, telecommunications equipment, and the like, even when our competitors do not?

Granted that it is ideal that they be open in both directions, but is the next best thing equally closed in both directions, or open in one?

Mr. OLMER. Well, I would say if that were the unhappy alternative, and I realize that life sometimes presents unhappy choices that have to be made, and I can't imagine that that would be the only choice, but if it were, for the sake of argument, I would still say keep our markets open. And I think that the majority of American manufacturers, let alone people who make a living out of importing, would agree.

Senator GORTON. Do you feel from your vast experience in this area, that you can have significant success in commodity-by-commodity or product-by-product negotiations?

Mr. OLMER. It is very, very difficult. The United States has traditionally avoided sectoral negotiations on the grounds that we really needed to look at the totality of our trade account and argue for open markets on both sides and not make compromises based on cars for cars or telecommunications for telecommunications. We have come to a different view with respect to the Japanese Government in recent months, and that view has altered as a consequence of years of failed negotiations to achieve rough equivalence and the belief that in some areas our worldwide competitiveness is not questioned, and yet we make no sales into the Japanese market.

And while that may have been, not necessarily should be, but may have been tolerated at a time when our trade deficit was marginal, it cannot be tolerated in an era when we are suffering the consequences of $120 billion, $130 billion of annual trade deficits, and with one country a third that.

So the answer is that at least with respect to Japan we are looking at the sectoral reciprocity, not dollar for dollar but access for access.

Senator GORTON. What do you think of the recommendation of the Commission for a Cabinet-level Department of Science and Technology?

Mr. OLMER. Well, the short answer, Senator, is it would create another bureaucracy. The longer answer would be that it would perhaps give a kind of necessary focus to an area that would prove of great value. I do not view that, however, as a likely proposition.

Senator GORTON. On balance, you think the threat of the former is greater than the promise of the latter?

Mr. OLMER. Yes, sir.

Senator GORTON. Would your answer be the same with respect to a Department of International Trade?

Mr. OLMER. Oh, of course not.

Senator GORTON. Why not?

Mr. OLMER. Well, because we know how to cut bureaucracy.

No, sir. It is no secret that Secretary Baldrige has expressed a supporting voice for the creation of both Science and Technology and for International Trade and Industry, but I understand the kinds of tradeoffs, and I understand the concerns of others, not merely for the image of the Reagan administration promoting the creation of Cabinet-level departments at a time when we are trying to cut budgets and so on. It is not just that. It is a genuine belief on the part of many that it would not achieve the desired objectives.

Our arguments in the case of trade, however, went to the question of joining operations and policy which are currently split. It isn't so much that a lot of different agencies have something to say about international trade. It is more that two agencies have responsibility independently for operations and for policy, and it is not practical to separate. That is not a persuasive argument, obviously, because we didn't get very far, but that was essentially the basis of it.

Senator GORTON. Would you characterize which of the recommendations of the Commission on Industrial Competitiveness you think are most urgent, most important?

Mr. OLMER. I will be happy to do that for the record, Mr. Chairman. I cannot do it from memory.

Senator GORTON. We will be happy to have you do that for us. We have our ranking member here.

You may go ahead with your questions.

Senator RIEGLE. Thank you. I have great regard for Secretary Baldrige and so, by inference, I do for all of his lieutenants and hand-chosen people that he sends up here. But I am very much concerned about our competitive situation, and in the nicest of ways let me say to you bluntly that I don't think the response to the question just now is adequate. I want to ask the same question.

I have a very clear working knowledge of what's in this document because it was prepared just recently at the President's direction and by his appointees. And I think the most important thing we can do here today is to review some of the recommendations and discuss what ought to be done about them.

So I am sure some are familiar to you, and so I will start with you.

Senator GORTON. We haven't heard their testimony.

Senator RIEGLE. I see. Well, we'll get to them in due course.

In any event, obviously one of the Commissions recommendations was the Trade Department. I don't have to remind you about that because it's something which is very much high on the awareness list of the Commerce Department. But from what you remember of the Commission's report, what in here do you think is important, and what are you trying to accomplish out of here?

Mr. OLMER. Recognizing that I have not full scope responsibilities in my area of international trade, perhaps the most significant thing for my limited area is the industrial target, is the effort to emphasize the elimination or the nullification of industrial targeting by others which acts as an impediment to access by American products and services.

I began by saying, Senator, that we have not had a great deal of success in many different parts of the world in that respect, but in some we have. And we have to keep working on it. But I do take that as one of the most important areas.

I guess if you would like, I will be happy to turn to the recommendations and go through them now.

Senator RIEGLE. I think it might be useful to do that. I am not trying to ask you to recall something that is not fresh in your memory, but let me start with one that I am sure is. And that is the recommendation of the Commission which was, of course, unanimous, to set up a Department of Trade at the Cabinet level.

Have you commented on that before I came?

Mr. OLMER. Yes, sir; I did. And let me go through the section of the report on international trade. We have undertaken one of the—and completed—as a matter of Government policy a review of our domestic trade laws.

Now, that was not undertaken by a task force, but it was developed in concert with private sector advisory groups working directly with the House and Senate committees charged with the responsibility of providing such legislation. Those laws embrace both the antidumping countevailing duty and general unfair practice provisions, and many of them were strengthened, a number were simplified. Other provisions were made to provide for small- and medium-sized companies to have greater access without having to come up with funding that was not available to set the complaints down in front of the Government and to have themselves a fair hearing.

In my judgment, we will never be completely happy with either the corpus of import—of restraint laws, the antidumping countervailing duty, because they at best act as one bandage, and sometimes it is impossible for those laws to take effect before serious injury has been visited upon the petitioners.

And then it's a matter of catching up and in some industries if you don't catch the first time around before the injury occurs, you may as well close up shop. But we have made major improvements that were enacted in December of last year, and a number of American companies have—or trade associations have expressed their belief that the law has been significantly improved.

Senator RIEGLE. Let me ask you, and I guess there is a copy of the report at the table, to look at one section. On page 38 of the report there is a chart, an organizational chart that shows the mish-mash of the existing system we use to handle trade issues within the executive branch today. That is one of the complaints of the Commission. We will have a Commission member up next who can address some of these issues.

But I think we need to discuss the report's recommendations. I think frankly that you should be prepared to discuss them because that is really why we are here; this is very topical, and it is something that originated within the administration. I think what we need in the trade area, which is your area of responsibility, is a point-by-point response as to your feelings about the recommendations of the Commission, what has been done since the report came out, where there is agreement, where there is disagreement, what is intended, what is in the mill.

I think we need a formal reponse on everything, ranging from the proposal that there be a Cabinet position for trade. I would like a formal response on that issue, as well as on everything else that is mentioned here.

Now, there are 10 specific recomendations in the trade section, and they are laid out in detail. I think we need to hear from you, you institutionally and personally, in some detail on this because we are in big trouble.

Everybody in the country that pays any attention to this is alarmed about the trade deficit. One of the reasons we are having hearings here is our concern about competitiveness, a factor which seems to be driving a large part of our trade problem. So I would

like to ask you to provide that response, and I think it is very important that we have it in some detail.

Mr. OLMER. Are you asking it of the Department of Commerce, of me personally, or of the administration, Senator?

Senator RIEGLE. Let me ask you which role do you think you are in today?

Mr. OLMER. Well, I am a part of a panel, one part of which represents the former Executive Director of this Commission. I would be happy to respond, both individually and on behalf of the Department of Commerce right here and now as to our sense of the significance of these recommendations, but if you want an administration view, I would have to take leave and say I do not have it except insofar as some things have been notorious.

The administration has decided not to pursue either of the major recommendations regarding the creation of a Department of Science and Technology or of International Trade, but as to the others I would be happy to.

Senator RIEGLE. I think that would be useful. So let me ask you then to speak from the point of view of your responsibilities in behalf of the Department of Commerce, as broadly as you feel comfortable speaking, and not for the administration as a whole, which I think properly, as you say, you cannot do. How you would feel about these recommendations?

Where do we stand in terms of implementation? Are we moving ahead on these recommendations in some aggressive way or not? That is really what I would like to hear.

Mr. OLMER. I think I can do that in a big hurry. The renewal of the Export Administration Act is, I think, one of the issues of the moment and it has been before the Senate of the United States awaiting its approval. It has been passed by the House of Representatives, and when and if the President gets it, it is going to be—assuming it comes to him in the form in which it passed the House of Representatives—it will be signed into law. If it has any changes, that is another matter.

The administration reached a compromise last year on that bill and some changes were made that necessitated some committee action subsequent to the early months of 1985. But we have reached agreement, and we are awaiting that act, and we need it.

Now, whether or not that act is going to minimize the impact of controls on competitiveness is a subjective judgment to make. It is going to impact competitiveness and there is no way it can't. Its intent is to prevent the diversion of high technology flowing to our adversaries. And that represents a cost.

Private sector people in high technology businesses will tell you that the act goes too far, even the new act goes too far, and that it controls too much. I happen to share that view. But it is not a uniform view either in the Senate of the United States or within the administration. Things can be done; things are being done to improve that. It is a time-consuming process because it has been the judgment of everyone, including myself, that you had best walk slow before you decontrol.

Now, I frankly think we have walked a little too slow and we need to speed up. I have some reason to believe we are going to do

that as soon as we get that act, but we need that act and it is still in the Banking Committee.

Senator RIEGLE. How about the Export-Import Bank? By the way, I might say I am for the Senate moving on these things. I happen to sit on the side of the aisle that is a little short in numbers, so we do not set the agenda, but I will see that that thought is passed along to my chairman. And I serve on the Banking Committee.

How about the Export-Import Bank where the Commission in effect assigns it an important role? Of course, we are looking at a budget in which the administration wants to go in the other direction.

Can you respond to that?

Mr. OLMER. Well, it is also no secret that the Secretary of Commerce for 4½ years supported an increase in the direct loan authority of the Export-Import Bank and believed he was doing for good and sufficient reason notwithstanding the budget impact.

He has accepted the President's budget proposal as something that is necessary. We think that some salvaging can be done in the insurance that the Export-Import Bank will be able to provide and that that can make up much of the difference. But there is no question that it is going to hurt some corporations.

Senator RIEGLE. But it is clear that the budget that has been put forward goes in exactly the opposite direction of the Commission's recommndation in this area?

Mr. OLMER. On that issue.

Senator RIEGLE. I guess, too, we have already touched on the Trade Department. That has been ruled out; is that not correct?

Mr. OLMER. Yes, sir.

Senator RIEGLE. How about the recommendation to intensify trade promotion efforts? The Commision says that the President should launch a major export promotion campaign in 1985 and require U.S. ambassadors to submit annual reports on this issue.

Has anything been done in that area as yet?

Mr. OLMER. That was a recommendation that I personally took and my recollection is that the Secretary also took. He does not always follow my recommendations, unfortunately, but I think on this one he did. But that was a bad recommendation.

In the first place, most U.S. ambassadors, every U.S. ambassador that I have met with in the course of the last 4½ years is thoroughly imbued with the importance of exporting. What we wanted to avoid was the submission of another report. We have already asked ambassadors to make comment on the performance of their senior commercial officers, and we felt that to ask them to write an additional report to the President of the United States would just add to the paper flow and would not make a contribution to the exporting potential of our country.

But as regards the earlier part of that recommendation, we can deal with that rather swiftly, I think. The Export-Import Bank and the Small Business Administration may not exist if the President's budget program passes.

And our efforts to clarify the Foreign Corrupt Practices Act failed in the House. We have tried for, I think 3 years. I personally

testified on it in both the House and Senate and could find relatively little support in the Congress.

There seemed to be a belief that changes in that act, ipso facto meant you were for bribery and corruption, and sight was lost—I don't mean just in the Congress. I mean I think that that is a perception out in the public, or some part of the public.

What we were trying to do, and I think we should continue to try to do was to clarify the meaning of foreign government official, determine what is a facilitating payment, what is an authorized limit to entertainment expenses; whether ponying up $10 to a customs official in an African country to get your goods processed is a violation of an American law subjecting you to criminal penalty.

Senator RIEGLE. I am not sure we are that concerned about the $10 payments. It is the payments well in excess of that that are well known and that tend to be the greater concern. But I mean, you can pick any example you want.

Mr. OLMER. But it does cut both ways. I understand what generated the Foreign Corrupt Practices Act, and I believe that the act should not be eliminated in its entirety. Not at all. I do think, however, there are uncertainties in it that give rise to questions in the minds of small- and medium-sized businessmen who say, "I can't afford a Washington lawyer to tell me whether or not such and such an act would be violative of it; I had better stay away. I am told all of these horror stories. I am not going to find out for myself and wind up in the press or behind bars."

That is the sort of change that we had proposed, and believe me it was not easy to get it out of the administration because there were those that said you export promoters are not sufficiently mindful. We convinced them finally that we were and that the changes we were seeking were consonant with ethics.

Senator RIEGLE. I am conscious of the time running here, and we may get interrupted for the vote. There are also other panelists, and we have another member that has not had a chance to participate as yet. So I just want to say one other thing, or pose one other thing to you.

The competitiveness issue worries me, and I would like to work with you to find answers. I am not trying to be confrontational for the sake of an argument. I am just worried about these trend lines in our trade account, and as the Commission report itself says, a reevaluation of currencies is not necessarily going to solve this problem for us. I tend to agree with that.

I think this is an extraordinarily well-done document that really provides an assessment of the problem. What I do not see in response to it is a full-blown coherent trade response or strategy. Now, somebody can say that they are not offering the right mix of approaches, and that can be debated. It may not be the best possible mix. I think it is at least affirmative. It is a set of positive suggestions.

But if we are not going to do what the Commission recommends, then what are we going to do? I am frankly at a loss to see what the answer to that is. It seems to me that trade it not getting a high priority at the moment. I mean it tends to get more attention when the trade numbers are published or heats up on this issue or that issue. But in terms of a top priority, or an all-fronts effort

within the administration to work out a new trade strategy that bites into the problem, I do not see any sign of that.

All I see is backing and filling on bits and pieces and not liking this recommendation or that, but I do not see a coordinated overall policy. And I am worried about it. That is one of the reasons why I thought the creation of a Trade Department with somebody like Baldrige in charge, who has signaled his concern about the issue, would mean that we would start to see some coherence.

I do not see it. And I am very much concerned about it, because I think time is running against us and not for us. So that is the concern that I work from in posing these questions to you, and I would like any response to that that you would care to make.

Mr. OLMER. If I might, in some respects I agree completely with you, the level of concern that you expressed regarding our trade position and the very worrisome trend line and the need to formulate a comprehensive response to a very thoughtful group of people that were personally selected by the administration.

Indeed, some of the members of that Commission have been part of the administration.

Senator RIEGLE. Exactly.

Mr. OLMER. I have already talked about some things which have been achieved that the Commission recommended. And on the next page, on page 60, there are two that have been enacted into law by the Congress, and that is the Foreign Sales Corporation, and the final one that I commented on with reference to these, the strengthening of the multilateral trading systems; that is the centerpiece of President Reagan's effort at the Bonn summit. And it has been the centerpiece of his view on the international trading system since the first days of the first Reagan administration.

We believe that the GATT system has many flaws, but those flaws can be corrected, but that we should not avoid or give up on the prospect of improving it. He has called for a new round of multilateral trade talks over and against objections by a number of leading trading nations that felt, well, that is only going to be rhetorical and it is not going to produce hard action. The United States merely wants it to sustain its own preeminence in certain areas; we don't see its value.

We have kept the—Bill Brock in particular and the President at the last couple of economic summits, and I know on this summit, have not lost sight of the essentiality of purusing that avenue, and we are going to get it. We are going to get it in 1986. In some way or other, it will be achieved. Not the actual strengthening, but the beginning of negotiations that we hope and believe will lead to that strengthening.

Senator RIEGLE. Mr. Chairman, I think I have taken all the time I properly should.

Senator GORTON. Senator Rockefeller, do you have any questions?

Senator ROCKEFELLER. No.

Senator GORTON. Thank you, Mr. Secretary. We are reserving our right to submit additional questions to you in writing and get a more detailed set of answers, but we do thank you and we thank the other two witnesses for their patience.

Doctor, we will start with you now.

Mr. OLMER. If I might, I feel in the interests of full disclosure, I need to tell you that I am leaving the administation on June 15, having served in this position since late January 1981. I will, however, ensure the submission of appropriate answers to all of your questions before I depart.

Mr. Chairman, I thank you again for your understanding.

Senator GORTON. Fine, thank you.

Doctor, we have your written testimony, your written statement will be included in the record as if read. We would appreciate your summarizing it. We are subject to being called for a vote at almost any moment. We hope we can finish with you.

Mr. MCTAGUE. Senator, members of the subcommittee, thank you for the opportunity to meet with you today to discuss the role of technology and industrial competitiveness. It is particularly appropriate that you are focusing on this issue at the same time that you are grappling with the intolerably large Federal deficit.

As we make the hard choices necessary to get our fiscal house in order, it is important that we also lay the rest of the foundation for our future economic well-being.

The President's Commission on Industrial Competitiveness in his aptly titled report, "Global Competition: The New Reality," succinctly stated the Government's role in building that foundation. One of the painful lessons this country has learned in recent years is just how adaptable we have to be in a world that is quickly changing. The rise of strong foreign competition for sales in the world market and especially for sales in our previously insulated domestic market means that U.S. industries no longer have the luxury of setting the pace at which new technologies are introduced.

Other have been working faster than we have. One direct consequence can be seen in our increasingly negative balance of trade. The trade situation has elevated the issue of industrial competitiveness in our national priorities and leads us to the question of how well-prepared we really are to compete under today's new conditions.

We have been forced to take a fresh look at what our competitive advantages really are. As pointed out by the President's Commission on Industrial Competitiveness, our high costs of capital and labor require offsetting competitive advantages in two allied and increasingly important areas: our technology and our talent.

And that in a nutshell is the prime reason why science and technology have become such important parts of Government policy.

In the United States, Government and industry will invest some $110 billion in research and development this year. Obviously, if it were simply the total amount of money a nation spends in research and development that determined its industrial competitiveness, the United States would be far ahead of everyone else, because at that level of $110 billion a year, we invest more than France, Japan, West Germany, and the United Kingdom combined. But obviously, there is not a 1 to 1 correlation between national R&D investment and industrial competitiveness. We simply must get more competitive advantage out of the Federal Government's half of this large investment.

In effect, we must get multiple payoffs from these Federal programs.

In the Federal Government, our response to this new reality has been to allocate very large increases in support for basic research which grew by 55 percent over the past 4 years. At the same time, Government has been reducing its role in the development of the kinds of technology that industry was far better qualified and motivated to do, such as commercially oriented energy technologies like synthetic fuels.

The result of this double shift in priorities has resulted in the clearest and most logical delineation of Government and industrial roles in support of R&D that we have seen for many years. Basic research or the pursuit of frontier knowledge is valued by society for many reasons, not the least of which is that the search for new knowledge satisfies a fundamental human curiosity.

However, the Federal Government's focus on support for basic research stems from more concrete benefits that are returned to the society that pays for the research. The first is the way basic research, as opposed to direct development of technology, can vastly multiply the base of scientific and technical knowledge. That knowledge then becomes the foundation for modern industrial innovation as well as for advances in areas like medicine and environmental quality.

As technological advance becomes ever more rapid, it becomes even more difficult to predict in detail. However, its link to advances in fundamental science become closer, so our investment in basic research becomes ever more relevant, and an ever-increasing competitive edge. The other major benefit we reap from investment in basic research, especially basic research in universities, is the stimulation and education of new talent. We realize that our continued national security, our continued industrial leadership, and our ability to remain competitive depend directly on the quality of that next generation of scientists and engineers.

For example, the National Science Foundation's Engineering Research Centers are an excellent model of an effective cooperative research arrangement among Government, industry, and universities. These centers, the first of which were announced this week, will encourage universities to formulate an entirely new approach to engineering education involving industrial participation and will stress the importance of creativity and multidisciplinary approaches to real problems.

The ERC Program has been enthusiastically received by both industry and universities. There were over 140 university proposals submitted to NSF totaling over $2 billion in requests. I believe the Engineering Research Center Program is critically important to the country's future and should be expanded to achieve the level of influence we need in the development of engineering education.

We are also currently exploring more effective means of technology transfer from our Federal laboratory system to private industry. The real key to technology transfer is on the bench level, in one-on-one interactions.

The PCIC concluded that there is an important need to elevate the priority for science and technology in Government, to match its

importance elsewhere, and to reflect the truly substantial national resources being devoted to it. I heartily agree.

In summary, the human material and institutional resources in our industries, universities, and Federal laboratories are a great potential advantage for the international industrial competition we are experiencing. Imaginative and flexible cooperative efforts among these three sectors will give us the leverage we need to maintain and increase our economic strength and national security.

Thank you.

[The statement follows:]

STATEMENT OF JOHN P. MCTAGUE, DEPUTY DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

Thank you for the opportunity to meet with you today to discuss the role of technology in industrial competitiveness. It is particularly appropriate that you are focusing on this issue at the same time that you are grappling with the intolerably large federal deficit. As we make the hard choices necessary to get our fiscal house in order, it is important that we also lay the rest of the foundation for our future economic well-being. The President's Commission on Industrial Competitiveness (PCIC) in its aptly titled report, "Global Competition: The New Reality," succinctly stated the government's role in building that foundation.

"Government should take the lead in highlighting the importance of competitiveness and should nurture an effective consensus-building dialogue among leaders in industry, labor, government, and academia. Government should provide a stable fiscal and monetary policy that ensures steady, noninflationary growth, an environment that nurtures and protects technological innovation, an educational system that prepares our people for the future, a free and fair world trading environment, changes in antitrust and export administration policies to reflect the new global environment, and policies to help American firms and workers respond to changing technologies and markets."

The deliberations of this Subcommittee are central to the government's response to the international challenge, for of the four major areas identified for focus, two fall under your purview. These are Technology, and the Talent that creates, refines, and utilizes that technology.

One of the painful lessons this country has learned in recent years is just how adaptable we have to be in a world that is quickly changing. The impressive emergence of Japan and other Asian countries as industrial leaders has forced us to think hard about our own industries, educational systems, and economic prospects. Certainly the United States has been profoundly affected by the realization that some of our own strongest industries are aggressively challenged by new entrants in the world marketplace.

Not too long ago U.S. industries strongly dominated the world's markets because U.S. industries were so dominant in the development of new industrial technologies. Much of that new technology was developed, in effect, for our very large domestic market. The strong industrial base we developed to meet our domestic needs made it possible for us to build a profitable export market as well—though that was never a primary consideration for most of our industries.

But in the past decade that situation has changed significantly. The rise of strong foreign competition for sales in the world market, and especially for sales in our previously insulated domestic market, means that U.S. industries no longer have the luxury of setting the pace at which new technologies are introduced. Others have been working faster than we have. One direct consequence can be seen in our increasingly negative balance of trade. Even though that worsening balance also reflects the effect of the strong dollar of recent years, it reminds us how directly our economy is linked to the health of our technology-intensive industries.

The United States' seriously out-of-balance international trade situation has elevated the issue of industrial competiveness in our national priorities and leads to the question of how well prepared we really are to compete under today's new conditions. We have been forced to take a fresh look at what our competitive advantages really are. We've been reminded that, for example, compared to many of our competitors, American industries operate at a competitive disadvantage in many ways.

First there is a large disparity in labor costs. It is likely that this disparity will remain with us, if for no other reason than that it reflects the high standard of living that American workers have attained—a standard of living, of course, that we want to maintain. The challenge then is to recover that high labor cost through high value added per unit of labor. Second, we are at a disadvantage because of exchange rates. While there is some possibility that the dollar will weaken, the U.S. will probably never achieve anything better than parity at best with our competitors' currencies. And third, we expect our costs of capital to remain higher than many countries because of the way we finance industrial expansion.

On the other hand, we do have significant competitive advantages, in fact potentially overwhelming advantages, in two allied and increasingly important areas: our technology and our highly skilled technical talent. And that, in a nutshell, is the reason that science and technology have become such important parts of government policy.

In the United States, government and industry will invest some 110 billion dollars in research and development this year. Obviously, if it were simply the total amount of money a nation invests in research and development that determined its industrial competitiveness, the United States would be far ahead of everyone else, because at that level of 110 billion dollars a year we invest more than France, Japan, West Germany, and the United Kingdom combined. But obviously there is not a one-to-one correlation between national R&D investment and industrial competitiveness. Moreover, we are not in a position—nor should we be—to dictate how industry makes its investment choices.

The government's concern should be focused primarily on that part of the R&D being paid for by the government, which turns out to be a little less than half of the total. That 55 billion dollars a year supports our R&D in defense, space, medicine, and many other programs, including most of our basic research. But, ironically, virtually none of the government's efforts seriously address potential enhancement of industrial competitiveness. The Commission found that to be paradoxical, since industrial competitiveness should be one of our highest national priorities.

The reason for this mismatch in priorities between national needs and government programs lies in the origins of our traditional structure for government support of R&D.

In the decades after World War II, technology spinoffs from R&D, particularly Defense R&D helped lay the foundation for some of our most successful industries—such as computers, semiconductors and integrated circuits, and commercial airplanes. In the decades after the war, a pattern emerged in which industry drew heavily on and prospered from the products of government's R&D.

But to a large extent that's no longer the case, because in the past few decades the commercial technology market has grown so remarkably. Today in the United States, industry, no longer government, is pushing hardest at the frontiers of technology. The result has been a dramatic shift in relationships, and now the government relies heavily on industry to provide it with the technology it needs.

So there has been a striking decline in industry's dependence on government for new technology. But there has also been an increase in industry's dependence on government for two things it does not produce for itself and which are a primary responsibility of government—the generation of new knowledge and of new technical talent.

In the Federal government our response to this new reality has been to allocate very large increases in support for basic research, which grew by 55 per cent over the past four years. At the same time, government has been reducing its role in development of the kinds of technology that industry was far better qualified and motivated to do—such as commercially oriented energy technologies like synthetic fuels. The result of this double shift in priorities has resulted in the clearest and most logical delineation of government and industrial roles in support of R&D that we have seen for many years.

In 1980 technology development was the largest portion of our Federal R&D budget, and it claimed 42 per cent of government supported non-Defense R&D; in just four years it *dropped* to 27 per cent and became the smallest component. And at the same time, basic research climbed from 27 per cent to 38 per cent, from the smallest to the largest component.

Was this shift in emphasis in civilian R&D out of proportion to our technological challenge? Instead of investing in research in physics, chemistry, mathematics and astronomy, should not the federal government put increased emphasis on development projects in fields where we are challenged? Past experience indicates that, however good our intentions, the government has neither the wisdom nor the incen-

tive to pick tomorrow's commercial winners. It does, however, have a trust function to maintain and expand the knowledge base.

Basic research, or the pursuit of frontier knowledge, is valued by society for many reasons, not the least of which is that the search for new knowledge satisfies a fundamental human curiosity. However, the Federal Government's focus on support for basic research stems from more concrete benefits that are returned to the society that pays for the research. The first is the way basic research, as opposed to direct development of technologies, can vastly multiply the base of scientific and technical knowledge; that knowledge then becomes the foundation for modern industrial innovation, as well as for advances in areas like medicine and environmental quality. As technological advance becomes ever more rapid, it becomes even more difficult to predict in detail. However, its link to advances in fundamental science become closer, so our investment in basic research becomes ever more relevant, and an ever increasing competitive edge. The other major benefit we reap from investment in basic research—especially basic research in universities—is the stimulation and education of new talent. We realize that our continued industrial leadership and our ability to remain competitive depend directly on the quality of that next-generation of scientists and engineers.

One of the most interesting conclusions to emerge from the PCIC look at R&D was in this area of the linkages between Federal programs and industry. It was interesting in several senses. First of all, there was unanimous agreement on the Commission that concern for the utility of Federal investment in R&D did not mean that the Federal government should in any way try to supplant the role of industry in identifying areas for technology development or in entering the commercial marketplace. The PCIC recognized the shift that had taken place since 1981 in getting the government out of technology development and they supported a continuing clear delineation of the role of government and industry.

Second, in spite of the size of the investment of the Federal Government in R&D, and in basic research, the PCIC wasn't satisfied that the funds were being invested as well as they could. In particular, there was a feeling that federal R&D suffered from both a lack of coordination and a lack of priority within government.

One point in particular galvanized that opinion. The federal laboratories spend about $18 billion each year on R&D. They spend one-sixth of the Nation's total R&D funds in support of specific federal responsibilities, such as national security, health, and energy, yet the PCIC saw few links to industrial competitiveness, even though the fate of our industries is surely one of the highest national priorities.

I think that mismatch had a great impact, because it implied to the Commission that government might not be doing nearly as effective a job as it could in getting a multiple return on R&D investments. The steel initiative is an excellent example of the kind of cooperative effort which fits the PCIC's recommendation and which offers the prospect of promoting significant technological change in a mature industry. The steel initiative, which began as a joint activity involving several steel companies, Argonne and Oak Ridge National Laboratories, and university faculty, is an attempt to get personnel from all three sectors—industry/ government/university to pool their talents both to work on a scientific and engineering research problem of significant national importance. The key to the usefulness of the steel initiative, and that feature which sets it aside from other endeavors, is its emphasis on establishing a one-on-one relationship between university, federal laboratories, and industry researchers. Such experiments in technology transfer seem to me to be a totally appropriate way for government to help promote technological change in industry by making available the talent and facilities of the federal laboratories. The Commission members also compared their own impressions of the importance of science and technology in their industries and in their communities with the importance of science and technology in government—and again found a disturbing mismatch. To them, science and technology were the important buttons to push to run the industrial engine, but government seemed to focus a relatively small amount of attention on them, compared to many other areas.

For example, the National Science Foundation's Engineering Research Centers (ERC's) are an excellent model of an effective cooperative research arrangement among government, industry, and universities. These Centers, of which only six were funded in 1985, will encourage universities to formulate an entirely new approach to engineering education. The ERC's will emphasize multidisciplinary education, and will stress the importance of creativity in the synthesis of solutions to problems, rather than the traditional concentration on engineering analysis. Industry participation in the Centers will benefit students and faculty by exposing them to the practical consideration of applying technology in business, an area in which the U.S. seriously lags behind its foreign competition. Industry will benefit by

having access to top-notch talent, trained in a new way which will lead to more effective and creative solutions to engineering problems in industry.

The ERC program has been enthusiastically received by both industry and universities. There were over 140 proposals submitted to NSF, totaling over $2 billion. Many of these proposals were outstanding, and it is unfortunate that only six could be funded.

I believe the Engineering Research Center program is critically important to the country's future, and should be expanded to achieve the level of influence we need in the development of engineering education.

The PCIC concluded that there is an important need to elevate the priority for science and technology in government to match its importance elsewhere and to reflect the truly substantial public resources being devoted to it.

To summarise the overall results of the PCIC, I would say that the Commission identified the strengths and weaknesses in our industrial world and suggested how we could capitalize on the strengths and minimize the weaknesses. Some of those emphases are already part of our federal programs, and we can expect to push them even harder. And as for many of the other recommendations, my own assessment of the impact of the PCIC is that, over time, we will see many if not most of them become part of national policy. Yet it is unlikely that we will be able to point to a specific act or a specific date and say that's where the PCIC was implemented. As the report of the PCIC said, "There is no single solution—no simple solution—that can reverse the competitive erosion we report. Competitiveness is a broad issue, affected by an in turn affecting a broad spectrum of our activities."

The PCIC is not alone in proposing cooperative research between industry and government. During the past few years there has been increasing interest within both industry and government in the transfer of federally developed technology to the private sector. Indeed, such transfer is encouraged by the Administration's science and technology policy. However, many people tend to think of technology transfer in terms of the supermarket analogy. They visualize Federally developed technology as items sitting on a shelf which shoppers can choose from as they go down the aisle. In practice, technology transfer is much more complicated. Typically, the receiver of technology must already have a highly developed technology base in order to perceive the value of the technology and be able to make the best use of it. Thus it is most natural for the developer of the technology, if it is a commercial firm working under contract for the government, to absorb that technology into its own business.

It is harder to transfer technology across organizational boundaries. If, for example, the technology has been developed by a Federal laboratory, it is less likely to find its way into a commercial product. Historically, U.S. industry, with a few exceptions, has shown little interest in what goes on in Federal laboratories. In principle, technology developed in those laboratories, paid for by the taxpayers, was available to everyone at no additional cost. In practice, private sector firms were reluctant to commercialize that technology because they could perceive no competitive advantage. The result was that our competitors overseas, who felt no such inhibition, took these technologies and made a profit on them.

The Administration has dealt with this problem in two ways. One has been to encourage Federal laboratories to grant exclusive licenses for commercial use of their technologies. The other has been to increase interactions between Federal laboratories and industry by more exchange of knowledge and personnel, collaborative projects and industry funding of laboratory work. These are the kinds of programs exemplified by the steel initiative, and the Engineering Research Centers which I described earlier. We believe that the greatest value of our laboratories lies in the technical talent and ideas that reside there. The development of commercializable technologies at Federal laboratories is not usually their major mission. However, their expertise is a dynamic resource that has been underutilized by American industry. Therefore, more is to be gained in the long run by greater interaction and transfer of technology related ideas, rather than transfer of technology per se.

I am not sure that the kind of technology idea transfer just mentioned is generally understood outside technical circles. It involves attitudes - attitudes both in and out of government. Industry must think of Federal laboratories as potential resources, resources of human knowledge, imagination, and skill, and the laboratories must view technical collaboration with American industry as part of their mission. As you know, attitude changes take place slowly and are hard to measure. However, the Administration's emphasis on increasing Federal laboratory-industry interaction is having an effect, and we expect steady progress in the coming years. mechanistic solutions are tempting, but the merging of federal laboratories and industrial cultures on a person-to-person level is more likely to produce substantive effect.

Let me turn now to methods for improving the management and coordination of Federally funded research and development. The key to good management is good managers. There is increasing concern that the overall quality of technical people in the government is declining. Two years ago, the White House Science Council's Federal Laboratory Review Panel, under the chairmanship of David Packard, issued a report pointing out that the federal government was having difficulty attracting young scientists and engineers at the entry level, and retaining experienced and qualified personnel at the top management level. That situation has become worse in the past two years as the spread between Federal and private compensation for top talent continues to widen. The Packard Panel recommended legislation to create a separate Federal personnel system for scientists and engineers that could eventually raise the quality of the Federal technical workforce. Our office has drafted such legislation and is participating in an interagency working group to evaluate this and other legislative approaches to the personnel problem.

The Packard Panel also noted that Federal research and development managers tend to be over-managed by their agencies, often in response to Congressional direction, and spend an inordinate amount of time dealing with the budget process and other paperwork. They recommended that laboratory directors be given more discretionary authority in the conduct of research research and development but that greater attention be paid by agencies to the output of that effort. In other words, the emphasis should be on product rather than process. Another recommendation of the Panel was that external oversight committee be set up for each laboratory to review the quality, relevance and appropriateness of the laboratory's work. Our office has been working with the agencies to follow up on their implementation of all the Packard Panel's recommendations.

In summary, the human, material, and institutional resources in our industries, universities, and federal laboratories are a great potential advantage for the international industrial competition we are experiencing. Imaginative and flexible cooperative efforts among these three sectors will give us the leverage we need to maintain and increase our economic strength and national security.

Senator GORTON. Mr. Milbergs.

Mr. MILBERGS. Thank you very much, Mr. Chairman.

I would like to submit my formal testimony for the record, and I would like to summarize it.

I appreciate the opportunity to discuss the Stevenson-Wydler Technology Innovation Act of 1980 and also the activities of the Office of Productivity, Technology and Innovation.

My formal testimony is in response to the letter that you submitted to Dr. Merrifield and is not focused on the work of the President's Commission.

The ability of American industry to compete both at home and abroad is essential to achieving an increased standard of living, more and better jobs and national security. While the economic recovery has been beyond our expectations, the issue now is sustaining this recovery for the long term in a drastically changed world trading environment, and indeed this was the major thrust of the President's Commission's Report.

The challenge is to create an appropriate policy environment to enhance the technology innovation process of the private sector to increase our competitiveness. Innovation and technology transfer is a major factor in achieving competitive advantage because it can help us reduce costs, improve the performance of existing products, create new products and businesses, help revolutionize mature industries, and foster innovation that has a very big multiplier effect in terms of economic growth, jobs and exports.

The major objectives of OPTI are to remove barriers and create incentives for the technology innovation process, to catalyze private sector self-help arrangements such as cooperative R&D, and to provide strategic information for use by the private sector to im-

prove productivity growth and competitiveness in both domestic and international markets.

The administration now believes that the tasks of the Office of Productivity, Technology and Innovation that it was created to perform have largely been completed. Many of the concepts and incentives we pioneered have become commonplace private sector activities. We are considering the options for placing some of the functions of the office elsewhere in the Department, but decisions have not yet been made.

We are aware of the Department's important responsibilities for technology and productivity policy and will ensure that they continue to receive attention within the Department.

The administation appreciates that Congress may want to express its priorities in the technology area in legislation. Specifically with respect to the Stevenson Wydler Act, the administration is opposed to an extension of the authorization of appropriations—that is section 14 of the act—since it has been shown that the objectives of the act can be achieved without direct Federal funding.

The Secretary of Commerce submitted a report to the President and Congress in February 1984 that summarized what had been accomplished during the first 2 years under the act, and I am submitting a copy of the report with this statement.

The most important question that I would like to discuss with you today involves activities carried out under section 11 of the act. Section 11 directs that agencies, establish Research and Technology Application Offices—the acronym is ORTA's—in large laboratories. These organizations have now been established and analysis of information provided by the agencies has led to an important conclusion: that four types of technology transfers are carried out by Federal laboratories. These include information transfers, personnel exchange, facility sharing, and intellectual property transfers.

Federal laboratories predominantly use the first three types of technology transfer and have been less involved in intellectual property transfers or what we call technology management. Yet, opportunities to help create competitive products, new industries, and substantial employment can be generated from appropriate management and development of intellectual property.

The White House Science Council Federal Laboratory Review Panel, the Grace Commission, and a number of other studies have recommended more collaboration between Federal laboratories and industry. For industry to provide resources, it must be able to recover its investment through commercial use of the results and this requires some changes in how the Government manages its intellectual property.

Government laboratories are quite similar to research universities and much of the university experience in owning and managing Government-funded inventions under Public Law 96–517 is directly applicable to the laboratories.

As universities began to market their federally-funded inventions, they often found that business was willing to fund additional work to continue development of those inventions, or to branch out into related areas. As result, university/industry collaboration has been increasing at an unprecedented rate within the United States.

We have become, for example, a world leader in biotechnology in part because universities that developed and patented the fundamental gene-splicing techniques under Federal funding were allowed to manage and promote their discoveries.

We have become convinced that inventing organizations, if they are given adequate authorities and incentives, are more motivated and can better achieve practical use of the technologies they create than are agency headquarters or centralized licensing operations.

We understand that Senator Dole has introduced S. 65 which would accomplish these purposes, which embody these kinds of principles. These comments represent our views only at the moment, since the administration has not yet formulated a final position on S. 65.

Congress took a significant step toward this objective under Public Law 98–620 last year which allows most nonprofit organizations that operate Government-owned labs to own and manage their inventions. We believe the time has come to apply these same principles to Government-operated labs.

We believe that Federal agencies should be allowed to delegate to their laboratories the decentralized authority the labs need to manage their technology and enter into a wide range of collaborative agreements. Some intermediate level of management authority may have to be provided for the smallest labs, but the authority normally should be as close to the operating inventing level as possible.

The actions the labs take under these authorities should be subject to minimal review, and certainly Commerce should not have any review responsibilities except when policy issues are involved. Agencies should be able to develop their own implementing regulations or guidelines.

We also believe that monetary incentives in the form of clearly-established amounts or shared royalties for inventors in the laboratories are vital to the success of any program to increase the transfer invention from the Federal labs to the private sector.

We know from the Commerce patent licensing experience and the university experience that such incentives are important. Private industry has all sorts of methods it can use to reward their most productive people, but Government is extremely limited in this important area.

I do not want to take the time now to mention all of our other activities under the Stevenson-Wydler Act. My testimony reviews the record of the past 3 years. Essentially what I would like to say is that the adminstration's strategy with respect to the implementation and the intent of the act has been focused on the multifaceted process of innovation itself rather than selected end products of the process.

Weak points in the innovation process have been identified. Options for remedial action have been analyzed and a number of initiatives have been undertaken and they are briefly described in the testimony.

I would like to conclude by saying that the steps being taken by both the public and private sector are beginning to define a unique American response to the competitive challenge we face. However, some of our traditional approaches are simply not going to do the

job. But the good news is we are moving forward; we are focusing on productivity, innovation, quality and competitiveness without intervention by the Government in business decisionmaking.

I believe the United States is well positioned to take advantage of its unique advantages. As the President's Commission pointed out, those two greatest advantages are technology and our talent. We have the most advanced basic research capability and technology in the world. We have an incomparable entrepreneurial spirit, the largest market in the world, a dynamic capital market, and an abundant supply of human resources. I am convinced that with sufficient vision and resolve, we can provide the public policies which will enable the private sector to meet the new global challenges successfully.

Thank you. That summarizes my statement.

[The statement follows:]

STATEMENT OF EGILS MILBERGS, DEPUTY ASSISTANT SECRETARY OF COMMERCE FOR PRODUCTIVITY, TECHNOLOGY, AND INNOVATION

Mr. Chairman, I appreciate this opportunity to discuss the Stevenson-Wydler Technology Innovation Act of 1980 and the activities of the Office of Productivity, Technology, and Innovation.

The ability of American industry to compete, both at home and abroad, is essential to achieving an increased standard of living, more and better jobs, and national security. The economic recovery has been beyond our expectations, but the issue now is sustaining this recovery for the long-term in a drastically changed world trading environment. Over 70 percent of the goods manufactured in this country face competition from products made abroad, increasingly from Japan and other Pacific Rim nations. Technology is accelerating, progressively obsoleting products and processes in shorter time periods. Mature industries are under pressure to reduce costs significantly and improve productivity and quality. At the same time, an explosion of entrepreneurial activity has been generating new business opportunities and jobs in the United States.

The challenge is to create an appropriate policy environment to enhance the innovative processes of the private sector to increase our competitiveness. Technology transfer is a major factor in achieving competitive advantage because it can: Reduce costs; improve performance of existing products; create new products and businesses; help revolutionize mature industries; and foster innovation that has a multiplier effect in terms of economic growth, jobs and exports.

The major objectives of the Office of Productivity, Technology, and Innovation (OPTI) are to remove barriers and create incentives for the technology innovation process, to catalyze private sector self help arrangements such as cooperative R&D, and provide strategic information for use by the private sector to improve productivity growth and competitiveness in domestic and international markets.

The Administration now believes that the tasks the Office of Productivity, Technology, and Innovation were created to perform have largely been completed. Many of the concepts and incentives we pioneered have become commonplace private sector activities. We are considering the options for placing some of the functions of the Office elsewhere in the Department, but decisions have not yet been made. We are aware of the Department's important responsibilities for technology and productivity policy, and will ensure that they continue to receive attention within the Department.

The Administration appreciates that Congress may want to express its priorities in the technology area in legislation. Specifically with respect to Stevenson-Wydler, the Administration is opposed to an extension of the authorization of appropriations since it has been shown that the objectives of the Act can be achieved without direct Federal funding.

The Secretary of Commerce submitted a report to the President and Congress in February 1984 that summarized what had been accomplished during the first two years under the Act. I am enclosing a copy of the Report with this statement. The most important question I would like discuss today involves activities carried out under Section 11.

Section 11 directs the agencies to establish Research and Technology Application Offices (ORTAs) in larger laboratories. These organizations have now been estab-

lished and analysis of information provided by the agencies has led to an important conclusion. Four types of technology transfer activities are carried out by Federal laboratories.

(1) *Information.*—which includes advice, technical assistance, reports, and other forms of aid, usually provided at minimal or no cost.

(2) *Personnel Exchange.*—which includes guest workers at the labs and lab employees working at other locations.

(3) *Facility Sharing.*—use of laboratory facilities by others for their own purposes, usually on a reimbursable basis. Laboratories may assist in performing the work or operating special equipment, but often do not have an interest in the results.

(4) *Intellectual Property.*—which includes patents, copyrights, technical data, rights to future inventions, and other forms of technology that can be identified, owned and protected, and then licensed, assigned, or used. The intellectual property may have resulted from prior laboratory work, or may result from work to be done in the future.

Federal laboratories predominantly use the first three types of technology transfer, and have been less involved in intellectual property transfers or what we call technology management. Yet, opportunities to help create competitive products, new industries and substantial employment can be generated from appropriate management and development of intellectual property. This is because the innovation process, which runs from identification of a need to marketing a product that meets that need, is usually very costly when new technologies are involved. However, without control of access to the new technology, there is a high risk that capital invested in the innovation will not be recovered and become profitable before others, who do not have to replicate the original development investment, copy the product and become competitors. The most significant opportunity for improving the transfer of technology generated by Federal laboratories to the economy and the competitive position of the United States lies in the area of improving intellectual property management.

The White House Science Council Federal Laboratory Review Panel recommended more collaboration between Federal laboratories and industry. But for industry to provide resources, it must be able to recover its investment through commercial use of the results, and this requires some changes in how the Government manages its intellectual property.

The Government laboratories are quite similar to research universities, and much of the university experience in owning and managing Government funded inventions under P.L. 96-517 is directly applicable to the laboratories. As universities began to market their federally funded inventions, they often found that business was willing to fund additional work to continue development of those inventions or to branch out into related areas. As a result, university/industry collaboration has been increasing at an unprecedented rate. The United States has become the world leader in biotechnology, in part, because the universities that developed and patented the fundamental gene splicing techniques under Federal funding were allowed to manage and promote their discoveries. We have become increasingly convinced that inventing organizations, if they are given adequate authorities and incentives, are more motivated and can better achieve practical use of the technologies they create than are agency headquarters or centralized licensing operations. We understand that Senator Dole has introduced S. 65 which would accomplish these purposes. These comments represent my views only, since the Administration has not yet formulated their position on S. 65.

Congress took a significant step toward this objective under P.L. 98-620, which allows most nonprofit organizations that operate Government-owned labs to own and manage their inventions. This was an additional step in applying the principles of decentralized management of inventions. We believe the time has come to apply the same principles to the Government-operated labs.

We believe that Federal agencies should be allowed to delegate to their laboratories the decentralized authority the labs needed to manage their technology and enter into a wide range of collaborative agreements. Some intermediate level of management authority may have to be provided for the smallest labs, but the authority normally should be as close to the operating/inventing level as possible. The record of less than 4 percent of all Federal inventions licensed does not support continued control of inventions by agency headquarters staffs. Decentralized management envisions the handling of an ever expanding number of technologies. The actions the labs take under these authorities should be subject to minimal review, and certainly, Commerce should not have any review responsibilities except when policy issues are involved. Because of the wide range of lab missions, we believe that Government-wide regulations are not advisable at this time. Agencies should be able to

develop their own implementing regulations or guidelines. Interagency teams working with a lead agency can develop models, agreements, and techniques that can be of use to individual labs.

We believe that monetary incentives, in the form of clearly established amounts or shared royalties for inventors and the laboratories, are vital to the success of any program to increase the transfer of inventions from the Federal labs to the private sector. We know, from the Commerce patent licensing experience and the university experience, that such incentives are important. Private industry has all sorts of methods it can use to reward their most productive people, but Government is extremely limited in this important area.

One example of effective collaboration helps illustrate the point. The Los Alamos National Laboratory recently announced a patent license agreement with a small firm to develop and market a laboratory invented device to identify bacteria and viruses in blood. Over $4 million was obtained from a research and development limited partnership to fund further development at Los Alamos. This collaboration is expected to advance the mission research of the lab, produce a major breakthrough in low-cost medical diagnosis as a by-product, and lead to a new product for export. It would not have been possible had the Department of Energy not waived its rights to the basic invention and follow-on developments to Los Alamos. The President alluded to this development in his State of The Union Message. Our objective is to make this type of collaboration, benefiting both the Government and the public, as common an occurrence for Federal laboratories as it has become for universities. This focus on the process of innovation does not require appropriations under the Stevenson-Wydler Act.

I would now like to mention some of our other activities that support the intent of the Stevenson-Wydler Act. That law was designed to stimulate productivity, technology, and innovation in the private sector for the purpose of regaining or maintaining U.S. technical and industrial leadership in global markets. The Administration strategy has focused on the multi-faceted process of innovation itself rather than selected end-products of the process. Weak points in the innovation process have been identified, options for remedial action have been analyzed, and a number of initiatives have been undertaken. These initiatives can be categorized as removing barriers to innovation, providing incentives for private sector initiatives, and increasing awareness of strategic opportunities in noninterventionist ways. For the most part, this has involved specific use or modification of Government antitrust, patent, procurement, regulatory, R&D, and tax policies.

Examples of initiatives that have been taken include the following:

The R&D Limited Partnership (RDLP) concept has been advocated as a new method of financing innovation that is equally available and useful both to declining and growth industries. It minimizes direct Government intervention in the private sector. This approach is designed to achieve the objectives of Stevenson-Wydler, but to a much greater degree and over a much broader spectrum of industries than originally envisioned.

The transfer of Federally funded technology to the private sector is being pursued through Federal patent policy changes that "automatically" transfer government-funded technology to the organizations that develop it and that have the incentive to commercialize it, rather than continuing the past process of "warehousing" and licensing it by government at a later time.

Private sector cooperative R&D has been promoted through the removal of antitrust barriers to procompetitive arrangements by the passage of the National Cooperative Research Act of 1984.

Federal research funding is being reallocated toward basic research, where commercial incentives are weak or do not exist, and away from development and demonstration of commercial technologies, which are more appropriately undertaken with private funding.

Basic research performers are being encouraged to be involved in shepherding their new ideas farther along the private sector innovation process toward commercialization.

Protection of intellectual property held by developers of new technologies is being increased and ambiguities in current laws are being clarified.

Assistance has been provided on the innovation process to state and local Governments and to small business.

Finally, OPTI has pioneered the development of new strategic analytic tools and data bases that firms or industries can use to assess their relative performance and formulate new competitive strategies.

Within this improved environment, the Administration's Stevenson-Wydler initiatives have led to results such as the following:

Creation of new roles and organizational structures to intensify the development and utilization of university, nonprofit, and Federal laboratory results.

A sharp increase in patenting and licensing of technology by universities. Further, the Department's Center for the Utilization of Federal Technology has increased its rate of licensing of Federally owned inventions from 10 licenses issued in fiscal year 1980 to 36 licenses in 1984. The Licensing Program has become self-sustaining, and the fiscal year 84 licensees pledged a total investment of $86 million in R&D and facilities construction.

An upsurge in private sector activity in R&D limited partnerships, estimated at more that $2 billion over the last three years.

Issuance of a Presidential Memorandum on patent policy extending contractor ownership of Federally funded inventions to all R&D performers to the degree permitted by law.

A dramatic increase in State and local Government economic development initiatives, often in cooperation with universities and small business resources, aimed at nurturing the creation of new high technology firms and at the application of new technology to existing companies.

The articulation of a major new concept of shared flexible manufacturing facilities that would allow one plant to serve the manufacturing needs of different businesses much as shared computer facilies serve multiple information needs.

In conclusion, the steps being taken by both the public and private sectors are beginning to define a unique American response to the competitive challenge we face. Some of our traditional approaches are simply not going to do the job. The good news is we are moving forward—focusing on productivity, innovation, quality and competitiveness, without intervention by the Government in business decisionmaking.

The U.S. is well positioned to take advantage of its unique advantages. We have the most advanced basic research capability and technology in the world, an incomparable entrepreneurial spirit, the largest product market in the world, a dynamic capital market, and an abundant supply of human resources capable of learning and applying the skills. I am convinced that with sufficient vision and resolve we can provide public policies which will enable the private sector to meet the new global challenges successfully. The key to this success is a dynamic process of innovation and its application.

Mr. Chairman, this concludes my prepared remarks.

Senator GORTON. Thank you.

Dr. McTague, the Commission's recommendations for a Department of Science include a description of its missions, its relation to R&D funding, planning, coordinating, and the like. They seem to me strikingly like the missions of the Office of Science and Technology Policy.

If we are unlikely to reorganize the Government in the way of creating a Department of Science, should we not, nonetheless, strengthen the existing institutions like OSTP and the Office of Productivity, Technology and Innovation?

Mr. MCTAGUE. Any help you can give our office will be gratefully accepted.

I think that the real issue is not so much a mechanistic one of either of our offices, but the question of elevating the level of priority with respect to science and technology in the Government to what it really is in society as a whole—there should be someone speaking at the Cabinet level about issues of science and technology which are so pervasive in our country.

I think that is the driving issue, not so much mechanisms. The Office of Science and Technology Policy is not a line office; it does function to give advice to the President on scientific and technological issues. It does participate in the formulation of the budget by cooperating with the Office of Management and Budget on the R&D budget.

But other than the President of the United States, there is no line officer in the Government looking over all of science and technology which is spread over, I would guess, about five departments which each handle more than a billion dollars of R&D.

Senator GORTON. One more question. The President vetoed my bill which was passed by the last Congress to establish Centers for Manufacturing Technologies at universities. The administration now supports and as a matter called for more of the National Science Foundation's Engineering Research Centers at universities.

What is the difference between the two?

Mr. MCTAGUE. The Engineering Research Centers have a structure which is dictated by the universities themselves. They decide which to propose. All they must have is multidisciplinary character and significant participation by industry.

They are focused mainly on training students in multidisciplinary approaches to real problems. I think that they answer the spirit of what you are after, and I think they are noble experiments. I would like to see them expanded.

Senator GORTON. I am delighted at that statement. I still do not see any difference. But nonetheless, if we reach the goal, we will be delighted to do so.

Mr. Milbergs, it is clear from discussions about the need for patent legislation such as Senator Dole's two bills, that not all Federal labs agree with you about licensing inventions and cooperating with industry.

Don't the technology transfer requirements of the Stevenson-Wydler Act strengthen the administration's hands in this debate? Wouldn't, on the other hand, its abandonment send the wrong signal about our intention to encourage technology transfer?

Mr. MILBERGS. I would like to separate the issue of reauthorization of section 14 and other sections of the act. With respect to other sections of the act, we have been in the process of trying to implement it. The issue deals with funding here. It is the view of the adminstration that, given the budget situation that we are in and the fact that many of the policies expressed in the different sections of the act could be carried out by the Commerce Department and its various offices. It is not necessary to reauthorize appropriations in section 14.

With respect to section 11, which deals specifically with technology transfer, we find the kinds of principles that are expressed in Senator Dole's bill, as being quite consistent with the section 11 intent.

If we could create the proper authorities to manage this intellectual property in laboratories, I think we would be able to increase the amount of technology that gets off the shelf of the labs to the private sector.

Senator GORTON. Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman.

I just want to say in passing how much I appreciate your leadership on these issues. The fact that these hearings are taking place and the initiative, legislatively and otherwise, I think is some of the most important work being done in the Senate.

And I want to particularly commend both witnesses that are at the table for their roles, respective roles—one directly, one less di-

rectly perhaps—in the work of the President's Commission. As the Executive Director of the Commission, Dr. Milbergs, you had a big assignment working with some exceptionally good people, I think, and I think the work product is outstanding. I think often times work products coming out of the Government, Senate, and the rest of the Government are not up to a sufficient standard. I think this is really outstanding work, and I think you have done a great service to the country in putting this together and sort of helping us get over some of the hurdles in the discussion that barriers—old thinking that have made it difficult, I think, to look at new realities and think constructively about them.

And Dr. Keyworth obviously had to play an important role as the direct representative of the President here, presumably most heavily in the area of science of technology. And because the Commission report was unanimous, obviously it reflects his view as well.

So through you, Dr. McTague, I want to extend that same appreciation to him for the work that he did on this product.

Now, let me ask you this, Dr. Milbergs, if I may. On page 1 of the report, you pose the question in the text of the report this way: Are we, meaning the country, meeting the competitive challenge?

The response that is written here, and I quote:

> Not well enough. Our ability to compete in world markets is eroding. Growth in U.S. productivity lags far behind that of our foreign competitors. Real hourly compensation of our work force is no longer improving. U.S. leadership in world trade is declining. Finally, pretax rates of return on assets invested in manufacturing discourage investment in this vital core of our economy.

And then if we go over to page 5, in the same vein there is this paragraph. In response to this international global challenge, you say:

> We have failed to respond adequately. Our ability to compete in world markets has been gradually eroding. Even our lead in high technology is slipping.

I was struck very much by one of the charts in here, one that laid out 10 categories of high technology exports and measured U.S. performance vis-a-vis the rest of the world over the years 1965 to 1980. You obviously used 1980 as a cutoff point, I think, to avoid getting a distortion because of the unusually high value of the dollar, which was appropriate to do.

But I notice in 8 of these 10 categories, ranging from things like plastic and synthetic materials, to optical and medical instruments, engines and turbines, and so forth, that we have lost relative market share in 8 of the 10.

There are many other things in here along these lines. But as I digest this and as I talk to other people out in the financial and economic world—in manufacturing settings, in financial institutions and so forth—I find a shared sense of apprehension by people who are operating in the highest level of our economy. Their concerns bear out what you have said here as a Commission.

At the same time, it is startling that when the report was finished and ready for presentation, it was not presented at the White House, which is normally the case. It certainly was the case with the Commission on Alcoholism where I was present for the presentation. But the Commission was sent down to the Commerce De-

partment, which is the way, normally, that the White House, any White House, underplays an event that they are not all that pleased about or that they don't want to associate themselves directly with. And I think everything since shows that the White House is really not terribly happy with what you have said.

They are not saying that what you have said is not true; they just seem to have a very hard time wanting to accept it or to be associated with it. Maybe it is because it is at odds with the notions that everything is fine, that nothing needs to be done, and that all of our problems are self-correcting.

Well, clearly they are not. And it is that dichotomy that really has me very concerned about the future. It seems to me we are drifting, while in fact we have been given a very good road map for a series of things that need to be done.

I strongly support the idea of a cabinet position on science and technology, as I do on trade. I think it is a logical consolidating point, particularly when you have got this sort of mish-mash of divided functions all through the Government. In fact, the technology area is even worse than the trade area if one graphs it out.

I would like each of you, if you would, to tell me briefly what you think are, in rank order, the three most important recommendations in this document, recognizing that all of them have their importance and degree of weight. But personally and professionally, which three would you rank in the highest order of need?

Why don't we start with you, Dr. Milbergs.

Mr. MILBERGS. Well, I appreciate the promotion. It is not doctor yet; it is mister.

Senator RIEGLE. Well, you are doctor on the official document that has been prepared here. So in any event——

Mr. MILBERGS. Is that right? Oh, good.

First of all, I believe there has been a misperception about how this report has been received by the White House.

John Young, the chairman, did have an opportunity to meet with the President and the full cabinet, and the entire report was presented to the President. Intensive review has taken place throughout the entire government of all the recommendations of the Commission.

You might know that during the life of this Commission, when the Commission formed a consensus, its recommendations were forwarded to the Cabinet Council on Commerce and Trade on an ongoing basis. It was not a report that saved up all of its recommendations. The Commission fed them in as we went along.

By the time the final report was submitted to the President, there had been an interagency process already underway on each of these recommendations in terms of getting an administration reaction.

Now, what I could tell you is, as I don't have a detailed scorecard about all of these recommendations—you heard Lionel Olmer talk about a few—but nearly 90 percent of the recommendations that this Commission has made—32 recommendations and 92 action items if you were to break those recommendations down in detail—have either been embraced as consistent with administration policy or the administration has a task group or a lead agency to look into the policy recommendation.

Senator RIEGLE. Can you give us, by the way, that listing for the record?

Mr. MILBERGS. I can just tell you that a lot of these recommendations are already implemented and I can tick off some right now for you.

I think it is important to recognize that this administration has been reacting and listening to the Commission's work. I think what has happened is that a lot of publicity has emerged around a couple of these—the Department of Trade and the Department of Science and Technology—and that has tended to create the overall imagery with respect to the reception the Commission report got.

But as I said, the majority of these recommendations are consistent with administration policy and the administration has been doing something about it.

Senator RIEGLE. Let me just say to you at that point, everything you say may be accurate. Still, it's obvious that the President has not chosen to invest himself in it. He is a very powerful figure in our society, and if he were to hold this report up and ask every business decisionmaker and manager in the country to get a copy and to read it and to do what they could to implement it, it would make a big difference.

Maybe you can get him to do it. If you can, I think it would be helpful. But I think the absence of any showing of personal commitment of that kind takes an awful lot of the emphasis away.

I am not sure I heard your view as to what you think is the single most important recommendation or the second most important recommendation, and I would like to hear that if I may.

Mr. MILBERGS. It is hard to single out a single recommendation because the Commission did not say there was a silver bullet that solves the competitiveness problem.

Senator RIEGLE. Understood.

Mr. MILBERGS. This makes it very difficult to handle in terms of the policy process. The most fundamental insight I gathered from my 16 months with this Commission is that the Government does have a role for competitiveness, but it is also a limited role. The Government has to create the climate and the environment, but the private sector has got the principal responsibility for competitiveness: to generate products that are cost-effective, high-quality, and can meet the test of international markets. The Government has a role in shaping that climate, but let's also recognize that the role is also limited to some degree.

I would like to point out that the Commission did make a series of recommendations also with respect to private sector action. While we may have seen a somewhat slower response, let's say from Government, both the congressional and the executive side on what we need to do, we need to recognize that this report also addresses some pretty good ideas for State and local government, for the private sector, and for educational institutions as well. There are also important audiences that the Commission had in mind.

So I cannot single out any three. Maybe you could ask Dr. Ian Ross, when he comes up here what three he thinks are the most important.

Mr. MCTAGUE. Senator, I would like to distinguish between short-term, intermediate-term, and long-term recommendations. In

the short time, I believe what Olmer addressed—that is to say, addressing trade policy is critically important.

And I am encouraged by the Herculean shuttle efforts that he has been making. No wonder he is leaving the Government.

In the intermediate term I believe that raising the priority of science and technology in the Government is absolutely essential, and I think that after one sees the emergency addressing of the Federal deficit, when we start seeing some more devotion to the effort of raising the priority of science and technology in the Government, in the longrun the most important things that we have to do, which are addressed there, are the cultural aspects of technology transfer, motivating people to be interested in pursuing the applications of technologies that they generate. And some mechanisms for doing that have been discussed by Mr. Milbergs.

The longest term one is support of basic research and training of talent, especially engineering talent, in particular in the area of manufacturing engineering in our universities, and we are pursuing that. I think that is where the longest range, highest payoff will be.

Senator RIEGLE. I was concerned in that area in that Japan obviously has a different system, and they focus differently than we have, but they are certainly not falling short in producing engineers. That is one thing they are very good at. And we have fallen short, I think, absolutely and comparatively.

Those are the second bells on a vote that we must attend, and we are both members of the Budget Committee, so if either of us or if I should get waylaid over there on the next item up, I want to say to Dr. Ross, who is up next, that I want to extend to him again my expression of appreciation for the work that he has done as a member of the commission. And again, I think this is the best piece of work I have seen the Government do in a long time, and I really think we ought to be following it with a vengeance. And I do not, frankly, have the sense that we are, despite what you so tactfully said a moment ago. I guess the things we are not doing stand out in very bright lights to me, and maybe we will see something more happen. I would be delighted at that.

Mr. MILBERGS. Senator, there is an opportunity this afternoon to follow one of the recommendations called cut the deficit.

Senator RIEGLE. I do not know if you mean that with respect to the vote we are about to vote on.

Senator GORTON. I am not sure that you would say that.

Senator RIEGLE. Reducing the defense increase.

Mr. MILBERGS. Oh.

Senator RIEGLE. But I appreciate what you said, and I will take that to heart.

Senator GORTON. Thank you both.

Dr. Ross, you are next. We will hear your testimony as soon as we get back from this vote. I will tell you now your written testimony will be included in the record, and if you can summarize it when we get back, we would appreciate it. We are in recess for about 15 minutes.

[Recess.]

Senator GORTON. Dr. Ross, our apologies for being gone so long, and our gratitude to you for your patience. We are now ready to hear from you.

STATEMENT OF IAN M. ROSS, MEMBER OF THE PRESIDENT'S COMMISSION, AND PRESIDENT, AT&T BELL LABORATORIES

Mr. Ross. Thank you, Mr. Chairman. I appreciate the opportunity to review for this subcommittee the report of the President's Commission on Industrial Competitiveness.

My filed statement contains such a review, and in particular, a review of the technology issues related to competitiveness. I will not repeat that statement here but just emphasize what you emphasized: that one of the most important conclusions of the Commission was that technology is one area in which we do have an advantage, a competitive advantage, and one in which we can expect to maintain that advantage.

What I will do now is draw on the work of the Commission and on my own experience in responding to the four specific questions that the subcommittee asked me to address. The first one concerns the Government role in promoting both the creation and application of new technologies.

It seems to me that the Government has three roles to play in creating new technology. One is in the funding of basic research. A second is in supporting universities in general. And a third is to provide incentives to industry to conduct research and development, whether that be through tax means such as tax credits or whether it be through better protection of intellectual property rights.

In the question of the application of new technologies, this is an area that the Commission felt had some of the weakest performance in some of U.S. industry; and there we feel that we require an economic climate and policies that will encourage investment based on a long-term, not just a short-term vision.

We think there needs to be support of university programs which increase the supply of engineers and managers skilled in manufacturing systems and technologies. And we do feel that making applied technology of commercial significance one goal of the Federal R&D programs would be important.

The second question that was asked related to methods to improve the management and coordination of federally funded R&D. As has been pointed out, the federally funded R&D is about one-half of the national total, a little over $50 billion. Importantly, $8 billion of that supports two-thirds of the Nation's basic research, which other people have pointed out today is very important. Some $18 billion is spent in 700 Federal labs, and those employ about one-sixth of the scientists and engineers in the country. And I think there is concern about the need to improve the effectiveness of the management of those 700 labs.

In general, we see that the current management of the Federal programs is too fragmented to achieve an effective melding of commission goals and industrial competitiveness concerns. And it was for that reason that the commission recommended the consideration of creating a Cabinet-level Department of Science and Tech-

nology to try and transform that fragmented policymaking into better planned programs.

The third question that you asked me was to discuss the government's role in developing and directing R&D towards revitalizing mature industries. And here we feel that a stronger support of universities in the area of technology application is important. We think there could be more sensitivity in the Federal R&D programs to the industrial application of their technology. And on the industry side we should encourage industry to participate in Federal lab programs to get higher utilization of those results.

The fourth and final question was on the type of cooperative efforts that industry, Government, and universities should participate in to promote technology and development. And clearly it is important to have increased interaction among universities, industry, and Federal labs. But I doubt that the Government has a very key role to play in this area except perhaps in reducing the antitrust barriers to such kinds of cooperation; and that has already been done.

Clearly, the Federal labs could play an important role if oriented more toward competitiveness concerns, and the universities should be challenged to play a nucleating role in creating these cooperative programs. The most useful type of interaction is likely to be in the information exchange area, though one must not discount the possible productivity of joint R&D in selected areas.

Overall, I think that the recommendations of the Commission in this area do not involve increased Federal spending. Rather, it is concerned with the better management of existing resources, of getting our technology act together. And we do see that success in this area requires joint action, not just from the Government but from industry and from academia.

Thank you.

Senator GORTON. Doctor, I would like to ask the question which you heard Senator Riegle ask earlier witnesses, and perhaps put a little different spin on it.

To what extent are the recommendations of the Commission interdependent—that is to say, that they are of little value unless all or almost all of them are adopted—and to what extent are they independent—that is to say, that each one of them even taken separately can do something to advance our industrial competitiveness?

Mr. ROSS. Well, clearly, Mr. Chairman, what we found was that this was not a simple problem with a simple single cause or a simple single solution. And for that reason I think your first observation is correct; that many of these are interdependent.

On the other hand, every little bit helps in this arena, and to the extent that you can get some of these things acted on, I think that is important, too.

Senator GORTON. One of the previous witnesses testifying for the administration said that close to 90 percent of the recommendations have either been adopted or at least are under careful study by the administration. Is that something that you find encouraging and impressive, or has the action been too slow to suit you to this point?

Mr. Ross. Well, I am a simple-minded engineer, and I am used to being patient on getting things acted upon. I would like to see more vigorous action, but I understand that there can be matters of higher priority at this point in time. I am hopeful, though, that this will become an issue that will gain more national attention. I think it is an important issue, and I think it needs to be a national priority, and I do not quite yet see it as being a national priority.

Senator GORTON. How high in the order of priorities among the recommendations are the twin recommendations for new Cabinet positions in trade and science and technology? And the other side of that question, at least in science and technology, can you get most of the same results by a strengthening of present Government agencies, OSTP, for example?

Mr. Ross. Well, let me give you our rationale for the suggestion on the Department of Science and Technology; and it is really a rather basic one. We felt, as you pointed out, that technology was the key in the future of industrial competitiveness, and if it is a key, we also recognize that the amount of R&D that we have in the country is about right. It is not excessive, nor is it underfunded. However, this does say that the management of the Federal contribution to that technology is critical to the future of the nation.

It is in that sense that we felt that such an important matter deserves a focus. It deserves to be brought together, and it is in that way that we recommended the consideration of the Department of Science and Technology.

I was less closely associated with the trade issue, but I think again it was a similar concern that international trade is very important to us. The chart that was on page 38 I believe that the Senator pointed out does illustrate that there again is something that is spread across a large number of Government entities, and a focus somehow or other would be important.

Senator GORTON. Can you in Bell draw a fairly precise line between basic and applied research? Can you justify a distinction between funding those two on the part of the Federal Government, and feel that it can be a line drawn accurately?

Mr. Ross. I think you can draw a pretty good line. We tend to look at our basic research, as I think the Government should, as work that is not aimed at a specific product or a specific project, but is aimed at increasing the fund of knowledge in an area that you believe is of importance to your mission. And we believe that your basic research program tends not to pay off in less than 5 years, and you are really dealing with horizons that may go out to 20 years.

In that respect, it is a high-risk program. In that respect it is a program where frequently the people who underwrite it do not get a chance to get total control of the proprietary results that come out of it. Therefore, I think it is something that the Government really must run in the interest of assuring that that base is there, because I do not believe we can expect industry to do much more than it now does. And as you know, some industry invests liberally in research. My own company is spending about a quarter of a billion dollars in what we would call basic research, and there are other big companies that are equally sharing that load.

But I do not believe that you would expect that what is needed to be done in basic research in the Nation could be handled without Government funding.

Senator GORTON. Can you see any positive impact at this relatively early stage in the changes in the antitrust law to protect joint research and development?

Mr. ROSS. Well, there is the activity in Austin, TX, that Admiral Inman is operating. I believe that is permitted to exist because of a change in the antitrust laws. I think that is a good thing. I think we need to test the antitrust laws to see what the proper interpretations are. But I think we have moved ahead and experiments of that kind can now take place.

Senator GORTON. It is not something which Bell is going to use?

Mr. ROSS. We are not a participant in that program.

Senator GORTON. Do you intend to utilize it? Do you have any idea?

Mr. ROSS. We have no immediate intention to do so. I see that kind of program as being more appropriate to companies who cannot afford any above-threshold activity in a given area. In my interpretation of what the Department of Justice has said, that is the kind of thing that they are encouraging.

Senator GORTON. Dr. Ross, again I want to thank you for spending so much of your time, not just here today but the time that you have given to the Commission, and to share Senator Riegle's statement that the report is a magnificent piece of work and one which I hope you will see tangible benefits and tangible changes come from. We appreciate it.

We may ask you a few additional questions in writing which we hope you will respond to as well.

Mr. ROSS. I will be happy to answer them, and I appreciate the opportunity in the interest of supporting this. I think it is a very important program.

Senator GORTON. Great. Thanks.

[The statement follows:]

Statement of Ian M. Ross
President, AT&T Bell Laboratories

Mr. Chairman:

I appreciate the opportunity to appear before your subcommittee to present some views on technology as it relates to industrial competitiveness. This was one of the major topics addressed by the President's Commission on Industrial Competitiveness (PCIC) and was the major focus of the Commission's Research, Development and Manufacturing Committee which I co-chaired with Mark Shepherd, Jr., Chief Executive Officer of Texas Instruments.

In January of this year, the Commission delivered its report "Global Competition - the New Reality" to the President. This report summarized our findings and recommendations not only in the area of technology but also in the areas of capital resources, human resources, and international trade.

The issues that this new reality of global competition have created for our country are both serious and profound. One of the issues addressed by the Commission was the realization that the seriousness of the problems created by global competition were not perceived by the public at large. The Commission concluded, correctly I believe, that we are not in a crisis situation. If we were, it would be easier to galvanize government, industry and the nation at large to take appropriate action. Therefore, a major purpose of the report is to alert the public to our eroding competitive position and to stimulate appropriate action before we do in fact face a crisis. These hearings and similar ones elsewhere in the Congress should be very useful in helping to increase public awareness.

I will not attempt to review the Commission's report since the report itself carefully outlines the competitive position of the United States and makes appropriate recommendations, all of which I support. Instead, I will address the subjects which you identified in your letter to me of April 3, 1985, obviously drawing heavily on the Commission's work in presenting my facts. In addition, I call to your attention Volume II of this report which contains undergirding support for the Commission's recommendations. In particular, you should be interested in the report of the Committee on Research, Development and Manufacturing which is set forth in Volume II, beginning at Page 54.

Before addressing your specific subjects, however, I would like to make some broad observations. These include pointing out two general misconceptions. The first of these relates to the criteria by which many Americans tend to determine our comparative competitiveness position. By virtue of our history and tradition, many people tend to compare our economic situation with Europe and take comfort in the relative success one derives from such a view. This engenders a false and dangerous comparison. We must realize that the major threat to our industrial and economic leadership comes from the pacific rim countries, principally from Japan but increasingly from several of its neighbors who are industrializing rapidly and effectively.

The second misconception, which has been reflected in the comments of some early reviewers of the PCIC Report, is that many of its recommendations have been heard before and, thus, present nothing new. Many of these recommendations are indeed familiar ones. What is new is the seriousness of the situation and the urgency attached to them.

As the Commission examined the causes of our eroding competitiveness and searched for solutions among the major ingredients of a competitiveness position, technology assumed special importance. We realized, for example, that in the area of capital resources, the most that we could hope for vis a vis our major trading partners was parity. Our capital costs are relatively high and our poor exchange rate position is well known. Thus considerable improvement will be needed even to reach parity.

Similarly, in the area of trade policy, parity is the most that we can hope to achieve. Again significant improvement is needed to reach that level. This is because our principles of free trade have yet to be completely reciprocated by some of our major competitors.

Our human resources are particularly valuable and we can hope for a comparative advantage in many areas. However, as we have been made painfully aware in recent years, we must make major improvements in our primary and secondary educational systems, must improve the training and retraining of our workers and must increase the pool of trained scientists and engineers.

This leaves technology as the area with the greatest promise for a comparative advantage. However, as I will discuss further, although we continue to be the world leader in many areas of science, we must improve the translation of that scientific base into products and services that can compete effectively in world markets.

Finally, I would note that, although I am here today primarily to discuss the government's role in technology and in the improvement of our competitiveness position, the Commission addressed many of its recommendations to the private sector -- business, labor and education. It was clear to us that government alone could not resolve our dilemma. All elements of our system must pull together, with the government, of course, playing a major leadership role.

Let me turn now to some specific comments, related to the issues you have raised. And here I will draw heavily on the findings and recommendations of our committee report, which benefited from a year long study of these matters and the contributions of many experts in various fields.

First let me emphasize the vital importance of research as an underlying strength of U.S. industrial competitiveness. While research is relatively well supported by this country, we must be certain that we maintain an adequate level and continuity of research. The reasons for this become clear when one examines the nature and role of research in today's high technology society.

For example, as our Committee pointed out, much of the basic research underlying our technological innovation is a high-risk and long-term endeavor. In contrast to the technologies of earlier times, based largely on invention and simple engineering principles and perhaps later refined and improved with the help of science, today's technologies are essentially dependent on scientific advances. The search for such advances increasingly requires large and more expensive efforts, more interdisciplinary research teams and more complex and costly equipment.

Despite the expense and complexity, vast benefits eventually accrue from basic research. Incremental scientific advances as well as major discoveries -- breakthroughs -- result in new technologies of great commercial leverage. They can spawn entire new industries, as is being done through advances in molecular biology. These technologies can create whole new ranges of products, as was accomplished by polymer chemistry. They can revolutionize other technologies and industries, as the transistor and the laser have.

Research is important to create not only new products but also new industrial processes and manufacturing systems. These can greatly increase industrial productivity, reduce costs, and improve the quality of products. For example, advances in microelectronics are influencing the production of steel, automobiles, and many other manufactured goods. Advances

in biology are influencing the processing and production of foods, pharmaceuticals, and chemicals.

When it comes to basic research we must continue to recognize that our universities remain our greatest assets. They are by far the major performers of basic research, the major portion of which is Federally funded. They are also the principal providers of scientists and engineers, those who work in our industry and Government, and those who remain in academia as researchers or faculty.

U.S. universities have established a singularly effective system of combining research with graduate education, one that attracts large numbers of foreign students, teachers, and researchers. But this great resource is under considerable stress in maintaining its effectiveness. University tuition fees cannot cover the rising cost of research. In important areas such as engineering, many universities suffer a critical shortage of faculty. Research and training equipment rapidly becomes obsolete and needs to be replaced if scientists are to remain at the frontiers of their fields and engineers entering industry are to be capable of using its state-of-the-art tools.

While both Government and industry have increased their support to universities in recent years, this support must continue and must be focused in ways that will improve both the quality and quantity of our scientists and engineers, with the needs in certain fields of engineering being particularly strong today.

In addition to the direct support of research at our universities, we must also be concerned with the level of R&D funding in U.S. industry. Other nation's have financial systems that facilitate the channeling of considerable resources to their industries' R&D. For example, our Japanese competitors' advantage stems in part from unique features of Japan's financial system that allow Japanese firms to succeed with only 1 to 2 percent after-tax profit on sales instead of the 5 to 6 percent that U.S. firms must earn to maintain investor confidence and access to borrowed capital. This difference in acceptable profit margins translates into extra funds available to our Japanese competitors for additional capital investment or research.

We cannot expect to offset advantages of competing systems by looking to them for changes. Instead, a hospitable economic environment should be fostered that will ensure the advancement of our own R&D. Private firms may tend to underinvest in R&D because of their difficulty in reaping the full rewards of innovations, particularly those with wide-ranging applications beyond the companies of origin. Thus it is

a legitimate concern of Government that private spending on R&D be stimulated in order to raise it up to the optimal level.

Under our existing tax system, permanent tax credits are a good way to encourage R&D spending and are far preferable to direct Government funding or other forms of "industrial policy" because they not only provide the funds necessary to improve product and process technology but, at the same time, let the marketplace determine where the money goes. To be the most effective, tax credits should be permanent so as to influence long-range decisionmaking. They should be applied to total R&D spending so as to encourage a steady flow of dollars for research. And they should cover the broad range of accounting expenses commonly defined as R&D, as well as costs incurred in development of equipment and processes required to take a prototype into full-scale production.

Let me turn to another matter related to the country's R&D. As our Committee's analysis shows, we do not as a nation underinvest in total R&D on a comparative basis. But the portion funded by the Federal Government is so large -- nearly 50 percent -- that the extent to which we approach effective R&D parity with our trading partners depends heavily on the extent to which we derive commercial benefits from the federally funded R&D programs.

One problem related to this is that, currently, the Government manages its R&D programs in a variety of largely uncoordinated mission-oriented organizations. There is no effective way to create or to implement policies for developing a technology base that would not only support necessary Government missions but also contribute to industrial competitiveness.

For example, a large fraction of the R&D supported by the Government is done in the relative isolation of more than 700 Federal laboratories, which spend some $18 billion each year and employ one-sixth of the Nation's scientists and engineers. Two recent studies of these facilities -- one by the David Packard panel of the White House Science Council and the other by Peter Grace's Private Sector Survey on Cost Control -- raised serious questions about how effectively that huge investment is benefiting the Nation. Both studies urged that the laboratories take steps to improve their relevance and utility to industrial competitiveness and national defense. These studies also commented on the multiplicity of congressional committees involved in the budget and oversight process for these laboratories.

But the problem of focusing more of the Nation's R&D toward industrial competitiveness is far

broader than that involving the Federal laboratories. As the findings of our PCIC report emphasized, the United States needs to embrace as a fundamental objective the enhancement of industrial competitiveness. A key factor controlling the pace of tomorrow's economic progress will undoubtedly be how well our science and technology base is matched to industry's technological needs. Yet virtually nowhere in the Federal Government is this need for a strong and industrially relevant science and technology base the explicit, high-priority mission it should be in the 1980's. Thus, although our national level of R&D may be adequate, there is a clear need for redirecting and refocusing for better support of industrial activity.

In supporting this contention our PCIC report offered a number of important observations. Let me cite a few.

Even today none of our industrial competitors spends a larger percentage (2.7 percent) of its gross national product (GNP) on R&D, nor do any of them approach the magnitude of our total spending, for R&D -- $110 billion in FY 1985. However, nearly half of this total is spent by the Federal Government for specific missions in such areas as defense, health, space, and energy. In effect, that means only half of the Nation's total R&D spending -- only the nongovernmental portion -- has industrial competitiveness as a primary consideration.

The Government-funded mission-oriented R&D is not a major contributor to industry's ability to innovate and produce. In the years after World War II, the Federal Government stimulated the development of important new commercial technologies such as computers, semiconductors, and commercial jetliners. Today, however, industry has long surpassed the Government as the main source of technological innovation, and the Government has increasingly become a net user, not a provider, of industrial technology.

Largely through its support of university research, the Government's most significant contribution to industrial competitiveness is in basic research. In 1984, two-thirds of the Nation's $11.9 billion, or about $8 billion, of basic research was funded by the Government. Of the R&D funders, however, only the National Science Foundation (NSF) has the explicit objective of maintaining the strength of our R&D base. And NSF accounts for only 18 percent of the Federal basic research budget and for less than 3 percent of all Federal R&D.

Thus, while the United States is the largest supporter of science and technology in the world, a

central feature of that support is the multiplicity of Government roles -- performer, manager, stimulus, funder, and policymaker. Within the Federal Government there is no operational focus for this critical element of our future.

Clearly then, science and technology need a higher level of attention, greater predictability of support, more coherent policies, and better long-range planning to enhance the competitive status of our Nation.

As a result of all these findings our Committee recommended the creation of a Cabinet-level Department of Science and Technology. Such a Department could transform the current, fragmented formulation of policies for science and technology into one that would be more effective in meeting long-term national goals. It would also improve the effectiveness with which Government, industry, and academia interact in the process of researching, developing, and commercializing technology.

By consolidating the major nondefense R&D funders into a Department of Science and Technology, the Government would have a focus for developing and implementing R&D policies better designed to meet the needs of industrial competitiveness. Such a department might also serve the purpose of heightened public awareness of the importance of science and technology.

In recommending a Department of Science and Technology we made no attempt to suggest its organization or structure. And we recognized that this was not the first time such a Department had been proposed. However, we believe that, considering the role of science and technology today in our lives and in the economic strength of the nation, our declining competitiveness position made this an idea whose time had come.

As our Committee examined ways that R&D could be enhanced and focused toward industrial competitiveness, we also recognized the existence of certain disincentives to R&D. We became particularly aware of the need to balance regulation with the needs of industrial competitiveness.

In general, a depressive regulatory climate, one based not only on a multitude of regulations but on regulations that raise uncertainties about entering or continuing an R&D venture, can retard research in a new field. It can hold back the flow of new knowledge and its possible application toward a new technology. It delays and decreases new product development and use. It can put us at a decided disadvantage in competing with other countries where regulation is based on a more sensible and broader risk/benefit outlook, one that allows new products to be brought to market often years ahead of ours.

The Commission recognized that health, safety and environmental regulations played essential roles in protecting workers as well as the public at large. However, improper or ineffective regulation can and in some areas has come to have a significant inhibiting effect on technological innovation. A considerable body of literature confirms the inhibiting effects of over regulation on innovation. In newer industries like biotechnology and medical devices, this impact is likely to prevent American industry from realizing its full potential. In industries like chemicals, pharmaceuticals, and pesticides, the negative impact on R&D is already well documented. Ultimately, the issue is not whether such regulations should exist. There benefits are clear, and the public and the Committee support the concept of regulation. However, there are many unnecessary or unintended regulatory constraints on R&D that should be eliminated.

The Committee published a special report discussing in detail the need for vigorous scrutiny of such regulations. This was the basis for a major recommendation that existing regulations should be reexamined and the full consequences of proposed regulations carefully examined to assure that safety concerns are balanced with the needs for innovation and industrial competitiveness. This issue should be placed high on the national agenda in 1985.

If the U.S. is to excel in technological innovation and industrial competitiveness, it must not only pay attention to its investment in R&D but to the application of their results. It must be able to capture and capitalize on its research rapidly and fully. In particular, our industry must do a better job in commercializing new technologies through improved manufacturing. As our PCIC report stated, the United States has not been doing this as well as some of its competitors. While we have long been a leader in research, as our domination in achieving Nobel Prizes indicates, many industries have not performed well in translating research results into competitive products for international markets.

In a world where the publication of research results and the transfer of technology takes place so quickly and widely, our R&D must be more rapidly translated into marketable technologies. To do this, we must facilitate the dissemination of research results among our industries and encourage rapid product development.

To be first in capturing research results, industry and universities must have a closer relationship. The success of such a relationship depends largely on industry's own research capability to prime

its receptivity to new research results and to be able to work constructively with university researchers. It also depends on the university's understanding of industry's needs and a familiarity with the specific problems of production. Both need to combine forces in translating new fundamental knowledge and ideas into technologically feasible, efficiently manufacturable, and economically competitive products and services.

Improved application of R&D in the United States also depends on improved private sector management of innovation. Industries and firms require knowledgeable and imaginative managers with the background and vision to recognize how basic scientific and engineering capabilities can be related to public needs. Industry must improve its role in the diffusion of new technology and its transfer to potential users.

As a result of quarterly earnings pressures, some American corporate management has tended to focus on short-term profits at the expense of long-term vision. Manufacturing has been neglected as a strategic objective. And there appears to be a lack of recognition that technology can, and should, be managed as any other critical resource.

In particular, attention should be paid to the total innovation process from R&D through manufacturing. The disciplines of R&D must be brought into the factory and the entire manufacturing process, using a total systems approach.

I believe that much of this is finally being recognized by U.S. industry today, and that we are seeing evidence of many companies moving in these directions. Also we are beginning to see activities, such as the creation of the first NSF-funded university-industry engineering research centers, that indicate a new movement toward focusing university resources toward the needs of industry, including manufacturing.

Finally, our PCIC R&D and Manufacturing Committee emphasized that, given the importance of technological innovation, it is not enough to simply nurture creativity and even apply it effectively. We must safeguard our innovations through the adequate protection of intellectual property rights at home and abroad. Such protection encourages new product and process development in both high-technology and basic industries.

To an alarming degree, intellectual property rights have already begun to erode. This is a result of problems that include inadequate or nonexistent patent protection, rampant commercial counterfeiting, copyright and design infringements, and improper use of the Freedom

of Information Act. Increasingly, American firms are being denied the benefits of their own inventions.

As intellectual property and innovation have become ever more complex and varied, our U.S. system often responds too slowly to the newest ideas and greatest advances in knowledge, such as biotechnology and semiconductor chips. We must not only rethink our entire body of intellectual property law, but move quickly and immediately to improve the present system to afford full protection to all forms of intellectual property. Therefore, to enhance U.S. industrial competitiveness, the PCIC recommended that the U.S. Government make the strengthening of intellectual property rights at home and abroad a priority item on the Nation's policy agenda and, together with industry, commit itself to implementing this goal.

Mr. Chairman, as your letter inviting me to testify requested, I have reviewed many of the matters related to this country's creation, application and protection of technological innovation, as examined by and reported on by the President's Commission on Industrial Competitiveness. As I stated at the outset of my testimony, the issues surrounding our industrial competitiveness are both serious and profound. I believe that the Commission addressed those issues in great depth, with much expertise and with a great sense of urgency. I also believe that our findings bring to light matters that this nation must confront and deal with forthrightly; and that our recommendations for dealing with them are sound, feasible and actionable. I hope that the member of this subcommittee and of the Congress agree. And I hope that the Congress, the Administration and the various sectors of the public to which our report is addressed will find it a useful and effective guide to this nation's global competitiveness.

Senator GORTON. Dr. Branscomb and Mr. Berlin.

Dr. Branscomb, we will start with you, and I will say to each of you, as I have to the others, that your written testimony will be included in the record. At this point we would appreciate it being summarized.

STATEMENTS OF DR. LEWIS BRANSCOMB, VICE PRESIDENT AND CHIEF SCIENTIST, IBM CORP.; AND F. BRETT BERLIN, ADVISORY BOARD MEMBER, NATIONAL COALITION FOR SCIENCE AND TECHNOLOGY

Mr. BRANSCOMB. Thank you very much, Senator.

The Federal role in technology promotion has both economic, human resource, and knowledge aspects. The economic policy is essentially, in fact I think today almost dominant, but it is not sufficient. The Government must bring expenditures and revenues into balance to close the trade gap, get the dollar back with the right kind of value, and increase private sector access to capital markets.

And I am not today going to suggest that the Congress ought to increase appropriations in order to fund activities, for example,

under the Stevenson-Wydler Act, that have not so far been funded, because I think we must put the priority in getting the economic house in order.

But the economic issue is a hopefully short-term issue. The technological capability of the country is a long-term issue, and therefore I think it is appropriate for us to talk about how the Government can help. I think the Government not only can, but must, help in science, engineering, and human resources if we are going to be competitive.

I think it is difficult for the Congress to provide long-term strategic help that industry will welcome, instead of the quick fixes that in some sense try to legislate competitive outcomes. In my prepared testimony I call attention to several provisions of the Stevenson-Wydler amendments that have been proposed in H.R. 1572 which are of this character, in my opinion. They try to legislate against undesired outcomes of a process that seeks to deal with the competitive commercial sector.

I think this illustrates why people in industry are often reluctant to encourage Federal action to help the private sector be more competitive. In fact, the Stevenson-Wydler Act itself illustrates this problem, and that's one reason why I have discussed it frequently in various places, for I think it is a useful mechanism for discussion of the principles.

My position on the Stevenson-Wydler Act is that its stated intent and the language that is used to describe the authorized programs, language like "centers for industrial technology" or "national industrial technology board," convey just the wrong notion of the Government's role. The words smack of central planning, of a MITI for America.

And yet the programs that are authorized in the act could be carried out in a way that would be entirely welcomed by the private sector. And in fact, proof of that is that the National Science Foundation, which is covered by the act, does carry out programs of industry-university cooperative projects and these are entirely welcome and very successful.

They do not engage in proprietary research, they do not develop commercial products. They do provide research-experienced graduate students in fields of great interest to industry and personal contact with technical people from industry who are assigned to the university laboratory.

They are not a conduit of Government funds to subsidize one company against another. The funds go to the university and provide resources to equip the university with skills and facilities in the scientific areas of interest to a broad base of industry, thus attracting industry's collaboration.

The National Industrial Technology Board and Centers for Industrial Technology are not a correct description of what I have just described. I do not understand why the Commerce Department cannot usefully share with the Science Foundation this kind of activity.

So it seems to me that it would make sense to consider extending the act, providing it is modified to eliminate the National Industrial Technology Board and to change the name of the centers to something more like the NSF name, "Centers for University-Indus-

try Cooperation," and to focus the act on the role of universities in voluntary cooperation with the private sector and perhaps also on an expanded role for the national laboratories in such collaboration.

I think the Department of Commerce should play its proper role, consistent with its mission, in support of the scientific base in our universities, on which industry so critically depends. And I am sorry to see the Department of Commerce playing down its need for technical competence, an activity which has been a consistent picture as I have seen it from the outside.

It is only fair for me to ask myself the question, why should the Department of Commerce play a direct role in the support of scientific and engineering activities? For example, why should education and research not be left to the Science Foundation or left to industry?

Let me first answer, why it should not be left to industry alone, for industry can and indeed does help. I think many people do not realize that industry spends in the aggregate over $1 billion on in-house training and education of its own people. That is a total investment as almost as large as what we spend on K through 12 education in this country.

The IBM company invests close to $60 million annually in U.S. higher education through corporate contributions alone, and in addition we have had since 1980 more than 1,100 cooperative projects with over 200 U.S. universities in which our scientists and engineers and those from universities worked together toward mutual ends.

And we have specifically begun, back in 1983, a competitive grants program of $50 million in manufacturing systems engineering education and research. Another program, at the $25 million level, on managing information systems; another one in process now, about $25 million in fundamental material science and engineering, of which the ceramics mentioned earlier are an example, again, for areas picked to be relevant to the microelectronics industry. We initiated a young faculty development grant program before the NSF did and we fund over 200 predoctoral fellowships in leading departments in American universities.

Industry can move quickly, we can initiate things, we can help universities get started. But I would remind you that 172 universities responded to our request for proposals on this manufacturing systems engineering grants. We funded only 22 of the 172. Many of the other universities have written us saying: We are sorry we did not win, but we are grateful to you because you have called attention to this area. We are going to do the program anyway. We are out looking for money.

And even the ones we fund, we are funding on an initiation basis, with a declining investment over a period of a few years. If you look at the aggregate numbers of industry support of university research, you will find that it is unreasonable to expect industry to support more than maybe 10 percent of university research directly.

Industrial support is a very important source of academic research investment. It could be expanded with participation of more

middle-sized companies if the universities' activities in engineering were more relevant to the interests of those companies.

But industry cannot do the job alone; the predominent source of support for university research must come from Federal agencies. Now, the Department of Commerce should participate for two reasons in my view. One is the traditional pluralistic strategy in which every agency of Government is expected to invest in the knowledge and human resources at a high professional level that are critical to the mission of that agency.

We refer to these as mission-oriented agencies. I submit that the Commerce Department is also a mission-oriented agency, its mission being to concern itself with the well-being of our competitive free enterprise economy. To the extent that that calls for Federal investments in science, then it seems to me that the Department of Commerce's participation emphasizing those fields of research of special interest to commercial industry would help bring balance to the areas of research interest of universities, for that is largely determined by the sources of funding that are available.

I am not speaking now about doing applied or development work. I am simply saying that in the distribution of effort among fields, there are fields that are popular in defense circles, there are other fields that are popular in commercial circles, and this should have its proper balance.

The other reason, of course, is that the Commerce Department has a superb institution in the National Bureau of Standards. It is very helpful to industry. It is there largely to serve industry, and the skills and experience of those people could be very helpful in managing a program of this type.

Finally, if the Commerce Department is itself involved in the support of the kind of research and educational investments that are appropriate for the Federal Government to make as as a help to industry, the sensitivity of the Commerce Department to industrial needs will cause it to help prevent Government from funding the wrong kinds of things and attempting to micromanage the private sector or to direct the private sector's research strategy.

The National Science Foundation has undertaken a very important effort to modernize and rebuild academic engineering through new engineering initiatives, and I was very much involved in the creation of that program. This NSF program will achieve some of the purposes of the very interesting manufacturing automation bill you introduced in the last congress, which I personally supported.

But the NSF must give top priority to the fundamentals of science and math upon which all technical activity in this country rests, and must help ensure U.S. science leadership. In this role, there really is not an appreciable industrial participation. It is an almost unique role.

So let me close by just asking, what are the strategic alternatives for carrying out this kind of research investment of the sort described in the Commission report? Well, the Commission came up with its recommendation and it was the Department of Trade and the Department of Science and Technology.

Those two proposals are coupled. That is, the one does not make sense without the other. The reason I say that is because the Department of Trade, rather like the idea of the Department of Inter-

national Trade and Industry that was discussed by the Congress last year, would involve the Commerce Department focusing on trade, not on technology, and would be consistent with the Department's view that it could divest the Bureau of Standards and NOAA and some other technical agencies without damaging its trade role. That may well be true.

But if it is true, then somewhere else in the Government the responsibility must be accepted for being knowledgeable on industrial, commercial technology, for making the appropriate kinds of fundamental research and educational investments that will further our competitiveness interests.

A Department of Trade implies a Department of Science and Technology or an agency such as the National Science Foundation, which broadens its mission explicitly to include the very kinds of technical concerns covered in the Young Commission report. The NSF would have to cover the materials science and engineering, metrology, instrumentation, systems engineering, robotics, and other activities which today play a very modest role in the National Science Foundation.

That would not be an easy task, for the scientific community would say this would be a terrible thing to do if we sacrificed our scientific leadership in the course of readjusting the budget to cover industrially interesting research that should be supported by the Department of Commerce.

For that reason, I would have to differ a little bit with my friend Ian Ross in the notion of whether or not there is enough money being spent on university research. I believe there is not. I believe there must be, in the future, a further development of the fundamental sciences of great interest to industry and the engineering that goes with it.

We cannot afford to do that right now, but I believe in the future we will. The only alternative is to evolve from our present structure. That means the National Science Foundation trying to build its academic engineering program through careful steps. It will get good priority, but it will take a long time to build a significant NSF engineering program, given the budget constraints. That implies to me that the Commerce Department should not renounce its role in this area.

Finally, let me say, to use a sports analogy, that our players are at least as talented as the other team's are, but I think it is time to forget about trick plays, booing the other teams, and jiggering the rules. What we need to do is to start building muscle, running wind sprints, improve the farm club—which is the educational system—and watch the clock and the score. And I think we already have enough coaches.

Thank you.

[The statement follows:]

STATEMENT OF DR. L. M. BRANSCOMB

My name is Lewis Branscomb, Vice President and Chief Scientist of the IBM Corporation. I am pleased to be invited to testify on the extension of the Stevenson--Wydler Act. I have three areas of experience on which to base my views:

1. my responsibility for guiding IBM's scientific and technological activities to insure they meet the Company's strategic needs;

2. my four-years experience (1980-84) as Chairman of the National Science Board, under whose policies NSF carries out, quite successfully, its responsibilities under Stevenson-Wydler; and

3. my former service (1951-1972) as a staff member and later Director of the National Bureau of Standards, which provides the Commerce Department its primary capability in scientific matters of interest to private industry.

I am eager to see this nation use its entrepreneurial and technical capabilities to stay internationally competitive. The innovative capacity of America's private sector was honored by the President's award of twelve National Technology Medals last month. Of these distinguished engineers honored for the development of the IBM 360 family of computers, one is now in business, one in a university and one in government--the Director of our National Science Foundation. Our U.S. economy works because of its flexibility and its people. If the Stevenson-Wydler Act sticks to these principles, it can be useful and should be revised and extended. One of the useful accomplishments of the Stevenson-Wydler Act -- let me note -- is its provision for these Presidentisl and Technology Medals. I am equally eager to see the government play a helpful, not a disruptive role.

The Administration has been correctly skeptical of many of the nostrums for making the country more competitive through federal programs under the heading "industrial policy." As I have testified many times, however earnest our government agencies may be to try their hand at judging marketplace opportunities, making commercial technical strategies, and managing programs intended to influence commercial product development, the temptation to do so must be resisted.

I know it is frustrating for government officials and members of Congress to watch private concerns struggling in the competitive arena, often these days against foreign firms with impressive, even superior technology, without intervening in the process. It takes even more levelheadedness to resist pressures for restrictive trade practices to protect our weaker sectors while they struggle to be more competitive.

But if government is going to help, it must provide real help, effective help. Identifying what constitutes real help requires a deep understanding of the interplay between the challenge and reward of competition, and the dependence of competitiveness on the base of scientific and technical skills in our country on which private companies can draw.

Those of us experienced in the most technically complex sectors of commercial business do not oppose industrial policy proposals because we believe government has no business being concerned about the competitive performance of private industry; you have every reason to be concerned.

We solicit your concern to focus on the areas where government not only can help, but must help. These are in the areas of economic and fiscal policy and in the provision of educational and scientific infrastructures so vital to competitiveness.

My position on the Stevenson-Wydler Act is that its stated intent, and the language used to describe the authorized programs-- "Centers for Industrial Technology" and "National Industrial Technology Board" for examples - convey just the wrong notion of the government's role. The words smack of central planning, of a MITI for Americans. And yet, the programs themselves could be carried out in a way that would be entirely welcome by the private sector. The proof of that is the success of the NSF in the operation of its University/Industry cooperation projects.

These NSF projects do not engage in proprietary research; they do not develop commercial products; they do provide research experience for graduate students in fields of great interest to industry and personal contact with technical people from industry on assignment to the university laboratory. They are not a conduit for government funds to subsidize one company against another. The funds go to the university, and provide resources to equip the university with skills and facilities in the scientific areas of greatest interest to a broad base of industry, thus attracting industry's collaboration.

There is no reason -- other than the troublesome language of the Act -- why the Commerce Department cannot usefully share with NSF this kind of activity. Indeed, the Commerce Department's greater experience in working with industry, and its fine staff at NBS, a great many of whom have worked in industry, is -- or should be -- in a better position to set scientific priorities from an economic perspective than is NSF. And, if the Department wants to avoid the overhead expense of operating a university grants program of this kind, it could ask NBS or NSF to do it for them, once program priorities have been set.

Thus, I am proposing the Act be extended with revisions to alter the policy language, change the names of the Centers, eliminate the National Industrial Technology Board and focus on the role of universities in voluntary cooperation with the private sector. The Department of Commerce should play its proper part, consistent with its mission, in the support of the scientific base in our universities on which industry so critically depends.

Now, I must at this point quickly add that I could not support a major appropriation for FY86, certainly nothing approaching the $74M authorized for FY85 in the original Act, while the federal budget remains so dangerously out of balance. My company feels very strongly that nothing imperils our competitiveness like the bloated trade deficit, the overpriced dollar, the threat of high interest rates and a resurgence of inflation from this intolerable public indebtedness we are incurring. The Congress must look to restrain the growth of all sectors: entitlements, military and domestic spending, and must, if necessary, find additional resources to close the yawning gap.

But I have to believe that when the President and the Congress understand how strongly the business community and the public feel about this, political leadership will be shown and action to close the gap will be taken. At that point we must be ready with carefully planned, affordable investments in our longer term future competitiveness.

In view of the programs in the NSF and the private sector's interest in help from the universities, you might ask why will additional resources be needed to help universities foster cooperation with commercial companies?

First, because a technical revolution is sweeping over the development, design and production engineering functions, and the universities are not able to keep up with it, much less lead it, as they should. Much of this revolution involves new information technology, and its focus is not so much increasing the productivity of manufacturing labor as it is speeding up a company's ability to respond to a market opportunity or a competitive challenge. Computers now play a critical role in supporting engineers, to tie the functions of development, design and production into a single creative process.

It was for this reason that IBM in 1983 offered over $50M in grants of money and equipment to schools of engineering who wanted to modernize their curricula and their research programs in manufacturing systems engineering. We were surprised, but very pleased, when over 170 schools applied. We made 22 awards in response to fine proposals, and many of the disappointed schools thanked us for the stimulation of this program and said they were going to proceed anyway as soon as they found other sources of funding.

Doesn't this indicate that industry can and will find the needed activities at universities, and Stevenson-Wydler is not needed? I would hope that many other companies will join with us in this kind of activity. Indeed, we have also launched a program in materials science of import to microelectronics. What all private industry can do, even a large and generous company like IBM, is to initiate such activities. Our Manufacturing Systems Engineering Program was funded for 5 years, with the funds available to the university declining in the later years. The 22 schools who won awards will have to find new funds to replace ours and grow their programs. All the other deserving schools will be looking for support.

The President has recognized the importance of this, and related, revolutions in engineering research and education, for one of the important Presidential initiatives in the FY85 budget was for the NSF Engineering Research Centers. $9.4 million was appropriated and the first 6 grants have been made. But so many requests from engineering schools were made, that the total was $2B.

Because the NSF must place its first priority on the support of the most fundamental science, it is unreasonable to expect that the needs of the economy can be fully reflected in federal R&D priorities through the NSF engineering program alone. When one looks at the total federal investment in research, it is clear that the priorities are, in order: defense, space, energy, health, and fundamental science. These programs all contribute something to the technology base for a competitive civil economy, but they also compete for scarce technical talent and bid up its cost. We need a national science policy that places a balanced emphasis on the needs of the civil economy for a strong scientific base.

The distinguished Director of the NSF, Mr. Erich Bloch, has defended the initiatives in the NSF 1986 budget as aimed at a long-range investment in the nation's competitiveness. Indeed, it is just that, and I hope the President's budget for NSF will be supported by the Senate. But NSF is responsible for 27% of the Federal support for basic research in our universities. It cannot give prime weight to research areas of strategic commercial interest.

The priorities in the federal R&D budget are determined by the summation of all the budgets of the departments, plus the independent technical agencies such as NSF. The economy is poorly represented in the funding distributions for different fields of research because the Department of Commerce has failed, over many years, to accept responsibility for representing the interests of industry in the science priorities debate. A revised Stevenson-Wydler Act could be a tool to redress that deficiency.

There is one more reason why the Department of Commerce should not shun its role in support of the nation's professional skill and research base. Middle-sized firms are not participating in the resurgent university-industry cooperation to the extent large and small firms do.

Where the universities have the resource to permit collaboration as equals with companies, and the companies share the academics' interests, the relationship seems to thrive. But with today's pattern of funding, this tends to restrict the activity toward those companies with large corporate research laboratories, specifically designed to take advantage of university research.

Thousands of intermediate-sized firms that do not pursue scientific research are nevertheless engaged in product and process innovation. They are determined to use the latest technology to be competitive. They should be able to benefit from collaboration with their local university, especially its school of engineering. But those schools of engineering are focused on preparing engineers for careers in R&D, not in design for manufacturing, manufacturing systems engineering, quality assurance engineering and other areas vital to industrial success and to a modern engineering education.

Thus, a properly run Stevenson-Wydler Act program, focussing on academic engineering, could benefit thousands of firms that are poorly served by today's academic enterprise.

Finally, let me make a comment about the proposals, in H.R.1572 and S.56, to give national laboratories more flexibility to work with industry. That is certainly a reasonable objective. The labs have a multidisciplinary, problem-solving orientation, often with facilities superior to those enjoyed by the universities. And the cooperative agreement is the correct contractual device for documenting the obligations in such relationships.

But the bills, as I read them, seem to expect too much to come from government-owned patents and seem to undervalue the laboratories as a place for collegial, non-proprietary, public domain research and post-doctoral training.

I agree that the agencies need more flexibility to negotiate licensing arrangements for Federally-owned intellectual property. And I sympathize with the desire to reward federal employee inventors for their ideas. But I doubt that government laboratories pursuing their proper missions will prove any more fruitful of commercially-valuable inventions in the future than they have in the past. And, you certainly don't want to build in legislative incentives for federal employees to divert publicly committed resources to projects motivated by personal gain. I was a civil service scientist for 21 happy and fruitful years. I wanted to be treated fairly, but I was not in government service for personal gain.

The Senate Bill S.65 is a simple bill, whose only problematic point is this matter of how federal employees, whose patents are licensed, are rewarded. But H.R.1572, which is introduced as an amendment to the Stevenson-Wydler Act, is encumbered with a number of restrictions that I feel would reduce to near zero any benefits that might otherwise have been obtained.

You cannot expect sell licenses on patents which restrict where products embodying technology covered by that license are manufactured. In many cases one does not know, without litigation, whether a particular patent may be involved.

The idea of giving small business first shot at opportunities for licensing is understandable, but these opportunities are expected to arise out of collaborations in technical work. No one will know, when the collaboration starts, whether any patents will result. Nor do I think it appropriate for national laboratories to use public funds for the intended purpose of developing patentable commercial products and processes, even though that might be the unintended by-product of a cooperative agreement for non-proprietary research of general interest.

Finally, to make an agreement concerning unclassified research vulnerable to nullification by any intelligence agency without fair process and compensation to law-abiding U.S. enterprises, would surely discourage any firm not already discouraged by other restrictions in H.R.1572.

There is entirely too much emphasis in this country today on the idea that restraints on the diffusion of scientific ideas is a good way to insure that only Americans benefit. In too many cases, it only insures that no one benefits, and U.S. research gets more deeply mired in red tape.

I appreciate that H.R.1572 is not before this Committee, and S.65 was referred to Judiciary, but I wanted to call attention to the difficulty of designing legislation to help industry be more technologically competitive without legislating the outcome of every technical transaction.

Science and engineering are powerful tools for economic progress, in the aggregate, of enormous value. But each effort taken separately is highly risky, and when embodied in an entrepreneurial effort, technical risk and market risk are multiplied together. I urge the Senate to restrict its legislative action to investing in the basic scientific and educational strength of the country and a healthy economic environment. Then rely on a competitive business environment and creative people to make the sparks fly. Some of those sparks might fizzle, or even help a competitor. But the fire they build in the economy of this country will brighten the prospects for Americans now and in the future.

Thank you for your patience.

Senator GORTON. Thank you, doctor.

Mr. Berlin.

Mr. BERLIN. Mr. Chairman, first let me apologize on behalf of NCST. My written testimony is not here. I had some written testimony until 8 o'clock this morning and I got involved with a little technology innovation when I decided to do my testimony on a personal computer using the paperless office concept, and I now have neither paper nor testimony.

But I have assured your staff that we will send testimony up later. We will reconstruct it. My computer experts assured me that they have found those bits somewhere on the disk.

But in the meantime, I would like to make just a few comments which are just some of the salient points of what we have to say, and I will organize them into three basic sections.

First of all, we believe there is an inherent role in Federal innovation, and in order to understand the Stevenson-Wydler Act and other such initiatives and put them in context, I think we need to decide what the inherent role is.

Second, a few comments about Stevenson-Wydler and some of our feelings about its proposed future directions and third, some final observations.

Now, the inherent role of the Federal Government in technology transfer and innovation, I believe, comes from three fundamental properties of the Federal Government. The first is a mission organization orientation. The preceding speaker referred to the Commerce Department and others as being a mission agencies, and I believe that direct sponsorship of innovation in order to meet specific short-term mission needs is probably one of the most fundamental ways that the Federal Government is involved in technology innovation.

I think the space program is a classic example of that. The Space Program resulted in probably more technology innovation in this country during a short period of time than we ever would have seen otherwise. But it is important to observe that the space program was not a program for technology innovation. It was a program to meet a need. We had an objective and a problem to solve, and we set out to solve it, and that was the Federal role. The private sector role and the university sector role then was to figure out innovative ways of meeting that need.

I believe today, regardless of what one's politics are, the strategic defense initiative is an excellent example from a defense point of view of something that could become, at least for the first 4 years—I am not talking about implementation—that kind of a program.

The problems to be solved are all fundamental problems that are needed to be solved by lots of industries. The approach that General Abramson happens to be taking, which is an unusual approach, is to work with universities and to work with industry in a very innovative way.

The space station could very well be another of that type. And once again we are not taking a position on whether those programs should be funded, but I think it points to the role that the Federal Government has.

And I think there are some other examples which are excellent programs, for example the Small Business Innovative Research

Program. And the important thing about that is it is not a basic research program; it is a program where mission needs are identified and innovative research is contracted against certain mission needs. It is very different from what the Office for Scientific Research, for example, in the Air Force does, where they go to basic research.

The second inherent Federal role is the indirect sponsorship of technology innovation via developing long-term a technology base. We are in complete agreement with Dr. Branscomb on the fundamental nature of that investment. It is something that the corporate sector cannot do.

The university community, of course, is a public sector operation, and we always have to remember that. Whether it is Federal public sector or State public sector, it is nonetheless public sector. And so the role that the NSF and similar agencies, like the Department of Energy the Air Force Office of Scientific Research, Naval Research Laboratory, and the Army Research Organization, has is a significant basic research role.

And I think it is important, by the way, to include those defense agencies, because they are funding very basic research. It is not mission-oriented research. It just happens to be that the mechanism for funding that basic research is through those organizations. They use the peer review process, as NSF does, and a number of other similarities, and they do cooperate quite extensively with their NSF and DOE counterparts.

So I think that developing a technology base is a fundamental role that nobody else can meet, and we have to put our resources there. And in times of scarce resources, we at NCST believe that that is a fundamental priority. It is the seed corn problem.

Now, the third inherent Federal role that we see is the economic sponsorship of technology innovation by building and creating an environment where an entrepreneurial activity will grow. The President's Commission made several recommendatiojs concerning such things as the R&D tax credits, intellectual property rights, capital formation. These are very fundamental.

And I think we have to understand at the bottom line that we can have perfect technology-based programs, we can have perfect transfer programs, we can have perfect university research programs, but if we do not have a fundamental climate for entrepreurial innovation we will not be competitive.

We cannot try to copy the Japanese or copy any other model, because it is not our model. Our model is the free enterprise system and the entrepreneurial venture process, and we have seen again and again that our ability to transfer information and technology and to commercialize it is totally dependent upon that climate.

So I think obviously some of these things are not in the direct purview of this committee, but they must be articulated as fundamental to our process. And that is something that can be done today, because they are not big revenue items for the most part.

And I think realistically, as Dr. Branscomb mentioned, we all realize this is not the year to propose big new spending, pragmatically speaking. But we can do something structurally, and we believe we must do something structurally.

Now, concerning the Stevenson-Wydler Act, we have a couple of perspectives which are similar to what other speakers have said today, so I will not go into a lot of detail, other than to say that we believe the act's purposes were very important and are and remain very important, and I think it would be a shame to just throw it out.

I agree with Dr. Branscomb that some of the language gives the wrong impression and there should be some changes like that. But I think we need to preserve the momentum and the consciousness that has been set out by that Act and similar amendments to it in acts like your own, for example, that was mentioned earlier today.

I think there have been some successes. One of the successes actually was the recognition by the Department of Commerce that the spirit of the act did promote the kind of activities, such as the R&D limited partnerships and other things that they included in their status report. I think that is an indication of success of the way the Act was written, and we would like to see that continue.

I will just share one story from yesterday. Yesterday I had a visit from the president of an organization called New Mexico Tech-Net. Now, I do not know if you are familiar with that, but it is an organization that is promoting the connection of laboratories, universities, and the private sector with a large network, computer network, in New Mexico.

The most interesting thing about Tech-Net is that it was made possible because of the spirit of Stevenson-Wydler. They are using some grants from the Department of Energy. They are not grants that are directly connected with the bill. However, Stevenson-Wydler provided the bureaucratic nod that allowed a bureaucrats in Washington to say, well, I guess that is something we should allow them to do.

And it allowed the laboratory then to do something that was in their interest, to begin interaction with universities in a more direct way, and which was in New Mexico's interests and certainly in all of our interests in terms of industrial competitiveness in New Mexico.

So I think that that kind of example, that is the exciting kind of thing that is happening out there where we see this kind of partnership.

Now, finally just a few perspectives on this process of innovation. I come from a company named Cray Research, which you are very familiar with, I know. And we believe that we know a little bit about now technology innovation happens, and yet within Cray Research we have had a number of discussions about the problems of how do we get information from one person to another and from the outside to the inside.

And we have discovered a couple of things. First of all, the only way you transfer technology is when two people sit over a cup of coffee and start talking and listening, and then they discover that they each have a problem and they each have a solution.

And the solution usually is not the solution—the person who has the solution usually does not realize he has the solution to the other man's problem, because it is a different kind of problem. It is a lateral thinking kind of issue.

We can promote that kind of interaction via such things as personnel exchanges, via giving the freedom at the Federal laboratory level to interact with scientists. Los Alamos Laboratory, for example, wanted to provide some of its computer expertise and some of the usage of its computer to the outside community. They had everything put together. They were going to work with NSF. And then they were told that they could not do it by Department of Energy headquarters.

I think that was a very unfortunate thing. It was unfortunate because that is the kind of technology transfer that really makes commercialization and innovation possible.

Finally, there are few things such as patent rights and intellectual property. Those have been addressed quite adequately, and we feel those are very important.

So in conclusion, I think the most important lesson of what's been happening in the last several years is that we need to have a governmental structure that is able to listen and understand what they are hearing, and then to respond based upon what they really heard, not on what they think the needs were before they started listening.

Seymour Cray rarely asks questions of the outside world, but when he does, people listen and they give him answers that he needs, and then he goes back and he develops the world's most powerful computers. And I would like to see that kind of an interaction happening, and I have seen it happen.

[The statement follows:]

STATEMENT OF F. BRETT BERLIN, CHAIRMAN, NCST EDUCATION FOUNDATION

Mr. Chairman and members of this distinguished committee, I am Brett Berlin, chairman of the board of the recently chartered National Coalition for Science and Technology (NCST) Education Foundation and a member of the NCST advisory board. NCST is a broad and growing non-partisan non-profit coalition which seeks to develop and promote policies that will help secure the research and development, education, capital, and organization infrastructure needed to sustain long-term U.S. excellence in science, engineering, and technology. NCST members include research scientists, engineers, educators, corporate representatives, and other citizens as well as corporations.

Thank you for this opportunity to deliver NCST views on the proper role of the Federal Government in promoting and facilitating the technology innovation essential to maintaining America's industrial competitiveness. We of NCST share your commitment to identifying and implementing a set of policies that can both maximize the opportunities that Federal resources can provide while minimizing the subtle, and often very harmful negative effects that tend to accompany quick fixes and "obvious" solutions. We also recognize the fiscal realities posed by the large budget deficit and are committed to helping the committee in any way we can in its task of ensuring that whatever funding is recommended for technology innovation programs are carefully reviewed to ensure maximum leverage of scarce taxpayer dollars. Finally, looking beyond this year's deficit to the future, we strongly support aggressive leadership and funding of the heartbeat of America's future industrial competitiveness: broad based research and development and pragmatic cooperation between federal laboratories, universities and the entreprenureal private sector.

TESTIMONY OVERVIEW

The specific objective of this testimony, as requested by the committee, is to address issues and to make recommendations relevant to the potential reauthorization of the Stevenson-Wydler innovation act of 1980. In support of the objective, we have chosen to comment in three broad areas. First, we discuss the inherent roles which we believe that the federal government has in the technology innovation process. By "inherent", we mean that there are certain roles that the government has regard-

less of what legislation emanates from this or similar deliberations. These roles form a natural basis for policy that can leverage current federal research dollars into major investments in America's industrial future. The Nation must move aggressively in these fronts as a first step to any innovation policy; NCST believes there is a national consensus to do so.

In the second section of our testimony, we discuss some of the details of the act and make some recommendations concerning its reauthorization. We believe that the act is making a contribution and should become the basis for follow-on legislation which can keep the momentum going. The act has helped focus attention upon the need for an environment conducive to technology transfer, innovation, and commercialization. It has also provided an "umbrella" for some activities that, while not specifically mandated by the act, were in the spirit of the act and made sense. The next step needs to continue in these directions. Furthermore, while major new funding is unlikely this year, the role of the Department of Commerce as the leading agency for Government policy in support of American technology innovation needs to be supported.

Finally, we suggest some initiatives that might help the process intended by the act but which may require other legislation action to accomplish.

INHERENT FEDERAL ROLE IN TECHNOLOGY INNOVATION

The Stevenson-Wydler Act provided for a number of special programs by which the Federal Government might enhance its role of encouraging innovation and commercialization. These types of programs will be discussed in more detail in the next section of this testimony. However, before even considering the act and related initiatives, it is critical that we pause to put the act within the broader context of the total Federal role. The Federal Government has three major "inherent" roles in fostering technology innovation.

1. Sponsor innovation to meet mission requirements

The first, and most direct role, is the "sponsorship" of innovation and commercialization in order to meet defined mission requirements. The space program was a prime example. The purpose of that program was to put a man on the moon, not to spawn innovation. But the result was a massive resurgence of innovation that changed the face of our nation and the world.

While certainly controversial for many political and significant reasons, the strategic defense initiative and the space station programs, could be key innovation drivers for the next decade. Both programs require substantial basic research and innovation which will be useful across a broad spectrum of applications. Both are also long term in nature and are focused on a mission, rather than a technology objective. Both will heavily utilize some of our most valuable talent—university based researchers—and will tend to bring them naturally together with industry and Federal laboratories. And finally, both will result in essentially "open" research. (I should state at this point that this discussion does not imply that NCST is taking a political position on these two programs. As would be expected, our membership has widely dispersed views, and many legitimate concerns as to the impact these programs could have. What we are pointing out, however, is that these programs are excellent examples of the potential power of the Federal role in sponsoring innovation to meet specific mission needs).

On a smaller scale, these are many programs which naturally encourage innovation. There are also some important mechanisms in place that tend to foster the type of innovation envisioned by Stevenson-Wydler. These include, for example, the small business innovative research program, the DOD independent research and development (IR&D) program, the multi-stage competitive acquisition process, and the encouragement of agencies to contract out by regulations such as OMB circular A-76.

The importance of this direct and natural Federal role cannot be under-emphasized. American leadership in supercomputer technology demonstrates this fact. While many see our leadership in this area as a result of better resources or people, I firmly believe that America leads the pack because we have the problems to solve and have decided to solve them. The result is a well-defined set of users who have formed a consistent customer base to whoever wanted to build the most powerful computers, as well as an effective test bed for each new supercomputer generation. This climate provides both the mechanism and the incentive for effective technology innovation.

2. Sponsor innovation by funding broad basic research

The second inherent role of the Federal Government that has developed over the years is that of funding large basic research programs aimed at building the country's technology base. This committee, as well as the current administration, has been a supporter of the bipartisan efforts to ensure continued funding of these investments in the future despite the cuts in other programs. We of NCST commend those who will take the farsighted view that our basic research is the "seed corn" for the next generation. We must, even in difficult budget years, continue the agressive rebuilding of our research and technology base.

If technology innovation is to flourish in the future, we must pay continual attention to our basic research program to ensure: (1) Long-Term consistency, both in program directions as well as funding, (2) broad dispersal across the country whenever practical, and (3) transferability to the civilian sector economy, even if the original funding came in support of a defense program. Now, more than ever before, we must look to develop a synergism that will allow us to utilize both our native talent and all Federal research dollars as an investment in our overall economic future.

3. Sponsor innovation by fostering entrepreneurial climate

The final, and from a new policy point of view the most urgent at this time, is the Federal role in freeing the american enterprise system to spawn and sustain entrepreneurial activity. No program will encourage the type of innovation envisioned by Stevenson-Wydler more effectively or with less Federal expense than a program designed to remove the fiscal and bureaucratic handcuffs from those who would otherwise lead the revolution.

Put directly, Mr. Chairman, the foundation for all technology innovation that helps America complete in world markets is the maintenance and strengthening of the entrepreneurial climate and the capital formation mechanisms essential to transform a good idea into jobs. Technology transfer programs can be perfect, research and development can be abundantly funded, and we can know all there is to know about the potential markets for our innovation. But if our policies do not encourage and reward the risks that accompany bold application of our technology, then we will never reap the true rewards of our labor. This committee is well versed on the issues of which we speak, and we cannot deal in detail with any one of them today. However, for the record, NCST strongly encourages the committee to continue its efforts in at least the following areas, all of which were addressed in the recent report of the president's commission on industrial competitiveness:

Capital formation.—The American entrepreneurial process is totally dependent upon availability of various forms of venture capital. Many proposals for "Tax Reform" call for increases in capital gains and other venture-related taxes, while also increasing corporate taxes in such manner as to exacerbate already existing differentials in the effective tax rates between industries. For example, Cray research, the world leader in supercomputer technology already pays an effective tax rate in excess of 42%—more than most individual tax payers.

Research and development tax incentives.—The current tax credit provisions enacted in 1981 will expire this year unless Congress takes action now. These incentives not only are considered a key element in corporate decisionmaking relative to new research, but as currently proposed they will provide strong incentives for increased direct "corporate-university partnership".

Stable trade environment.—Recent discussions of possible "trade wars" with our allies point to the dangers inherent in our current situation. While it is important that we press for "fair trade" with all of our allies, protectionist legislation could quickly undermine our ability to compete both at home and abroad.

Federal spending controls.—NCST strongly supports efforts to bring the Federal deficit under control. We recognize that hard decisions must be made in order to reduce this deficit. For several years, we have lived with tight budgets in the scientific, engineering, and technical communities. Across the board the "burden of proof" must be placed on those who would defend against some cuts. Furthermore, we encourage the committee to look for opportunities to encourage agencies to work with one another to ensure that innovations developed for one Federal mission are transferred to other agencies. The President's Science Advisor has provided some lead in this area by sponsoring interagency groups such as the Federal coordinating Committee on Science, Engineering, and Technology (FCCET). This type of "AD HOC" initiative is to be commended both because it makes sense and because it can help us stretch already scarce budget dollars.

Government reorganization. During the last several years a number of major reorganization proposals have been proffered as potential "solutions" to some of the

difficult programs facing us in technology innovation, trade, education, energy, etc. Most recently, the President's Commission proposed establishing two new departments: Trade, and science and technology. While both proposals have considerable merits, a pragmatic view of reality tells us that reorganization will not cause difficult problems to disappear overnight. NCST strongly encourages, therefore, dealing with the "hard" issues more directly first.

Education.—The President's Commission identified several priority programs and issues related to education. NCST strongly endorses any efforts to strengthen the quality of education in this country. In fact, the NCST membership so strongly endorses the need for better education that we have formed the NCST education foundation.

The policy issues addressed above deal with the broad environment—the "life support system" of entrepreneurial activity. Assuming that these issues are being dealt with, we can begin to address the more specific question of how to best spawn technology ventures based upon the very extensive research and development being accomplished with Federal funds.

REAUTHORIZATION OF STEVENSON-WYDLER—THE NEXT STEP

As we turn to the specific issue of reauthorization of Stevenson-Wydler, we are faced with a somewhat unique scenario. On the one hand, there is considerable evidence that the goals articulated in section 3 of the act have been accomplished. Indeed, it appears in some cases that the act has made a contribution far more important than even any of the specific programs it authorized: It began to change the bureaucratic mindset towards supporting, rather than frustrating technology transfer and commercialization initiatives. Just yesterday afternoon I met with the president of New Mexico's technet, a nonprofit organization working to build a computer network linking universities, major Federal laboratories at Los Alamos and Sandia, major NSF facilities such as the very large array, and the private sector. This exciting and ambitious project is being supported by the department of energy via grants and, much more important, via expertise from the Doe Laboratories located in New Mexico. According to technet officials, the "bureaucratic nod" for the Doe cooperation was made much easier because of the "umbrella" provided by Stevenson-Wydler.

Beyond the specific accomplishments, it appears that the issue of Federal technology transfer and innovation has found considerable support at the state, local, and private sector levels. As the Secretary of Commerce noted in his report to the Congress on the implementation of the act, there appears to have been a resurgence of activity that has multiplied the act's intent many fold with the happy consequence that the concept of technology innovation and transfer seems once again imbedded in our system. By these standard measures alone, many of us have concluded that the act has succeeded and does not need to be reauthorized in its present form. However, there are several questions that remain unanswered:

If there is no new act, will the programs that now seem to look to Stevenson-Wydler for back-up—such as Technet—be unable to continue?

What about the most important technology transfer function of all, that of promoting exchanges of scientific and technical personnel between Federal and private sector laboratories, particularly smaller businesses?

How can the congress ensure that opportunities for such exchanges are being agressively pursued unless some lead agency, such as Commerce, is asked to monitor this program from a central vantage point?

Is reauthorization of the act required to foster or perhaps even allow for extensive activity in this regard? Is a continuing program of studies concerning the innovation process still necessary? If so, will those studies be accomplished without a new act?

Assuming that the process that Stevenson-Wydler appears to have helped foster continues without a new act, is there some monitoring and program evaluation mechanism that can ring the warning bell when a new course correction is needed?

Because these questions remain, the majority of the NCST task Force on Technological Innovation believe that the act should be reauthorized after some "tuning" to reflect the changes that have happened since 1980.

Specifically, the task force asked me to present the following ideas for your consideration as you evaluate the merits of reauthorization:

1. To ensure small business participation in nsf industry/university centers, future centers might be targeted to include small high-technology companies. The caveat to this, of course, is that the emphasis must be on companies that are engaged in a pre-disposed business direction that substantially benefit from the coop-

eration (such as a bio-technology company), rather than companies who view the funding for such a center as a major revenue item.

2. While "hard" science is the core of high technology success, the emergence of artificial intelligence and medical technology as crucial "next generation" technology areas points to the importance of research in social, behavioral, and physiological sciences. This importance should be reflected in future legislation in some way.

3. The issue of patent rights as well as incentives to Federally funded researches to transfer and commercialize inventions was raised by all members of the task force as critical to the success of Federal technology transfer and innovation. Reform in this area could go a long way towards accomplishing Stevenson-Wydler objectives with virtually no additional Federal expenditures.

4. The majority of NCST task force also recommended that the Department of Commerce's hand be strengthened by allowing the secretary to designate a modest fund for Research, Education, and Development (FRED) which would be used to provide seed money and matching grants for projects in support of Federal technology transfer and innovation. This money would be used for studies designated by the Secretary as well as to provide special grants to Federal laboratories or other agencies. This year's act should require the secretary to study this proposal and to report to the Congress on how such a program should be administered so that it could help lead the process without appear to set "industrial policy" and without introducing new bureaucracy into the process of government - university - industry cooperation.

5. Prior to enacting new legislation, a review should be made of the statutory inhibitors to cooperation between Federal laboratories, local governments, and the private sector. based upon this review, new legislation should be specifically designed to allow broad flexibility directly to the local laboratory management.

FINAL OBSERVATION AND SUMMARY

In summary, Mr. Chairman, we of NCST believe that the issue of technology transfer and innovation is fundamental to America's economic future. We have tremendous advantages in the world market place—we only need to use them wisely. The temptation always exists to copy others, to try to duplicate their success. But, while we must always resist the temptation to shut out foreign ideas, we must also never forget that our free enterprise entrepreneurial system has always, even during slack times, demonstrated vitality not found elsewhere. There are never any easy answers, particularly in hard budget times. But on balance perhaps the lack of dollars for major new programs can provide us with a unique opportunity to work together towards new, innovative approaches that can carry us into future generations. As a first step, we suggest that the committee work to focus attention first on the areas where we already have considerable consensus, only when we have unified to deal with these "easier" issues will we be adequately prepared to resolve the "harder" ones. We of NCST look forward to being an active part of that innovative process.

SUMMARY OF KEY ASSUMPTIONS

1. The Federal government already has a major technology innovation role by virtue of the large Federal commitment to basic research and support of "core" missions such as defense.—Regardless of any new programs or initiatives, the Federal government already has a very major role in technology innovation. In fact, while the committee is aware of the significance of this already entrenched Federal role, many others do not realize that the U.S. investment in Federal research and development dwarfs similar expenditures by countries such as Japan. Thus, the issue before this committee today is not whether the Federal Government should have a role, but, rather, how the role it already has can be properly managed to ensure maximum leverage of scarce Federal dollars to fuel strong economic growth.

2. Major new program.—Is unlikely, we recognize that the budget situation is such that major new funding for second generation Stevenson-Wydler type programs is unlikely to be available. Yet, we have found within NCST a broad concensus that the commercialization of technology—particularly that technology developed with Federal funds—must be afforded a high priority if the U.S. is to continue its currently industrial leadership in the next decade and beyond.

3. Additional bureaucracy will hurt, not help innovation at this time.—We recognize that if a Federal initiative is to indeed result in new technology ventures, it must be so structured as to remove impediments that may now exist without creating new impediments in the process. Any programs or initiatives that attempt to "institutionalize" technology transfer at a high level rather than simply streamlining the mechanisms so that it can happen at the working scientist level must be

carefully constructed if they are to succeed. Stevenson-Wydler took some initial steps designed to "untie" the hands of agencies at the laboratory level; this process should be continued.

4. Technology transfer happens when technology developers are joined freely with technology users.—It does not happen as a function between two organizations. In determining future policy, the programs and organizations established by Stevenson-Wydler should be evaluated by how effectively they have facilitated the joining of research scientists with technology users. We believe that this is the spirit behind the act and have taken this into account in suggesting some future steps.

Senator GORTON. Thank you very much. I must say that I have enjoyed immensely the testimony of both of you.

It was enlightening to me, Mr. Berlin. We will look with great eagerness to see whether or not what comes out of that word processor is as eloquent as what has come out of the word processor you brought with you here today.

Mr. BERLIN. Thank you.

Senator GORTON. I am sorry, because of our vote and the lateness of time I do not have time to ask questions of each of you, though many were produced by your testimony.

In some respects we saved the best for last. We are very, very happy that you were with us here today.

Thank you.

[Whereupon, at 4:50 p.m., the subcommittee was adjourned.]

EFFECT OF NEW TECHOLOGIES ON ECONOMIC COMPETITIVENESS: TECHNOLOGY TRANSFER

MONDAY, JULY 1, 1985

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Seattle, WA.

The subcommittee met, pursuant to notice, 9:00 a.m. in the South Auditorium, Henry M. Jackson Federal Building, Hon. Slade Gorton presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. I want to call this meeting to order and welcome all of you to this hearing of the Subcommittee on Science, Technology and Space of the Senate Committee on Commerce, Science, and Transportation. Our subject today is technology transfer: How does an invention get from the laboratory to the marketplace? Our interest is in accelerating the rate of technological innovation, for the benefit of consumers here at home and for the benefit of American industry competing in the international marketplace.

The Federal Government will invest $60 billion in research and development in 1986. Much of that money goes to our universities. Over $17 billion goes to 380 government laboratories, which employ one out of every six research scientists in this country. There are eight of these laboratories here in Washington, conducting research in such diverse areas as agriculture, fisheries, mining, and energy.

Our State's reputation as a leader in high technology industries is due to a great extent to the close relationship between our universities, our research laboratories, and our private industries. The State is enhancing its leadership image through projects like the Washington Technology Center. The announced RCA-Sharp plant in Camas is proof that Washington is one of the most attractive States in the union for new, high-tech businesses.

Despite these successes, our purpose today is to ask: What problems remain? How can we do better? A few years ago a White House panel chaired by David Packard was commissioned to see if we are getting our money's worth out of the Federal laboratories. It concluded that the Federal laboratories need to provide much more access to their facilities by universities and industry.

This year the President's Commission on Industrial Competitiveness concluded that the U.S. needs to support basic scientific research and make it more useful for commercial purposes. Both of these reports, in other words, advocated technology transfer.

There are several bills before Congress designed to allow the Federal labs to enter into the kinds of joint research and licensing arrangements with which research universities have had so much success. Today we will hear about technology transfer at the University of Washington, Washington State University, the Washington Technology Center, and some of the Federal laboratories.

Our last panel of witnesses are perhaps the most important, because they are from the private sector. It is Congress' job to clear away unnecessary legal and institutional barriers to technology transfer. But, ultimately, technology transfer depends on the private entrepreneur, who takes the risks and makes the investment once the scientist's work is done.

Our first panel will consist of: Donald Baldwin, Ray Bowen, Deborah Illman, and Paul Young, all from the University of Washington. Would you come forward, please, and we will be delighted to hear from you. We will take you in that order; it is alphabetical.

Mr. Baldwin, I will say to each of you that your entire written statements and any accompanying papers will be included in the record as if given in full. If short, we will be happy to have you go through your statements. If they are relatively long, we would appreciate your summarizing them.

Mr. Baldwin.

STATEMENTS OF DONALD R. BALDWIN, ASSISTANT PROVOST FOR RESEARCH AND DIRECTOR OF TECHNOLOGY TRANSFER, UNIVERSITY OF WASHINGTON; DR. J. RAY BOWEN, DEAN OF ENGINEERING, UNIVERSITY OF WASHINGTON; DR. DEBORAH L. ILLMAN, ASSISTANT DIRECTOR, CENTER FOR PROCESS ANALYTICAL CHEMISTRY, UNIVERSITY OF WASHINGTON; DR. PAUL YOUNG, PROFESSOR AND CHAIRMAN, DEPARTMENT OF COMPUTER SCIENCE, UNIVERSITY OF WASHINGTON

Mr. BALDWIN. Senator Gorton.

I am glad you are having this hearing on technology transfer and economic competitiveness. These are topics that are extremely important to the well-being of our nation. I am convinced that the universities can and should play a key role in developing new technology and transfering those technologies to the private sector, and it is a pleasure for me to report that the university that I represent, the University of Washington, has taken some very dramatic steps to play this role as effectively as possible.

The initiatives that I will mention are based on the assumption that the university must be pro-active in its choice of policies and procedures in order to effectively foster technology transfer; that we must break away from the business as usual mentality and really take some new steps to be sure that technology gets out of our laboratories and into public use.

I will mention just the highlights of these steps that we have taken, and then of course we will be glad to respond to any questions that you have. My comments will be at the overview level, since there are three others from the University of Washington who will discuss specific models of the university-industry interaction which is the primary mechanism through which we address the transfer issues.

Our consideration at the university of the technology transfer issue brought us to two major conclusions. One was that we needed a new pro-active set of policies and organizational mechanisms that would be responsive to the needs that we could identify in this area; and secondly, that we needed to greatly expand interaction with industry.

We have taken many initiatives, but I want to mention three that I think are particularly important in this regard.

One is that we have revised the university's patent policy so that the policy now gives greater emphasis to technology transfer; makes explicit the expectation that the university will cooperate with industry; and provides monetary and support service incentives that are designed to encourage employees to disclose inventions and cooperate in the steps that are necessary to commercialize those technologies.

The second is that we have established within the university organization the Office of Technology Transfer so as to give greater visibility to this function within the university and as seen from the outside.

The third is that we established an active working relationship with the Washington Research Foundation, located right here in Seattle. It now serves as the university's primary agent for patenting and licensing. Based on over 2 years of experience in this working relationship, it is clear to us that the foundation is very aggressive in moving the university's technologies into the private sector.

Although these initiatives are relatively new, having been framed and implemented only in the last couple of years, there are already some encouraging results. For example, we have doubled the number of invention disclosures from only 25 per year to 50. We were successful in licensing six new technologies last year.

We are, through the Washington Research Foundation, in various stages of negotiations on about a dozen other technologies that will soon be in the hands of licensees. Beyond that, we have a reservoir of over 100 technologies that have been identified and are currently in various stges of evaluation as to their commercial potential.

But perhaps the most important sign of progress is the dramatic increase that we have seen in university-industry interaction. I stress this because I think this interaction is the heart of any successful technology transfer program. When I talk about these dramatic increases, I should acknowledge that there are of course many modes of interaction between the university and industry, but let us focus for just a moment on what we refer to as cooperative research agreements.

As was indicated in my written testimony, the university currently receives over $200 million a year in grant and contract support. Last year, about $7 million of those awards were derived from industry and

that was a 17 percent increase of the previous year. So far this fiscal year we have seen another 79 percent increase in awards from industry, and I believe this increase is the direct result of some of our new initiatives.

As to the mechanisms for this cooperative research interaction with industry, at our university we use primarily a sub-set of four different models. One is a set of interactions through the Washington Technology Center that you will hear about separately from Dr. Stear the Center's executive director. Another is the industrial affiliate program; still another, the consortium arrangement; and the fourth is the sponsored research projects.

Since you will hear about the Washington Technology Center separately, I will not elaborate on that.

As to the industrial affiliate programs, these are generally organized on a department or school basis, and this is a case where some number of industrial corporations pay an annual fee for a window on the research that goes on in that unit. They routinely receive reports of that research and are invited in once or twice per year for oral presentations of the research and an opportunity to raise questions.

The third model, the consortium arrangement, is somewhat similar to the affiliate program, but tends to be much more interactive between the university and the industrial sponsors. Here again, I will not take the time to elaborate since two specific consortium models will be discussed by two other panelists.

The sposored research model is a case where the university carries out research funded by a single sponsor at an agreed upon dollar level in a specific time period.

I attached to my written testimony a model agreement that we have evolved from our considerable experience now in dealing with industrial sponsors, and we are able to consummate that agreement quite quickly. The agreement is designed, as you will see, to protect the university's usual policies concerning publication and invention rights. It also indicates the university's willingness to enter into appropriate license agreements to foster the flow of technology into the private sector.

So we are very positive about industry-university relationships and certainly want to continue our efforts to expand and enhance those relationships.

In our experience, perhaps one of the most serious problems in this area is that of getting such a relationship started. They tend to be based on personal trust and respect, which means that our university researchers have to come in contact with industrial researchers so that they get to know each other to some extent on an individual basis.

So, in an effort to break down that barrier, one of the things that we have done is to arrange day-long presentations at the university that are built around certain of our major research units—the bio-engineering center, for example, or as Dean Bowen will mention, around the College of Engineering; one such presentation was around a set of science departments within our College of Arts and Sciences.

The whole thrust of these is to introduce some of our university researchers to industrial representatives who are invited in from the local community, to show them the kinds of research we are doing and, perhaps more importantly, to impress upon them the capabilities that we have for doing research. We generally arrange those presentations so as to be able to show them some of our research facilities and the kind of equipment and instrumentation that we have. Generally, our visitors leave with a much better understanding ot the resources available to them through interactions with the university.

In a slightly different vein, we are also providing a wide range of information about the university to the State Department of Commerce and Economic Development and to organizations like the Technology Corridor and the Columbia River Economic Development Council. Those organizations can use this information about the university in their efforts to attract industry to this area.

As to the barriers, I don't perceive any absolute barriers in our university context to inhibit technology transfer. I do believe that on the Federal level it is important to protect the favorable Federal patent policy. I am referring to Public Law 96-517, which assures the universities the right to take title to inventions that come out of Federally supported research. That probably was the single greatest incentive for our university to establish these new policies and mechanisms and take this whole topic much more seriously than we had in the past.

Also at the Federal level, I think it is important to insure that there is adequate funding for programs that encourage university-industry interactions. I am thinking particularly of two of them within the National Science Foundation. One is the University Industry Cooperative Research Centers program, and the other is the new program for Engineering Research Centers. Both of these are designed to foster these relationships between the university and industry, and I think they are very important programs.

I think it is also important that the Federal legislation assure certain tax incentives for industry expenditures for R&D and for equipment donations to the universities.

In a slightly different way, I think it will be terribly important that there be considerably more Federal dollars available to update university laboratories and to provide new state of the art equipment and instrumentation. As you know from reports by the National Academy of Sciences and others, this is a very serious problem in the academic community, top notch facilities and instrumentation with which to conduct really first-rate research are needed to entice industry in to cooperate with us in research and technological innovation.

It would be important also to continue the SBIR program, which is designed specifically to help small business get into the technology transfer activity. We at the university are trying to be sensitive to opportunities to join with small business to make their programs more effective than they might be without some university involvement.

Within the university, I see no barriers to technology transfer now that we have our basic policies in place and have committed ourselves to a set of mechanisms that will foster the broadest possible interaction with industry. We must simply refine these policies and mechanisms so as to get all the mileage we can from them.

Thank you very much for the opportunity to speak.

[The statement follows:]

STATEMENT OF DONALD R. BALDWIN, ASSISTANT PROVOST FOR RESEARCH AND DIRECTOR OF TECHNOLOGY TRANSFER, UNIVERSITY OF WASHINGTON

Mr. Chairman and members of the subcommittee, I'm glad you are having this hearing on technology Transfer and economic competitiveness. These topics are extremely important to the well-being of our nation. I'm especially pleased that I have this opportunity to speak to you because I'm convinced that universities play a key role in developing new technologies and transferring those technologies to the private sector where they are converted to products and services that simultaneously meet people's needs and bolster the national economy. It's a pleasure to report that the university I represent, the University of Washington, is very mindful of this role and has taken fairly dramatic steps during the last couple of years to enhance its technology transfer functions.

In order to convey the essence of these steps, I'll focus on just three items that I hope I can wrap into a message that will be useful to the Subcommittee and the Senate.

First, I'll outline the scope of our university research programs because that's where most advances in technology come from.

Secondly, I'll describe some of our new initiatives that we believe will expedite the transfer of technologies from our research programs to the private sector.

Thirdly, I'll describe some of our efforts to interact more effectively with industry—especially local industry here in the Pacific Northwest.

Although many are not aware of it, the University of Washington is one of the leading research universities in the entire country. Our grant and contract awards received last year to support research and training programs amounted to nearly $204 million (see Appendix 1).[1] And so far this year awards are over 6% higher than last year's level (see Appendix 2). We are estimating that total awards this year will amount to about $215 million.

For 15 years now, the University of Washington has ranked in the top five universities in the United States in receipt of federal grant and contract awards. It currently ranks fourth behind only Johns Hopkins University, MIT and Stanford. As is shown in Table 1, about 85% of these awards come from various agencies of the federal government. This includes over $90 million from the Department of Health and Human Services, about $20 million each from the National Science Foundation and Department of Defense and lesser sums from the Departments of Energy and Education, NASA and other agencies. The remaining 15% comes from non-federal sources including private foundations, state and local government, industry and various health and trade associations. During the 1983–85 biennium the University has received slightly more funding from sponsored program awards than from State General Fund Tax Appropriations. Due primarily to the State's poor economic condition and narrow tax base, the University has suffered severe budget problems during the last 5–6 years. When the State is able to make larger and more predictable investments in the University, it will be even more effective in realizing its potential as a force in the State's economic development.

Turning now to technology transfer, the importance of Federal policy should be acknowledged. As noted earlier, the University of Washington receives about 85% of its sponsored programs funding from Federal agencies. Thus, the passage of Public Law 96–517 assuring universities the right to title in inventions derived from Federally supported research provided a much needed incentive for the University to pay more attention to technology transfer. The amendments contained in Public Law 98–620 further improve the position of universities. Against the backdrop of this favorable federal Patent Policy and the recommendation of an internal University task force, the university has implemented several new technolgy transfer initiatives during the last couple of years. The three most important ones are:

[1] The appendices are in the Committee files.

(1) Revision of the Patent Policy. That policy now gives greater emphasis to technology transfer; makes explicit the expectation that the University will collaborate with industry; and provides monetary and support service incentives to encourage the faculty and other employees to disclose inventions and new technologies.

(2) Establishment of an Office of Technology Transfer to give greater visibility to this function both within the University and as seen from the outside and to provide coordinated administration of the patent and copyright policies.

(3) Establishment of an active working relationship with the Washington Research Foundation (see Appendix 3) which now serves as the University's primary patent and licensing agent.

Although these initiatives are only a couple of years old, there are already some encouraging results. For example, we will have about 50 invention disclosures this year compared to an average of only 25 per year during the 1978–82 period. Six new technologies were licensed last year and negotiations are in progress now with various licensees on about a dozen other technologies. Beyond those, there is a reservoir of over 100 other technologies that have been identified and are currently being evaluated for their commercial potential. As still another sign of progress, there has been a dramatic increase in the University's interaction with industry. I'll try to describe some of that activity because it is the heart of a successful technology transfer program.

First of all, it should be understood that the University and industry work together because both anticipate benefits from the relationship. Typical benefits to the University include: Funding for important research; collaboration with industrial scientists; useful contact with real world problems; graduate student exposure to prospective employers; access to state-of-the-art facilities/equipment; and identification of licensee for new technologies.

Typical benefits to Industry include: Access to expertise available on campus; window on research in the project or department, depending on scope; access to unique instrumentation; opportunity to interact with students—prospective employees; objective scientific analyses and reports; and new technologies to license.

There are many different modes of interaction between the University and industry. These include at least the following:

Direct funding of research agreements.

Joint University/Industry cooperation through the Washington Technology Center (which is described later).

Three-party cooperative research projects including the University, Industry and Federal Government. (An example is given later).

Use of unique university facilities by industry and of unique industry facilities by the University (example: College of Forest Resources and The Weyerhaeuser Company).

University/Industry faculty/scientist exchange programs and student internships.

Specialized programs designed by the University for continuing education and training of professionals working in industry (some of these are even given at the Corporation and some are available in A/V form).

Gifts and endowments including faculty chairs (one was recently announced for new Manufacturing Engineering program—a very generous gift from the John Fluke Manufacturing Company.

Participation of industry representatives on visiting committees and campus advisory groups, and

Licensing of new technologies (commonly include consulting arrangements with the faculty inventors or funding for further research).

For the moment, I'd like to focus on the direct funded research agreements between the University and Industry. I mentioned earlier the $204 million in awards received last fiscal year. That included $7.2 million of awards received from Industry which was a 17% increase over the previous year. As is shown in Appendix 2, eleven months into the current fiscal year, there is a further 79% increase in research awards from Industry. While we surely won't sustain that dramatic increase on a regular annual basis, we certainly do expect some level of growth to continue. It is interesting to note that these interactions with industry are widely dispersed throughout the University with some industry funding in twelve of the University's sixteen schools and colleges (see appendix 4).

In this direct funding mode, the University uses a subset of four different models. I'll just list them first, then elaborate on each one.

These are: (1) interactions through the Washington Technology Center; (2) Industrial Affiliate Programs; (3) consortium arrangements; and (4) sponsored research projects.

The Washington Technology Center was established by the State Legislature last year to bring together the academic and industrial communities of this State in certain theme areas of research where there is high promise of commercial products. The University of Washington is, of course, an active participant in the Center along with Washington State University, Seattle University and the other public and private higher education institutions of the State. In most cases, Center projects are jointly funded by a combination of State and industry funds—and sometimes are assisted by Federal funds too. Eventually, the overall funding for the Center will be about one third each from State, Industry and Federal sources. The WTC will be fully described in separate testimony by Dean J. Ray Bowen.

The second model, Industrial Affiliate Programs, are generally organized on a department or school basis. This is a case where some number of industrial corporations pay an annual fee for a window on the research going on in that department or school. The affiliates routinely receive copies of research reports from that unit and are invited in once or twice a year for personal presentations of the research. Examples of such programs exist in our Department of Chemical Engineering and several other units mostly elsewhere in the College of Engineering and among the science departments in the College of Arts and Sciences.

The third model, Consortium arrangements, are similar to the Industrial Affiliate Programs in that the cooperating corporations pay a specified annual fee but these consortium relationships tend to be much more interactive. They often involve the assignment of corporate technical liaison people on the campus to work directly with faculty and graduate students. The activities of consortia are generally guided by an advisory board made up of a combination of University and industry representatives. One example of a Consortium is the new Center for Process Analytical Chemistry (CPAC) in which our Chemistry Department has joined with about 25 industrial sponsors each paying $30 K per year to fund research of mutual interest. The Federal Government is also a participant in that the National Science Foundation is providing partial support for the first five years, after which the Center must be funded entirely by the University and industry. The CPAC will be fully described in separate testimony by Dr. Deborah Illman.

Another example of a consortium is the so called VLSI (Very Large System Integration) Consortium in which the University's Computer Science Department has joined with five large Northwest firms to do research and produce computerized design tools for use in manufacturing processes. In this case the five companies each provide an annual fee and also appoint a senior scientist to be located on campus. This program even has an international flavor. Its design tools have been transferred to a research and training institute in Malaysia under an appropriate Export License prepared with assistance from the U.S. Department of Commerce. We anticipate more such transfers and are trying to inform ourselves about export provisions. The VLSI Consortium will be fully described in separate testimony by Dr. Paul Young.

The fourth model, sponsored research, is a case where the University carries out a research project funded by a single sponsor at an agreed upon dollar level and within a specified period of time. Such arrangements are quickly and easily consummated now by use of a Model Agreement (see Appendix 5) that we have evolved, based on experience with industrial sponsors.

I trust that it is clear from my testimony that the University has very positive feelings about its relations with industry. We don't share the negative, pessimistic views that some other universities hold toward University/Industry interactions. Certainly, both sides must bring some imagination and flexibility to these transactions but once policies are understood and operating procedures are clear, we have found industry quite tolerant of our usual policies on open publication, patents, copyrights, use of names in advertising, etc.

In our experience, one of the toughest elements of the University/Industry interaction is getting it started. On the University side, we don't know what industry needs. On the Industry side, they frequently don't know what we have to offer. We are trying to overcome this barrier in a variety of ways. Some of those steps are apparent from items already mentioned. We are also trying to be more astute in choosing the content of some of our major publications—and in the distribution of those publications so as to get the right message to the right audience.

We also hold day-long presentations in some of our key research units—the Bioengineering Center, College of Engineering, etc.—to which we invite local industry representatives. Each presentation provides an opportunity to introduce some of our researchers, tell industry representatives about our research capabilities, and show them our facilities/instrumentation. In a slightly different vein, we are also providing a wide range of information about the University to the State Department of

Commerce and Economic Development and to organizations like the Technology Corridor and the Columbia River Economic Development Council so that all of them can use that information to help attract new high tech industry to the area.

I have touched only lightly on lots of things but I hope it is clear that the University is definitely committed to a vigorous and effective role in advancing technology transfer.

Thank you again for this opportunity to participate in the hearing.

Senator GORTON. Thank you, Mr. Baldwin.

Dr. Bowen.

Dr. BOWEN. It is a pleasure to be here. For the record, my name is J. Ray Bowen. I currently serve as Dean of Engineering at the University of Washington, and have been working in the past several years to foster mechanisms which improve efficiency of technology transfer.

My written testimony deals with the following subjects: an overview of research conducted at the College of Engineering, with particular reference to that conducted in cooperation with private industry; the mechanism by which technology generated by government-funded research is transferred to the private sector; the existing barriers which impede technology transfer from universities or the Federal laboratories; and possible Congressional action to remove those barriers or to otherwise enhance technology transfer; then finally, I comment on the college's policies on publication, patent rights, and proprietary research.

In my oral testimony today, I would like to emphasize the importance of this technology transfer to the maintenance of competitive advantage of the American manufacturing industry. That industry will need a continuous stream of new technology, both to preserve the existing industrial base and to provide for the development of new industries.

I would like to emphasize that American universities play a primary and significant role in this process since they are the largest creators of new technology.

My testimony also emphasizes the increase in the College of Engineering's research activities, both in terms of Federal support—it has grown at the annual average rate for the past 2 years of approximately 20 percent, which is about twice the national average. If one examines the contributions of industry to that growth and research support, we find that over the past 6 years the industrial contributions have increased fourfold. The industrial support of the College of Engineering is about 60 percent higher on a percentage basis than that of the entire university.

The college's policies on patent rights, publication, proprietary information are the same as those of the university and, as Mr. Baldwin has already emphasized, these policies are such that they are not inhibitors to the technology transfer at this point in time.

I would like to point out that the transfer of technology from the university or any other entity such as the Federal laboratories is but the first step in the chain. Much time and investment, significant sums of dollars, are usually required before that product or that technology is ready for the marketplace; and in many cases the cost, market size, the

vulnerability of the product to evolving technology are such that the idea will not lead to fruition.

As a consequence, the universities and the Federal laboratories should be careful and be prudent in the estimate of the impact of technology transfer in terms of direct returns to the faculty, inventor, university, or the Federal laboratory.

Also, in many circumstances the technology evolves so rapidly that industries oftentimes have little interest in patent protection. As a consequence, the university's strategy in marketing technology must be adaptive to the existing constraints and the outside forces that rule an industry.

My testimony also is concerned with what the Federal Government has done or may do in the way of improving technology transfer, and my comments are much the same as those of Mr. Baldwin.

Finally, in my testimony I cite some specific examples of past successful technology transfers or technology transfers that we see on the horizon. It is interesting to note that most of those instances are related to health sciences, and that is an area in which the university has had its maximum amount of support over the last several years, and that also these technology transfers have occurred over the period of several years.

In my testimony, I also enumerate several instances where we perceive opportunity for successful technology transfer, and it is interesting to note that the shift seems to be from the bio-medical or bio-engineering sciences over to the manufacturing technologies, which represents the influence of the shifting interest of Federal Government support and also the shifting interest of industry.

I would be pleased to answer questions at the appropriate time.

[The statement follows:]

STATEMENT OF DR. J. RAY BOWEN

Senator Gorton, it is a pleasure to appear before your subcommittee and to comment on the matter of technology transfer from universities to the private sector. For the record, my name is J. Ray Bowen. I currently serve as Dean of Engineering at the University of Washington and have been working in the past several years to foster mechanisms which improve the efficiency of technology transfer.

My testimony will deal with the following subjects: An overview of research conducted at the College with particular reference to that conducted in cooperation with private industry; the mechanism by which technology generated by government funded research is transferred to the private sector; the existing barriers which impede technology transfer from universities or the federal laboratories and possible Congressional action to remove those barriers or to otherwise enhance technology transfer; and the College's policies on publications, patent rights, and proprietary research.

Hopefully, these comments will provide your subcommittee some further insight into the importance of technology transfer from the university laboratories to industry to the maintenance of the nation's competitive position in the evolving international economy. Clearly, the nation must maintain a vibrant and dynamic technology base to ensure that our industries can maintain a competitive position and sustain the standard of living enjoyed by American citizens. Despite the growth of service industry, basic manufacturing will tend to be a linchpin in the economy. To maintain the competitive advantage American manufacturing industry will need a continuous stream of new technology, both to preserve the existing industrial base and to provide for the development of new industries. American universities will play a significant role in this process since they are primary creators of new technology.

The total funds expended from all sources for R&D in the nation is expected to exceed $100 billion in 1985. Of that total $9.6 billion will be expended at universities. The federal government is expected to provide about 64% of those funds. Most of the effort at universities is devoted to basic research. Over the past several years, the University of Washington has been among the top five universities when ranked according to total grant and contracts received and has been a major source of new technology. The recent statistics concerning grant and contract awards to the College of Engineering are similarly impressive. The annual totals now exceed $12 million as shown in attachments provided with testimony. In FY 1984 the annual increase in awards for the College was 30% and the annual percentage increase in awards to the College averaged for FY 1984 and 1985 is expected to be 20%. This latter figure is approximately twice the national average increase in research and development support. The distribution of the College's grant and contract awards amongst the providers show that industry contributes about 8.6% of the totals and that over the past 6 years the total industrial contribution has increased by fourfold. The figure of 8.6% for industrial support of College research should be compared to the projected level of 5.0% of the total research support for universities being derived from industry.

Against this background of statistics, I would like to discuss some aspects of the issue of technology transfer. First, there are several modes by which transfer of technology is accomplished. The most common mode occurs through one-on-one exchanges of scientists and engineers. It occurs through the minds of individual students who have worked in university laboratories. Upon completion of their studies many will go into industry, taking with them and hopefully applying the results of their studies. Technology transfer occurs through exchanges that result from industry university consortia such as the UW-VLSI consortium or the CPAC or through university industry cooperative research efforts such as the WTC. It occurs when faculty investigator meet with their industrial counterparts. Technology transfer occurs through more formal mechanisms via technology licensing agreements and patents. To facilitate the formal transfer of technology, the University of Washington has established the Office of Technology Transfer, and the Washington Research Foundation has been established to market technology generated by the University of Washington, other Washington universities, and nonprofit research entities in the state.

The University has modified its patent and copyright policy to encourage faculty to bring forth research results which may lead to technologies with potential commercial value. The University has also developed a policy on proprietary research which protects insofar as is possible the University's interest in open publication of research results and at the same shields the interests of research fund providers who have a proprietary interest in the research outcomes. The College's research

programs and resulting technology transfers are subject to these policies. At this stage, it is safe to say that the policies as such are not inhibitors in the technology transfer chain.

One must caution that, whereas the University and the College maintain a positive posture on technology transfer, the progress out of the university door of any specific piece of technology does not pre-ordain its successful commercialization. Research by University faculty at best leads to proof of concept and hardware prototypes or software packages for example. The questions of manufacturability, marketability, size of market, cost of production start-up, product lifetime, and product vulnerability to evolving technology are not answered in the university laboratory. The costs of product development and market analysis are oftentimes many fold of the initial cost of the basic research which led to the technology. These costs and associated risks are borne by industry. As a consequence, one should be realistic about the actual direct returns to the faculty inventor and the university of a technology transfer. In many circumstances the evolution of technology is occurring so rapidly in some industries that there is little interest in patent protection. As a consequence, the university strategy in marketing technology must be adaptive to the existing constraints in industry.

As to the question of barriers to technology transfer and potential Congressional action to mitigate those barriers, I would like to note that the principal barrier for federally supported research was removed when the federal government changed its policy on the ownership of patent rights for federally supported research projects. To enhance industry support of university research, the Congress should give serious consideration to extension of the Research and Development tax credit. This tax credit provides incentives for further corporate investment in R&D in university laboratories. The SBIR act supports the development of new technologies in small companies and has the potential for creation of new jobs as is well known from recent experience. Under the terms of the SBIR universities can support the research efforts of the recipients of SBIR awards.

The following examples will provide a pointilistic representation of past and ongoing research with technology transfer implications at the College. As noted earlier, it may require several years for a technology transfer to result in a technology transfer. There are several examples of research efforts which produced successful transfers leading to: kidney dialysis machines, the insulin pump, the application of ultrasound for imaging of human organs, the use of ultrasonic doppler velocimetry to observe blood mass of flow in the aorta. Some examples of recent transfer of technology which have promise of commercial value include the following.

1. KIDNEY STONE REMOVAL BY NONSURGICAL MEANS

The kidney stone project is an example of current research supported by industry that involves technology transfer. The technology has been purchased by a local firm, which is now funding continuing research in Aeronautics and Astronautics ($120,000 this year) and in urology. This research is directed to basic scientific studies of the fluid dynamics and physics of laser-driven stone fragmentation, this work has been described in recent newspaper articles.

2. OPTIMAL NONLINEAR DISCRIMINANT FUNCTION ALGORITHMS

The objective of this research is to develop real-time computer-based algorithms for the identification and classification of objects from non-imaging radar returns. Applications include air-traffic control, ship traffic control, law enforcement systems, and defense systems. Technology transfer is an ongoing activity in this research which is sponsored by the Boeing Aerospace Company.

3. DEVELOPMENT OF GENERAL PURPOSE THREE-DIMENSIONAL COMPUTER HUMAN BODY MODEL

The objective of this research is to develop a computer-based model of the human body for the study of electrical activity, both natural and induced (e.g., by defibrillation). The purpose of the model is to aid in the development of safe medical electronic instrumentation for emergency and hospital care of patients. The research is funded by Physio-Control Corporation and technology transfer is anticipated over the next six to eight months.

4. DEVELOPMENT OF MULTI-AXIAL FORCE SENSOR FOR MACHINE TOOLS

Operation of automated factories requires continuous online sensing of the condition of the cutting edge of the machine tool. This project is supported in part by a local small industrial firm, and is directly aimed at commercialization.

5. AUTOMATED HOLE GAGING FOR MECHANICAL FASTENERS

Invented in our Manufacturing Research Laboratory, the prototype-automated hole gage is nearing the commerical application state. This automated device verifies roundness and internal surface finish quality of a drilled hole, essential to assuring the structural integrity of mechanical fasteners (such as rivets) designed to fill the hole. Combined capacitive and electrostatic real-time signals are analyzed online by software written in our laboratories. The basic technical principle has proven so successful that two related technologies have spun off, one currently being commericalized through an NSF SBIR cooperative grant with a firm in Kent, Washington.

6. CONTROLLED PULSE ELECTROMAGNETIC RIVETING

Through use of controlled discharge of large capacitor banks, electromagnetic motive forces can be controlled so as to upset rivet heads at a controlled, optimal rate to minimize formation of stress cracks. This in turn permits the use of significantly stronger rivets than is now possible. This device has been developed to the prototype stage, and is expected to have a major impact on manufacturing fabrication in the ship and aircraft industry. It is probable that this project will spin off a small business to further develop and market the "shaped electrical pulse" innovation to other areas of hot and cold metal forming.

Unfortunately, technology transfer sometimes results in the loss of distinguished faculty. In the recent development of a thermal cantery probe, the faculty investigator first took a leave of absence for two years to work on product development and subsequently resigned his faculty appointment to continue industrial development of biomedical devices.

The College, of course, is disappointed at the loss of a leading researcher but is also pleased that this lifesaving device will now be available to doctors. It is a small price to pay for such progress.

Hopefully, these remarks will be helpful to the subcommittee in its efforts to define appropriate roles for the Congress to play in the enhancement of technology transfer.

Senator GORTON. Thank you, Dr. Bowen.

Dr. Illman?

Dr. ILLMAN. Yes. Senator Gorton:

My name is Dr. Debora Illman. I am the assistant director of the Center for Process Analytical Chemistry, or CPAC, at the University of Washington. In summarizing my testimony today, I will first present a brief description of our program, then I will comment on our mechanisms for technology transfer, and will conclude by discussing concerns we have encountered in running a university-industry research partnership.

CPAC is an industry/university cooperative research center, founded with a half million dollar grant from the National Science Foundation's program for Industrial Science and Technological Innovation. It was officially founded in July of 1984 after a planning phase conducted by its co-directors, Bruce R. Kowalski and James B. Callis, both of the Department of Chemistry, and myself, with assistance from the Chemistry Department's Chairman Alvin L. Kwiram.

The mission of CPAC is to advance the state of the art of sensors that can monitor and control chemical processes. In many types of industries, chemical reactions are used to convert raw materials to finished products. But as markets become more competitive, raw materials more costly, and as American industry moves toward increased automation, we need to build sensors directly into the processes themselves to operate as chemical "eyes", if you will, watching the process and relaying information to the control computer. Sensors are currently the missing link in any automated manufacturing that involves chemical materials.

There has been a tremendous driving force by industry to establish this center, simply because they need the technology. It is sponsored by 25 organizations. Each pays a $30,000 annual sponsorship fee. Of these 25, 4 are national laboratories and the remaining 21 are major companies, such as DuPont, 3M, Exxon, IBM, and others.

I would now like to comment on technology transfer through CPAC. I have described in the written testimony the various ways in which technology transfer occurs at CPAC, but I would like to note that CPAC is much more than an industrial affiliates program, in the sense that it has an infrastructure which is dedicated to promoting interaction between the university and industry.

Ours is based on the NSF center model that has been evolving over the past 6 or 7 years and the sponsors like it. They are satisfied with our policies and operations, and I believe they feel they have a voice in what goes on at the center. Both industry and government have been able to work hand in hand to arrive at a mechanism that really meets the needs of all the groups involved.

The strong driving force that has carried CPAC this far is still pushing very hard to expand it even further. Our sponsors have come to us to suggest that we seek major State and Federal funding to make this program commensurate with such an urgent national need. In order to begin, CPAC needs a sizable commitment from the university and the State, mainly for laboratory and office space and faculty positions. Obtaining these resources and support remains one of our most crucial problems.

The final topic I would like to discuss today relates to two barriers to technology transfer that we have encountered so far.

The first barrier concerns participation by Department of Energy's national laboratories. Many national labs and DOE contractors have expressed interest in sponsoring CPAC, but they have encountered three basic problems:

Number one, the DOE laboratories do not have a convenient mechanism for funding programs such as CPAC.

Number two, the DOE and NSF sponsorship provisions are not entirely compatible.

Number three, DOE has apparently tried to limit the number of labs and contractors participating in CPAC, even though these organizations have unique interests and needs.

For example, DOE refused to allow Westinghouse, Rockwell-Hanford and Battelle to have separate sponsorships in CPAC and actually expected all three to participate through the Battelle Pacific Northwest Labs. There is a limit to the size of an operation that can effectively "interface' with our program and it is unrealistic to expect these three organizations to participate in this fashion.

In view of the formidable challenges faced by the national laboratories in monitoring and processing of nuclear materials and even moreso in the accountability of nuclear materials, I would urge a greater and not a lesser participation of these labs in CPAC. Furthermore, we would like to urge the NSF and DOE to facilitate and not impede the joint funding of such programs as CPAC.

The second difficulty we have encountered relates to sponsorship of CPAC by foreign-owned companies. Several have requested to join the center. Apparently there is no official NSF policy on this, and furthermore the sponsors are barred by antitrust laws from voting on this issue as a group.

Now, CPAC was set up with NSF support to stimulate technology transfer, but to what extent should it facilitate the export of technology to foreign countries? The heart of the issue is that the directors of our program have been put in the position of making this decision with no formal guidelines from NSF, the Federal Government, nor the sponsors of this program. In fact, the Director of the National Science Foundation has actually encouraged our research directors to approach the Departments of Commerce and Defense about this.

We do not believe it is appropriate for university researchers to take this matter into their own hands and would vastly prefer that Federal agencies establish a consistent national policy.

In conclusion, we believe CPAC is a very viable model for basic research and technology transfer with industry. CPAC has gathered an extremely strong base of industrial support, from which we hope to grow in the future, and this mechanism could be improved if DOE would establish more realistic procedures and if the Federal Government would develop a consistent policy for foreign sponsorship for NSF centers.

In closing, I would like to thank you for this opportunity to present this material.

[The statement follows:]

STATEMENT OF DR. DEBORAH L. ILLMAN, ASSISTANT DIRECTOR, CPAC

I. INTRODUCTION: OVERVIEW OF THE PROGRAM

The Center for Process Analytical Chemistry (CPAC) at the University of Washington (UW) is an industry/university cooperative research center founded in July of 1984 with a $550,000 grant from the National Science Foundation's Industrial Science and Technological Innovation Program. The program in operation today is the outgrowth of a 1982–1984 planning phase which was funded in part by a $52,000 grant from the National Science Foundation (NSF), and which was conducted by Drs. Bruce R. Kowalski, James B. Callis, and Deborah L. Illman of the Department of Chemistry, with assistance from Chemistry Department Chairman Alvin L. Kwiram.

The Center is dedicated to the advancement of technology for monitoring and controlling chemical processes. Basic research at CPAC focuses on new sensors, instrumentation, and strategies that will enhance the productivity of chemical and other manufacturing industries.

Many types of industries, ranging from semiconductor manufacturing to food processing, utilize chemical processes to convert raw materials to finished products. During the manufacturing operation, it is usually necessary to measure the chemical composition of the materials in order to adjust product quality, measure levels of impurities, and accurately control the performance and efficiency of the process.

Today, only very rudimentary measurements on such systems can be made directly. This is a severe limitation on the performance of these manufacturing operations and on the kind of control that plant operators can achieve.

American industry is looking toward increased automation in order to remain competitive in world markets, especially as energy and raw materials become more costly. Automation will require more sophisticated chemical sensors and measurement technologies that can be used to fine tune manufacturing procedures and thereby improve efficiency and productivity. It is becoming imperative to build sensors directly into the manufacturing plant to operate as "eyes" in a chemical sense, to monitor the reactions and relay information to the computer network controlling the process. American industry can no longer afford the time-consuming manual labor to test samples in a remote laboratory, and it can no longer afford to operate at less than optimal efficiency.

In the broader scope, these new sensors will have many features that make them useful for medical and environmental monitoring as well. After all, the human body or the complex ecology of a watershed are both dependent upon chemical processes. Research projects in many such areas are being conducted at CPAC with the central theme of developing new measurement tools that are real-time, non-invasive or non-destructive, and that are incorporated directly into the system that they are analyzing. Also, they are usually coupled with the latest microcomputer or integrated circuit data processing capabilities to permit automated control of the system based on the results of the analysis.

A list of research projects undertaken during CPAC's first year and their principal investigators is provided in appendix A, together with a brochure about our program.

There has been a tremendous driving force by industry to establish this Center. CPAC is sponsored by 25 organizations that each pay a $30,000 annual membership fee, which is pooled and distributed to about a dozen interdisciplinary research projects involving chemistry and engineering. Of these 25 sponsors, 4 are National Laboratories and the remaining 21 are major national companies:

3M
Battelle Pacific N.W. Labs
Combustion Engineering
DuPont
Exxon
Goodyear
IBM
Los Alamos National Lab (2)
Perkin-Elmer
Procter & Gamble
Savannah River Lab
Technicon Instruments
Amoco Corporation
Beckman Industrial Corporation
Dow Chemical
Eli Lilly and Company
Foxboro Analytical
Hewlett-Packard
Kodak
Monsanto
Phillips Petroleum
Rexnord
SOHIO
Weyerhaeuser

In addition CPAC has received a $550,000 NSF grant over 5 years for core support. At the end of this period the Center is to become self-sustaining by means of industrial and other support.

The University has pledged two faculty positions, two technicians, operating funds, and 7,000 square feet of space in support of the CPAC program.

II. CPAC POLICIES, PROCEDURES, AND MANAGEMENT

CPAC is more than an industrial affiliates program; it differs in its infrastructure, which is dedicated to promoting interaction between the University and industry. CPAC is based on the NSF model for cooperative research centers that has been evolving over the past 6 or 7 years. The sponsors seem satisfied with our patent and other policies and procedures. They are extremely positive about the contracts they have with faculty and students, which are usually coordinated through the CPAC office. I believe they feel they have a voice in CPAC's decision-making process.

A detailed description of the management structure of CPAC is contained in appendix B, which is taken from the CPAC grant proposal to the NSF.

Our patent and publication policies and sponsorship agreement are presented in appendix C. Sponsors have the right to review research results before they are published, and to request a publication delay of 6 months if they feel a discovery is patentable. While the UW retains the rights to patents and inventions, sponsors are guaranteed at least a non-exclusive, royalty-free license to use them.

Because close interaction between University and sponsor personnel is an important key to the success of such a research partnership, we have devised a set of guidelines for CPAC-sponsor interaction. There are a number of ways of interacting, some desirable and encouraged, others potentially counterproductive. These guidelines, which are presented in appendix D, are set out to protect the educational and professional careers of the University personnel, and to ensure that the sponsors' investment in basic research will yield maximum productivity.

III. TECHNOLOGY AND BENEFIT TO INDUSTRY

The CPAC sponsors have been an extremely strong driving force to initiate this program because of the opportunity to fund basic research in an area of such vital concern. The Center provides continuity of funding to these basic research efforts in a highly interdisciplinary and rapidly evolving field. Participation in a cooperative center offers the advantage of leveraging a company's research dollars by combining federal, university, and industrial resources in a joint venture. A cooperative also allows the pursuit of a broader range of projects, perhaps of higher risk, than is often possible within a single sponsor organization.

Sponsors also receive many tangible benefits for their $30,000. These constitute many of the ways technology transfer actually occurs through CPAC. One of the most important ways technology transfer occurs is via the transfer of people themselves. Sponsors are extremely eager to hire the specially-trained analytical chemists graduating from this program. Industrial personnel will also have the opportunity to participate directly in CPAC research. For example, one of the National Laboratories will send a visiting scientist to spend a year's sabbatical at CPAC.

Other means of transferring technology include: (1) Semi-annual technical meetings on campus; (2) progress reports; (3) access to a CPAC computer network and database; (4) early transmittal of preprints, theses, and meeting abstracts; and (5) short courses.

Now at the end of its first year of operation, CPAC can report a rough quantitative measure of its progress toward its research goals and toward the transfer of technology to industry. Beyond the dozen or so technological advances that we can cliam in the areas of sensors, spectroscopic instrumentation, data processing, and others, we have routed 10 manuscripts to our sponsors for patent review and another 6 are on their way; moreover, 2 patent disclosures and 3 other review articles have also resulted from the program. These are detailed in the Executive Summary of appendix E. It is unlikely that the personnel in these sponsor companies would have learned of these results at such an early time without the CPAC interface. In summary, CPAC research results are definitely not just being published and sitting on a library shelf for many years before companies find out about them.

Moreover, we collect on paper and at meetings the input from industry about the directions they feel are useful and important; they have a great deal to contribute. These are communicated to the faculty researchers as well as incorporated into the Director's decision-making process as discussed in the management plan of appendix B.

The Center is anticipated to benefit Washington state in seveal ways and to stimulate the transfer of technology to existing as well as new companies in the region. These potential benefits are presented in appendix F.

IV. BARRIERS TO TECHNOLOGY TRANSFER

The strong driving force that has carried CPAC this far is still pushing hard to expand even further. Our sponsors have come to us to suggest that we seek major state and federal funding to take this program to a level commensurate with such an urgent national need. In order to begin, CPAC would need a sizable commitment from the University and the State of Washington mainly for faculty positions, operating support, and at least 7,000 square feet of laboratory and office space for the CPAC program. However, of this promised support we have so far only 1,000 square feet of space; the funding for faculty and staff positions is still uncertain. We have encountered relatively few problems in the course of our evolution, but these resources remain our most crucial difficulty.

A second set of difficulties I would like to mention are the problems the National Laboratories have faced in trying to sponsor CPAC. They have encountered three stumbling blocks: (1) The DOE Laboratories only have a mechanism for funding contract-type research, not for paying "sponsorship fees"; (2) the rather lengthy DOE and NSF provisons for sponsorship were apparently at odds upon first examination; and (3) the DOE apparently feels that the various National Laboratories should not be considered separate entities, or at least wished to limit the number of Labs participating in CPAC.

For example, it was suggested by the DOE that Los Alamos National Laboratory should not join CPAC since the Pacific Northwest and Savannah River Laboratories were already sponsors. The DOE also suggested that Hanford contractors such as Rockwell and Westinghouse should participate in CPAC through the sponsorship of the Battelle Pacific Northwest Laboratories. Although these three companies have substantially different interests and sought separate sponsorships, the DOE prohibited Rockwell and Westinghouse from joining the Center. Apparently the DOE does not understnd that part of the sponsorship fee actually "purchases" the services of the CPAC staff to provide an interface between the sponsor and University personnel. There is a limit to the size of an operation that can effectvely interface with CPAC. Moreover, each sponsorship corresponds to one voting member of the CPAC Industrial Advisory Board, which allows input from sponsors to CPAC's decision making process.

In view of the formidable challenges faced by the National Laboratories in the areas of remote sensing, automated processing of nuclear materials, monitoring of storage facilities, and the need for accountability of nuclear materials. I would urge greater, not lesser, participation in CPAC. Furthermore, we urege the NSF and the DOE to facilitate and not impede the joint funding of such programs as CPAC.

The third difficulty I would like to address concerns the question of foreign-owned companies sponsoring CPAC. Several such companies—Rhone Poulenc of France, Matsushita Electric of Japan, and Ciba-Geigy of Switzerland—have asked to become sponsors. Apparently there is no official NSF policy on this matter (see appendix G) and furthermore the sponsors are barred by anti-trust laws from voting as a group on the question of admitting these companies. CPAC was set up wtih NSF support to stimulate technology transfer, but to what extent should it facilitate the export of technology to foreign countries? The Directors of CPAC have been put in the rather uncomfortable position of making this decision with no formal guidelines from NSF, the federal government, or the sponsors of our program. Should the CPAC Directors take the responsibility for contacting the Departments of Defense or Commerce to assess the consequences of admitting foreign sponsors, as has been suggested by the director of the NSF? It certainly seems that this issue has much broader policy implications and is worthy of some attention from this committee or another appropriate government office.

Finally, the issue of patent policy remains somewhat delicate for both industry and the University. In the basic sciences at least, patents are not held in the same esteem as publications and so there is some resistance to comply with the industrial review procedure. Industry on the other hand tends to be too eager to request a publication delay. While these are not serious concerns, they reflect the tension that exists when entities with such dichotomous interests, objectives and methods are brought together. CPAC acts as the stabilizer that allows these two groups to work together.

V. CONCLUSION

The National Science Foundation's Industry-University Cooperative Research Center for Process Analytical Chemistry has provided a successful framework for technology transfer to industry. This Center at the University of Washington is an excellent example of how such a research partnership can focus on a national technological need. Our program has gathered an extremely strong base of industrial support from which we hope to grow in the future. The NSF Coopertive Center model on which CPAC is based has been an effective mechanism for interaction between industry and the University.

To enhance the success of this and other university-industry cooperative research centers, we recommend that the DOE establish more realistic procedures and that the federal government develop a consistent policy for foreign sponsorship.

With this fine-tuning, this cooperative research center will make a significant contribution to our national technological strength and to the competitive posture of American industry.

Senator GORTON. Thank you very much, Dr. Illman.

Dr. Young?

Dr. YOUNG. Senator Gorton.

My name is Paul Young and I am the Chairman of the Computer Science Department at the University of Washington. In that capacity, I serve on the board of directors of the University of Washington's VLSI consortium. In my oral testimony this morning, I will attempt to briefly summarize the operation of this organization.

The consortium was formed by the Department of Computer Science and five high technology firms in the Pacific Northwest: Boeing Aerospace, John Fluke Manufacturing, Honeywell Marine Systems, Microtel Pacific Research in Canada, and Techtronics. Its objectives are the enhancement and promotion of computer-aided design technologies for complex integrated circuits. It tests its experimental software with practical design examples taken from industry.

Its history goes back to the summer of 1979, when Carter Mead of the California Institute of Technology, under the sponsorship of the Boeing Aerospace Company, conducted a course at the University of Washington based on the Mead-Conway principles of VLSI design. Enthusiasm created by this class caused Boeing Aerospace and the university to propose an organization involving both academic and industrial participants and dedicated to further exploration of the Mead-Conway approach.

They invited other companies to join and, after a lot of effort, settling the organizational and legal issues and a written operating agreement, the consortium commenced operations during the summer of 1982. Initially, the companies contributed funds for the purchase of an appropriate computer system and made internally generated software available. They also agreed to pay annual fees for

operating funds and, most important, each assigned their own liaison person to work full-time on campus. In addition, the consortium obtained a major contract from DARPA for evaluation and system integration of software generated both within the consortium and software from other academic institutions.

The operating agreement specifies that no proprietary work may be done within the consortirum and that all results will be available publicly. Research results are published in the open literature and software developed is licensed to members at no charge on a non-exclusive basis. Releases to academic and government agencies are essentially free. Industrial firms receive the software and other benefits—that is, educational programs and technical consultation—by paying a fee to join the consortium as associate members. Such membership is open to all U.S. and Canadian companies and cost varies with the size of the company.

We believe that in order to ensure the free flow of information among the members and to underscore the cooperative nature of its missions, the consortium should not engage in any proprietary activities, nor should there be any limitations on publication. This policy of openness does not hold in some other university-industry cooperative arrangements.

We believe that this openness is in the tradition of academic freedom and scientific cooperation and that it fosters the most rapid technological advancement. Thus, the consortium shares its results with the greater VLSI community and also benefits from the ideas of others.

Periodically, the consortium's design system is packaged for distribution to the VLSI community. This entails adding documentation and preparing installation directions. To do this, we have added tutorials that assist new users of the system in use of more advanced features, such as the simulators.

Release 1.0, a reasonably comprehensive set of tools to support NMOS technology, was distributed in October 1983, and ultimately 83 universities and research labs received copies.

The first comprehensive CMOS tool set was announced in August 1984. Since that time, two subsequent releases have further enhanced the system and the list or recipients now exceeds 140. The release of an improved design system occurs approximately every six months.

The tool sets, which integrate software donations from Boeing and Microtel Pacific Research, software from the University of California, Berkeley, from Carnegie Mellon and M.I.T., as well as locally developed software, provide the designer with a reasonably VLSI CAD system. This effort, originally funded by DARPA and now supported by the consortium pro bono, reflects the consortium's commitment to enhance the general VLSI environment.

Another important consortium contribution to technology transfer in the Northwest design community is in the form of education. This occurs in two ways.

The consortium supports approximately two VLSI design classes per quarter on behalf of the University of Washington's Computer Science and Electrical Engineering Departments. Assistance includes computer-aided design, software, computer resources, and personnel. The university could not offer these courses without consortium support.

But in addition to these regular university classes, the consortium provides a number of educational opportunities for industrial designers and engineers. These include intensive design courses lasting a few weeks, 1-day overview courses, advanced seminars on special topics, as well as an ongoing colloquium series. Research and development programs also provide support for graduate students.

In general, the development work of the consortium is financed by industrial members, while basic research is dependent on government contracts. The key ingredient in the consortium's current funding mix is a research contract with DARPA. This award provides funding for the consortium's basic research program as well as access to the MOSIS facility for fast turn-around multi-project chip fabrication.

Our research now focuses on computer-aided design tools to support the design of VLSI circuits. One such tool is a design generator, a program that, given some inputs, generates a complete layout from which the circuit may be fabricated. The generator may free the designer from the time-consuming task of handcrafting layouts of circuits that are used over and over.

The key point about generators is that they package expertise in such a way that others can build on techniques developed in other settings.

The regional nature of our consortium provides two unique benefits.

First, the Governing Board, which consists of local industrial lab managers and university administrators, meets monthly, enabling close industrial-university supervision of the consortium's activities.

Second and perhaps the most important, the industrial liaison personnel, while spending one full year working with the consortium on campus, maintain close links with their home companies. This contributes to technology transfer in three ways: first, to the university from the companies; among the companies themselves; and from the university back to industrial, keeping the university well informed about industrial needs.

For all of these reasons, the University of Washington Northwest VLSI consortium has played a very significant role in the continuing transformation of ICD design technology in the Pacific Northwest.

In closing, let me draw your attention to our most critical problem. Due to high demand, there is a continuing shortage of high quality personnel in computer science and computer engineering. The consortium itself has had vacant research positions for several years which we have been unable to fill. This is part of the more general national problem.

For the past several years, in spite of increasing demand for computer scientists and engineers, according to NSF statistics, Federal obligations for support of basic research in computer science have grown more slowly in support of basic research than any other major related scientific engineering area. This makes industial careers increasingly attractive to computer scientists, leading to severe shortage at the research level computer scientist in the universities.

This is a problem which your Committee might want to address at an appropriate time.

Thank you.

[The statement follows:]

STATEMENT OF DR. PAUL YOUNG, PROFESSOR AND CHAIRMAN, DEPARTMENT OF COMPUTER SCIENCE, UNIVERSITY OF WASHINGTON

UNIVERSITY OF WASHINGTON/NORTHWEST VLSI CONSORTIUM

High Technology Cooperation

The University of Washington/Northwest VLSI Consortium is a cooperative effort between the Computer Science Department of the University of Washington and five high technology corporations from the Northwest. The purpose of the Consortium is to promote research and education in very large scale integrated (VLSI) circuit technology, and to encourage technology transfer among the members and to the community at large.

The agreement creating the Consortium was signed in 1982, but the recognition that cooperation would be crucial to realizing the promise of VLSI dates back to the late 1970s. In a month-long intensive course in 1979, Carver Mead electrified members of the UW and local electronics communities with his vision of the future: VLSI will be a powerful medium to be exploited, not just by an elite few, but by many practicing engineers and computer scientists. These people will require intensive training on state-of-the-art facilities if they are to become accomplished in the many topics required of designers: device characteristics, circuit and logical design, architectural and algorithmic structures. Moreover, to manage the complexity of assembling 10^3—10^6 transistors into a useful, effective system will require sophisticated and innovative design tools.

Everyone wanted to benefit from the coming VLSI revolution, but no one could do it alone. Cooperation was in everyone's enlightened self-interest.

Although the need for cooperation was obvious, the mechanism for cooperation was not. University/industry consortia, now rather fashionable, were all but nonexistant at the time. The final structure—a permanent organization housed in the computer science department composed of a mix of faculty, graduate students and liaison personnel from the member firms and guided by a board of directors—has provided to be a flexible, productive environment built upon the resources of the members and serving their needs.

Goals

There are three objectives which the Consortium pursues on behalf of its members:

Education: To provide and support instruction and training of university students and practicing engineers from the Pacific Northwest.

Technology Transfer: To exchange among the membership software, methodologies and other technical expertise that improves VLSI design capability.

Research: To study and discover new ways and to exploit VLSI technology and to make fundamental contributions in algorithms, circuits and data representations.

The pursuit of these objectives has motivated a variety of activities, as outlined in subsequent sections. It has also prompted the Consortium to widen its perspective. Once regional in focus and of necessity largely retaining that character with its educational mission, the scope of the Consortium's other activities now encompasses North America generally and often the wider international VLSI community as well.

Education: Learning through doing

The Consortium supports approximately two VLSI design classes per quarter on behalf of the Computer Science and Electrical Engineering Departments. Assistance includes computer aided design, software, computer resources and personnel. A three quarter sequence of classes: Introduction to VLSI; advanced VLSI design-laboratory; test and reliability provides hands on experience with the complete design cycle: architectural issues, planning, circuit design, layout, simulation, checking, fabrication, and testing. The students' chip designs are fabricated using the MOS Implementation Service (MOSIS) provided by the Defense Advanced Research projects Agency.

In addition to these regular University classes, the Consortium provides a number of educational opportunities for industrial designers and engineers:

Intensive design classes to introduce the fundamentals of CMOS design, instruct in the use of the design tools, guide the student through the design of a complex chip of his choosing, and finally to provide for the fabrication of the chip.

One-day seminars to introduce the techniques of custom VLSI design and provide limited hands-on experience with the tools.

Workshops which focus on advanced topics of particular interest to the VLSI community, and provide a forum for sharing experience and discussing future directions.

The Consortium welcomes University faculty and graduate students who require the Consortium's hardware and software resources for research. Recent projects include microcomputer architectures, image processing, digital circuit simulation, and test stimulus generation.

Experts sharing expertise

There is VLSI expertise to be found in industry and the university but they are of essentially different types. The Consortium members benefit from both types of expertise through the mechanism of the

Consortium liaison: A scientist or engineer of a member firm who spends a year on campus participating in all Consortium research and development activities.

The liaison brings experience and a knowledge of challenging, practical problems together with a business-like propensity to get a project done. The liaison receives exposure to the active research projects of the academic community plus an opportunity to explore interesting topics and contribute to the Consortium's projects without deadline pressure. In this way the liaison is a conduit between the industrial and academic communities, exchanging information and knowhow.

Research results are published in the open literature and software developed is licensed to members at no charge on a non-exclusive basis. Releases to academic and government activities are essentially free. Industry may receive the software and other benefits (educational programs and technical consultation) by paying a fee to join the Consortium as Associate Members.

We believe that in order to insure the free flow of information among the members and to underscore the cooperative nature of its missions, the Consortium should not engage in any proprietary activities nor should there be any limitations on publication. This policy of openness does not hold in some other university/industry cooperative arrangements, but we believe this is the tradition of academic freedom and scientific cooperation, which fosters the most rapid technological advancement. Thus the Consortium shares its results with the greater VLSI Community and also expects to benefit from the ideas of others.

Tools of the artisan

The Consortium collects VLSI design tools from other universities and from its industrial partners, and it also writes new CAD software. The purpose of collecting tools produced by others is to evaluate them, the ideas, the quality of the implementation, and the degree to which they assist the designer. The purpsoe in writing new tools is to fill gaps in the tool set thus far assembled, to incorporate new advancements developed here or elsewhere, or to unify distinct systems. An efficacious subset of the CAD software thus assembled has been packaged into a unified system for use in our lab. The designers who use the system are our students, liaisons, and staff personnel with diverse backgrounds, and the chips produced range from several transistor homework assignments to full 32-bit microprocessors. As a result the software is stressed in a variety of ways and opportunities for advancing the state-of-the-art are exposed.

CMOS Toolset.—Graphical layout editor; procedures for algorithmic layout; finite state machine/PLA generators; standard cell library; circuit extraction; analog/switch-level simulators; and plotting utilities to aid layout and simulation.

Periodically, the Consortium's design system is packaged for distribution to the VLSI community. This entails adding documentation and preparing installation directions. To this we have added tutorials that assist new users of the system in the use of more advanced facilities such as the simulators. Release 1.0, a reasonably comprehensive set of tools to support CMOS technology, was distributed in October 1983, and ultimately, 83 universities and research labs received copies. The first comprehensive CMOS tool set (Release 2.0) was announced in August 1984. Since that time, two subsequent releases have further enhanced the system and the list of recipients now exceeds 140. The release of an improved design system occurs approximately every six months. This effort, originally funded by the Defense Advanced Research Projects Agency and now supported by the Consortium *pro bono,* reflects the Consortium's commitment to enhancing the general VLSI environment.

Organization: Pooling for mutual gain

The Consortium's activities are governed by a Board of Directors, formed of representatives from full member firms and the University of Washington. This Board provides long-term direction guidance on matters of policy, and a direct interface to the member firms.

A key element in the staffing of the Consortium is the contribution of technical liaisons by member firms. These liaisons, a responsibility of full member firms, serve a one year term and provide continuous member representation in all Consortium activities.

Membership categories.—There are two categories of membership available to interested firms.

Full members contribute a substantial initiation fee and provide a technical liaison; benefits are the close working relationship provided by the liaison and the influence of Consortium activities through representation on the Board of Directors.

Associate membership is provided for those firms which desire some involvement in Consortium activities but cannot afford the commitment of full membership.

Both membership categories have access to the educational programs, technical consultation and the release version of the design software.

A permanent staff of scientists and engineers provides continuity for the research effort and trains new members of the group. Graduate students in both Computer Science and Electrical Engineering contribute to Consortium projects while working on research projects in VLSI design leading to graduate degrees.

A very important ingredient in the Consortium funding mix is a research contract with the Defense Advanced Research Projects Agency (DARPA). This award not only provides funding for the Consortium's basic research program, it provides access to the MOS Implementation System (MOSIS) facility for fast turn around multiproject chip fabrication, and contact with other DARPA VLSI research contractors, a major segment of the VLSI research community.

Research

Current research focuses on software tools that aid the design of VLSI circuits. One such tool is a design generator, a program that, given some inputs, generates a complete layout from which the circuit may be fabricated. A generator may thus free the designer from the time-consuming task of handcrafting layouts of circuits that are used over and over.

The benefits of our work can be viewed from three different distances. At the closest range we will write generators that will help other designers. At the midrange we will describe a methodology of constructing generators that will enable others to expand upon our results. At the longest range our work will validate the concept of separated design and fabrication. By making robust, quality parts, we will establish that production grade circuits can be produced in a brokered environment.

In the course of developing and demonstrating our ideas about design generators, we will build a variety of generators that will distributed to the VLSI community. The key point about generators is that they package expertise in a way that we and others can build on them.

Senator GORTON. Thank you, Dr. Young. We have your statement earlier on.

You do not sponsor any strictly proprietary research?

Dr. YOUNG. We do not.

Senator GORTON. Is that true of the other group of schools in this area at the university?

Mr. BALDWIN. We do not engage in strictly proprietary research. On the other hand, we certainly are open to entering into a relationship with a given industrial sponsor which involves the use of some of their proprietary information. We have a set of policies and mechanisms within the university which can assure the industrial sponsors that that proprietary information will be appropriately protected.

Senator GORTON. What about the results?

Mr. BALDWIN. We are not willing to be bound in any case by a circumstance where we could not publish the results of our research within a reasonable time. If we are dealing with an industrial sponsor where we have had access to some of that sponsor's proprietary information, we are quite willing in the agreement with that sponsor to

assure them of the right to look at any anticipated publication before it goes to press, just to be sure that we have not inadvertently disclosed any proprietary information.

Senator GORTON. You seem to be agreeing, Dr. Illman?

Dr. ILLMAN. Yes. That is consistent with our operations. Our basic research is of a very general and basic nature and, while we may have obtained a research contract, in no case are the results simply returned to the company. They are all publishable.

Mr. BALDWIN. This is one of the considerable advantages to the consortium type of arrangement the specific project arrangement. Where several industrial sponsors are contributing to an overall program, there is a considerable reduction of any conflict of interest issues and virtical elimination of the proprietary mission problem.

Senator GORTON. So is it accurate to say in the case of all of you that all results are subject to being published?

Mr. BALDWIN. Indeed they are. The one point that perhaps should be mentioned is that we do sometimes agree to delay publication for what we consider a reasonable time so as to be able to file, ourselves or have our agent file for us, a patent application to protect that technology. Such a delay is generally on the order of 3 to 6 months.

Senator GORTON. That leads to the next question. What are your policies on patent ownership and licensing? Is it the same across the board?

Mr. BALDWIN. They are all consistent, because we have a single body of university policies which applies to all of its units and programs. The essence of that policy is that the university owns the technology. It is a condition of employment at the university that employees agrees that they will assign their rights and interests to the university, so the university is then in a position to proceed with commercialization of it.

Senator GORTON. Does the university get all of the royalties or are any of those royalties passed through to the faculty who have worked?

Mr. BALDWIN. We have what we think to be a very generous policy for the inventor and the inventor's department. In our case, the inventor receives 100 percent of the first $10,000 of the fees and royalties, 50 percent between $10,000 and $40,000, and 30 percent beyond $40,000 in accumulated royalties.

In those three thresholds, for example, the first one, nothing goes to the department nor to the university in general. In the second one, where the inventor gets 50 percent, the inventor's school or department gets 25 percent and the graduate school research fund gets 25 percent. The latter is recycled through a series of faculty committees back into additional research for faculty and graduate student support.

Where we get over $40,000 in cumulative royalties, then the balance swings more favorable to the university in general. In that ratio, the school and the department of the inventor get 20 percent of the royalties and 50 percent goes to the graduate school research fund to be recycled in the manner that I just mentioned.

Senator GORTON. Do you have significant income at the university through these royalties?

Mr. BALDWIN. No, we do not at the present time. We are hoping that the future will hold a somewhat different story.

Senator GORTON. Do any of the rest of you want to comment?

Dr. ILLMAN. I just wanted to comment that our royalty distribution schedule was modified so as to allow CPAC to receive some of those royalties back into the CPAC organization itself, which is an interdisciplinary cross-college center.

Dr. BOWEN. The only comment I would like to make is based on my experience at the University of Wisconsin, and there it is about a 50 year experience of the Wisconsin Alumni Research Foundation. It was established in the late twenties to hold patents that were developed by the College of Agriculture and Life Sciences there.

Over that 50 year experience, they have had about 2,000 disclosures. Only about 40 of the patents actually recovered all the costs and produced a profit. And only four of those had royalties that would be measured in the orders of magnitude of hundreds of thousands and millions of dollars. So there are very few winners and you are lucky to get one.

Mr. BALDWIN. We do not anticipate that the university would ever enjoy large sums from royalties and fees on its inventions. We think that the areas where there will be substantially greater gains are in the response to these mechanisms I mentioned earlier, our efforts to interact more and more effectively with industry.

For example, this year we already have $5 million more in industry-supported research than we had last year. So that is the important growth that we want to keep our eye on. We believe that the nation as a whole benefits from the greater effectiveness in transferring technologies out of our university laboratories and into the private sector. So those will continue to be our areas of primary emphasis.

The fact is, we believe if we do a decent job in those areas that the dollars from royalties will take care of itself.

Senator GORTON. Have the results of the changes in 1984 been sufficient with respect to patents?

Mr. BALDWIN. Others may wish to comment for themselves. My own personal view is that those amendments now give us a very good Federal patent policy. I would not at this moment suggest other changes. I think they are quite viable.

Senator GORTON. Are most of your joint research programs those which involve really large companies, or are you getting interest and participation by medium-sized and smaller corporations?

Dr. ILLMAN. I was going to remark that most of ours are larger companies. Some of the smaller ones tend to be instrument companies, which from our point of view is great because we have the large companies which are the end users of this sensor technology and in the same group we have the instrument manufacturers.

That is kind of a synergistic mix that the companies even stated themselves that they wanted to see. However, there is a range in size of company. The very small firms which cannot afford our membership fee, we have discussed many times what to do about that, whether we should create a special category for them or involve them in some other way.

We have decided to do that on a case by case basis because it does increase the complexity of the whole organization if we consider doing that. So at this time we will consider bringing in a small company if they have something of special value to contribute to our activities. But otherwise we do not include them.

Mr. BALDWIN. In the cooperative research projects that were funded last year, we have been very sensitive to the spread among size of companies, and size of projects. It was interesting for me to note that over 70 percent of those relationships last year were in an amount of $25,000 or less coming from the industrial sponsor, nearly 25 percent were in the category of $25,000 to $100,000, and only 5 percent of those relationships involved dollar amounts over $100,000.

So it seems to me this is indicative of the opportunity for even small companies to interact quite effectively with the university.

Dr. YOUNG. Our five member companies are all quite large, but the board has been very sensitive to the needs of smaller companies. We have had interest from a number of small software houses to join or get some kind of benefit, and in response we established an associate membership where there is a sliding scale. Fees for associate members depend on the net sales of the companies, and we are just now beginning to have associate members join.

Dr. BOWEN. I have one comment. I think to some extent the size of the industry really is a function of the state or the history of the industry. Say in the bio-medical instrumentation, which is relatively young, the companies are usually small companies.

With a more mature industry, and a more mature area of research, you are likely to find a mix of very large companies and small companies that are trying start-ups. So it depends upon the area and the history of that industry as to the response to that question.

Senator GORTON. With respect to proprietary information, is that an inhibitor to an exchange program which would allow private scientists to work in your organization?

Dr. YOUNG. We have had some large companies refuse to participate in the consortium because of our unwillingness to do proprietary work. There is a very strong feeling among companies that are represented that part of what they are doing is pooling their effort and this cannot be attractive in an atmosphere which does not permit free exchange of ideas.

Initially, when the consortium was set up, there was a great deal of discussion about that. I was not here at the time, so I am reporting history. But ultimately, I think there was a feeling that VLSI is an area in which the technology changes so rapidly that thre is a huge benefit just being in on things in the beginning instead of waiting to see what

happens. If you get a year's lead time by participating in the research and development process, you already have a substantial benefit.

Dr. ILLMAN. When the issue of proprietary information has come up, we have assured the sponsor personnel that we would take every measure to protect such information and, for example, allow them to review a publication that contained any reference to such material, and we have several companies that are interested in sending their personnel to work in the university. One will be coming on sabbatical in August to spend a year. So we do not see any barrier in that sense.

Senator GORTON. To what extent do you limit the ability of faculty members to consult?

Mr. BALDWIN. The university has a general policy on this point under which the faculty are allowed to engage in outside consulting up to 13 days per quarter, and the limitation is expressed solely on the basis of time. The university does not get at all into the business of how much money that faculty member is paid.

The presumption that underlies the policy is that the faculty member and students that that faculty member advises will benefit from the involvement with industry and the association with real world problems in the state or the community.

Dr. ILLMAN. In our center, we have taken some special measures to protect all of the faculty members involved as far as consulting requests go. Because we have the center involving so many companies, we do get a lot of general requests.

They usually come into the center and they are usually received by the directors or by myself, usually a general request for consultiong help in a particular area. It was requested that we develop some sort of mechanism by which such requests are handled and reviewed by an independent group of people to ensure that there is no conflict of interest, they are not abusing the position, because these are usually just general requests for help from anyone.

So we have a procedure which is outlined in the appendix of my testimony there called "Guidelines for CPAC-Sponsor Interaction," which describes how we handle consulting requests that do not name any particular faculty member involved in CPAC.

When there is a specific request made to a CPAC researcher directly, we do not interfere at all with that request, but we do maintain a file on that so that we can keep track.

Senator GORTON. Dr. Bowen, how does the cooperative research being done in your department compare to the engineering research centers with NSF?

Dr. BOWEN. Well, we of course are very interested in the engineering research centers at the National Science Foundation and have made applications to the NSF in the past round. We will continue our efforts with the expectation that we will have a good opportunity to be awarded one of those centers. It is largely a scale and magnitude, because the National Science Foundation Engineering Research Centers would provide a scale of funding of $1 to $2 million per year if one was successful, and it would be focused in a very narrow area.

That is to be compared with our present annual expenditures of research supported by industry of about a million or so dollars a year over the entire college. So it would enable us to have a better level of resource support, a group of faculty and researchers that are more narrowly focused into one significant area. We have identified areas within the college and some which would involve, say, interactions with CPAC, which appear to be very promising.

Senator GORTON. But it would not conflict?

Dr. BOWEN. No, it would not conflict. It would provide a very major enhancement, and the College of Engineering is very supportive of the National Science Foundation's Engineering Research Center program.

Senator GORTON. Dr. Illman, in your testimony you at least implied a degree of frustration in dealing with the Department of Energy. Do you think that the Department lacks the legal authority to participate in your center? Is it something we should be doing at the Congressional level, or is it simply an administrative problem which can be worked out?

Dr. ILLMAN. It is hard for me to answer that because I do not understand why there was such difficulty. I really do not know. It seems to be a lot of red tape, a lot of policies and regulations referred to that I have no knowledge of that seemed to be impeding progress of their sponsorship. I do not know why there was a problem.

I think, for one thing, it boils down to an incompatibility with the DOE provisions for sponsoring research and the NSF provisions, which of course are part of our center because we are funded by NSF. So that was one stumbling block right here.

Senator GORTON. Did you ask NSF for assistance?

Dr. ILLMAN. Yes. And they designed this sort of end run around the regulations—a maneuver to try to transfer money from the DOE contractors to NSF and then from NSF to us. That was one thing we were going to try, but then there seemed to be a breakthrough and we went on from there.

But there seems to be some desire on the part of DOE to limit the number of sponsorships, and then when Battelle came up with theirs then that jeopardized Los Alamos' participation. They do now contribute two sponsorships. They are a dual sponsor.

There are two organizations which are of sufficient size and have enough interest to warrant their participation. So it went on for a year, that negotiation. Now, Savannah River Laboratory somehow—through their DuPont connection, I do not know—they had a much easier time of it. I do not understand why.

Senator GORTON. I would like to thank all of you for a most enlightening and helpful discussion. Thank you very much.

Our next panel will be Dr. Barron and Dr. Miller. Dr. Barron.

STATEMENTS OF DR. JAMES BARRON, COOPERATIVE EXTENSION, WASHINGTON STATE UNIVERSITY COLLEGE OF AGRICULTURE AND HOME ECONOMICS; AND DR. REID C. MILLER, DEAN, COLLEGE OF ENGINEERING AND ARCHITECTURE, WASHINGTON STATE UNIVERSITY

Dr. BARRON. Cooperative Extension at Washington State University. Cooperative Extension is a unique partnership among the Federal, State and local governments in non-formal education to extend research and experience-based knowledge to farmers, agri-business, families, community organizations, and youth.

The Smith Lever Act of 1914 and subsequent amendments provide the funding base for Federal funds through the U.S. Department of Agriculture to the land grant university in each State on a matching basis with the State.

The original purpose was to improve production and marketing within agriculture and the development of rural areas. Agriculture and natural resource programs constitute about half of the total program in the State of Washington. Those programs deal with both on-the-farm technology transfer and adaptation and that with agri-business and the other supporting industry sectors that serve agriculture.

In addition to agriculture and natural resource programs, about 20 percent of the extension program deals with family living or home economics. Nutrition education, family strength, health and well-being concerns are the educational focus here.

The 4-H youth program is also about 20 percent of the total program, and its emphasis is on human resource development of youth and their families, and a good deal of technology transfer that goes to the youth is adopted by the families themselves.

The community resource development program is about ten percent of our program, dealing with community and public issues, education with groups, and organizations in communities.

The four main focuses of that effort are economic development; local government education natural resource policy and planning; and leadership and organizational development.

We have county extension offices in each of the State's 39 counties. They are funded for the local expenses there and a shared portion of the salaries by county government. We have a staff of State specialists in academic departments, most of them in academic departments in various subject matter disciplines in the College of Agriculture and Home Economics. They provide training and support to that county faculty and work closely with research faculty in both State and Federal funded research programs.

We have State extension faculty at Washington State University and at five off-campus research and extension centers.

Cooperative extension exists in a similar form that I have described here in each of the 50 states and five territories and also through the 16 1890 land grant universities in the southern part of the country.

[The attachment referred to follows:]

Cooperative Extension: Its Mission, Organization, and Programs

MISSION AND GOALS

The five-part mission of Cooperative Extension is to assist the people of Washington State in making informed decisions through research-and experience-based educational programs, to improve agriculture and natural resource management, to improve capabilities of individuals and families, to aid communities in developing and adapting to changing conditions, and to provide developmental opportunities for youth.

Extension's goals are:

To strengthen agriculture in the state by promoting efficient production, marketing, processing, and distribution practices and technologies.

To promote management and conservation of soil, water, energy, and the renewable natural resources important to the economy and environmental quality in the state.

To help people identify and resolve critical community needs and issues through education in leadership and organizational development, economic development and community change, local government, and natural resource policy and planning.

To help individuals and families identify their needs, manage their resources, foster human growth and development, become more self-reliant, and be informed participants in decision making on public issues that affect them.

To assist youth, an audience of all Extension program areas, in acquiring knowledge, developing life skills, and forming attitudes that will enable them to become self-directing, productive members of society.

ORGANIZATION

Cooperative funding

The "Cooperative" in Cooperative Extension relates to the unique cooperative funding arrangement of three levels of government: county, state, and federal. (See top pie chart on next page.) Cooperative Extension is administered by Washington State University.

Today, all 39 counties have Cooperative Extension offices, usually in the county courthouse. The offices provide diverse educational opportunities and counsel at the individual, community, and county level. Extension is uniquely prepared to rapidly identify and help resolve the increasing number of technological, economic, social, and political problems facing this state's citizens, communities, and businesses.

History

The cooperative arrangements were developed over time beginning with the Morrill Act of 1862. This act established the federal land-grant philosophy of higher education under which Washington State University was organized.

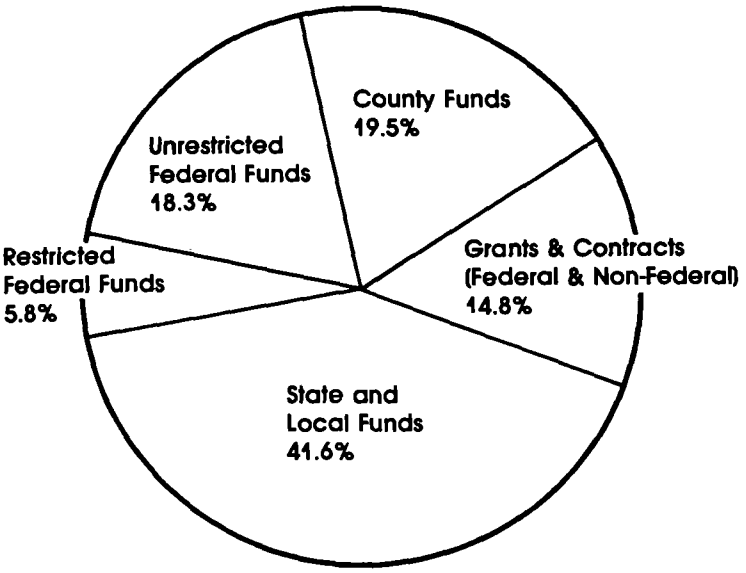
As land-grant universities were established and the teaching of scientific agriculture commenced, it became apparent that there was a lack of scientific knowledge to teach. The Hatch Act of 1887 and subsequent legislation provided federal funds with state-matching requirements to generate new knowledge for the development of agriculture and home economics. The success of generating new knowledge was immediate as each state developed agricultural research capabilities and USDA efforts in research expanded.

It soon became apparent, however, that there needed to be a technology transfer capability to teach the results of the research to practitioners in the field. Off-campus teaching efforts were implemented by most states, and the federally funded support came in 1914 with the passage of the Smith-Lever Act. This act resulted in the establishment of present-day Cooperative Extension.

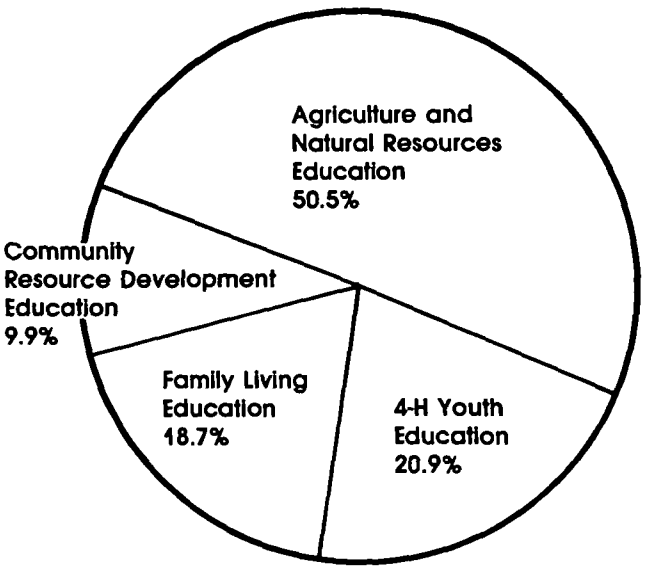
To assure that faculty members did indeed relate with local citizens and would be present in each of the counties, county governments became involved. County and area Extension agents fulfill this off-campus informal teaching function. They also serve as liaisons so that local citizens can relate their research and education needs back to the university. (See map on last page.)

PROGRAMS AND AUDIENCES

All citizens of Washington are potential recipients of Cooperative Extension educational efforts. It is obviously not possible to provide for informal education needs of all persons in all subject-matter areas. Efforts are concentrated in four programs areas. (See bottom pie chart on next page.)



Sources of funds, 1983-84.



Distribution of funds among program areas, fiscal 1983-84.

Agriculture and Natural Resources [ANR]

Programs.—Agriculture and Natural Resources programs are developed to help people improve the quality of their lives through educational programs and experiences that apply scientific knowledge and techniques to:

Food and fiber production, including the management of agricultural inputs; energy conservation; management of natural and economic resources to safeguard the environment; marketing of food and fiber products from farmers to consumers; and management of the community and home grounds environment.

Audiences.—Primary recipients of ANR educational programs are:

Commercial agriculture and forest producers; small and part-time agricultural and forest producers; farm and forest workers; agribusiness marketing and supply firms and consultants; urban, suburban, and rural citizens involved in food and ornamental gardening and related agricultural or forestry endeavors; agriculture, foresty, and commodity interest organizations; youth interested in agriculture and natual resources; and public agencies related to agriculture and forestry.

Family Living (FL)

Programs.—The educational programs offered by Family Living are designed to teach participants to:

Acquire skills necessary to enhance self-reliance; understand and strengthen family roles and relationships and make effective use of support systems when necessary; understand the dimensions of economic change and acquire appropriate personal and family resource management skills; maintain mental, physical, and emotional wellness through basic health practices, including nutrition, environmental quality, and effective human interaction; be aware of the rapid technological advances that affect families and optimize the use of technology for the achievement of family goals; and assume effective leadership roles, participate actively in their community, and address public policy issues that affect families.

Audiences, general.—The general audiences for Cooperative Extension Family Living progams are individuals and family members who have responsibility for:

The provision of daily life needs for themselves or others; management of personal or family resources; and assuming effective roles in their family and community.

Audiences, specific.—The specific target audiences consist of:

Volunteers who have the potential for expanding the outreach of Family Living faculty; low-income families; adults who have limited opportunities to acquire skills necessary for effective daily living; youth who are preparing for adult family roles and responsibilities, and communitiy agencies with responsibilities for family-oriented services.

4-H/Youth

Programs.—4-H/Youth Development programs are focused on helping youth to acquire knowledge, develop life skills, and form attitudes that will enable them to become self-directed, productive, and contributing members of society. This mission is carried out through the involvement of parents, volunteer leaders, and other adults who organize and conduct educational subject/project experiences in community and family settings. Programs are designed to help young people learn about:

Agriculture, home economics, science, and technology; natural resources; leadership development; personal and human development; community involvement; and organizational development and management.

Audiences.—The audiences for 4-H/Youth Development programs are:

Youth between the third grade and 19 years of age, the parents and families of youth participants; and volunteer adult leaders who work directly with youth in program delivery.

Community Resource Development [CRD]

Programs.—Community Resource Development programs provide education to help people identify and analyze community and public issues, develop alternative actions or strategies, evaluate consequences, and implement actions. Cooperative Extension avoids the advocacy of specific policy decisions, but seeks to assist people to make more effective choices based on their individual and group goals.

Program efforts concentrate on the following priority areas:

Economic development and community change, including demographic and regional analysis, employment and business development, and economic and social impacts of change; local government, including provision of public services and facilities, financial management, citizen involvement in local decision making, and improving skills of local officials; natural resource policy and planning, including land use, agricultural land policy, environmental quality, water planning and allocation,

and public land management and use; and leadership and organizational development, including working with groups, community development planning, and organizational analysis.

Audiences.—The audiences for Community Resource Development programs consist of individuals, groups, organizations, and institutions that make, implement, or are affected by community and public decisions, including:

Elected or appointed officials; public agency representatives; citizen and civic groups; community organizations; and commodity and other special interest organizations.

Table 1 relates the number of clientele contacts in each of the four program areas that are made by faculty members.

TABLE 1.—FISCAL 1983–84—FACULTY YEARS EXPENDED, CLIENTELE CONTACTS, AND AVERAGE CONTACTS PER YEAR EXPENDED

Program area	Clientele contacts [1]	Years expended	Average contacts per year expended
Agriculture and Natural Resources	921,302	130.1	7,081
Family living	496,828	51.4	9,666
4-H/Youth	640,170	65.5	9,773
Community Resource Development	35,431	19.2	1,845
Total	2,093,731	266.2	7,865

[1] Contacts include number of persons seeking educational information or experiences by attending meetings, phoning, writing letters, calling at offices, etc. Mass media contacts are not included.

Many volunteers assist in conducting Cooperative Extension programs. Table 2 summarizes efforts expended by volunteers in 1983–84.

TABLE 2.—VOLUNTEER ASSISTANCE TO COOPERATIVE EXTENSION, 1983–84

Program	Volunteers	Estimated volunteer hours (number)	Citizens assisted by volunteers
Master gardeners	[1] 1,066	31,250	154,300
Master food preservers	[2] 372	12,648	45,750
Master food shoppers	[3] 48	1,602	5,080
4–H leaders	[4] 7,427	891,000	26,015
Homemakers clubs	[5] 2,700	38,200	30,625
Family community leadership	[6] 200	9,000	2,756
Total	11,813	983,700	264,526

[1] Program in 20 counties.
[2] Program in 27 counties.
[3] Program in 4 counties.
[4] Program in 39 counties.
[5] Program in 30 counties.
[6] Program in 16 counties.

BENEFITS AND COSTS

Expenditure of public funds for education has long been considered a desirable long-term investment in the economic and social welfare of citizens.

In recent years, educators have been challenged to evaluate the effect of education on society in terms of increased income for individuals, economic benefit to a state or area served by a governmental unit, or in terms of behavioral changes of citizens deemed desirable by society.

The effects are difficult to measure. Even when effects are measurable, it becomes difficult to separate the credit among the various inputs responsible for the change. For example, much of the educational information taught by Extension educators comes from research done by scientists at Washington State University and other state agricultural research centers. Research results have little value until applied; technological advancement is not feasible without research results to teach. Assign-

ing a value to the original research and another to the technology transfer function is difficult.

Despite the difficulties, Cooperative Extension educators have accepted the challenge of measuring effects of their educational efforts. In the following examples attempts have been made to take credit only for that portion considered to be a result of the educational function.

It is recognized that much of the educational efforts were based on research work conducted by the Washington State University Agricultural Research Center and other similar research units.

Senator GORTON. Thank you very much, Dr. Barron.

Dr. Miller.

Dr. MILLER. My name is Reid Miller. I am the Dean of the College of Engineering and Architecture at Washington State University.

Washington State University interacts with industry in a wide variety of ways. These multifaceted arrangements are vital to stimulate economic development and increase competitiveness of industry on the one hand and to provide needed directions and supplementary support for educational programs on the other.

In areas like business and engineering, our relations with industry are undergoing unprecedented growth and development. Critical analysis shows that benefits to the economy of the State and nation from education and research activities of the College of Engineering and Architecture are very large compared to the costs.

Industry recognizes the need to share the burden of these costs, and the university and industry are currently attempting to identify additional ways for this to be accomplished with mutual benefit.

One of our ways to interact with industry is through off-campus programs to provide continuing education for employed professionals. We offer both formal course work for credit and non-credit seminars, workshops, and short courses. Master's degrees can be earned by completing a sequence of courses.

Many of these programs replicate on-campus programs in the various disciplines. The master of engineering management program has been developed specifically for industrial need at off-campus locations. Programs are offered through higher education joint center arrangements in the Tri-Cities and Vancouver, and by cooperative arrangements with Eastern Washington University and Gonzaga University in Spokane. There is close interaction with industries in these areas to ensure that offerings meet industrial need.

The availability of strong educational programs, both on campus to provide new employees and near the company location for continuing education, is an important element in a company's decision to locate in a given area. This fact is evidenced by companies that have recently decided to locate new facilities in the Vancouver area.

A long-term strength of our college has been the quality of bachelor's degree programs in engineering and architecture, with very high industrial demand for graduates. Due to restrictions on faculty, facilities, equipment, and other instructional support we, like many other schools, are forced to severely limit admission to these programs.

We meet neither the student demand nor the professional demand for graduates. As a worst case example, we are able to accommodate only one-half of the qualified third year students who desire to major in electrical engineering or contruction management.

An important way in which our undergraduate students interact directly with industry is through the industrial internship program. Over 20 percent of our undergraduate students obtain work experience related to their major or career interests by industry employment through this program for a summer or for more extended periods. Many other students obtain summer jobs in industry, independent of the formal internship program.

Each year, companies provide the college with undergraduate scholarships amounting to over $100,000, which provide financial support for over 170 students. This past year, the college received over $1 million in scholarships, equipment gifts, and monetary donations. These donations represent nearly 15 percent of the total college budget. Equipment gifts were twice the size of our state budget for equipment.

These donations are made for two reasons: First, because industry recognizes the need to help fund these critical programs; and second, because of the favorable tax structure for donation. It is impossible to estimate what the reductions would be if tax incentives were eliminated, but from my conversations with industrial leaders the effect would be quite dramatic, and quality of our programs would be greatly diminished.

With the shortage of faculty in many technical areas, it is not always possible to hire faculty members with professional experience. This results in weaknesses in some areas of the curriculum must closely related to industrial practice.

Recently, the faculty has been trying some new ways to alleviate this problem. We are asking engineers in industry to give us some real problems they are encountering that might make good design problems for our seniors. Student solutions are so good that companies are often anxious to put them into practice to make their products more competitive and their plants more efficient.

Another way we are introducing undergraduates to industrial practice is by employing students to help with research projects. Over 50 undergraduate students were so utilized last year, and this number should increase significantly in the coming years.

Many of our interactions with industry involve research and graduate education. Companies are interested for three reasons: first, they recognize that universities must help develop new technologies through research; second, companies hire students with advanced degrees; and third, industry understands the strong synergistic effect that graduate programs and research have on the undergraduate program. These synergistic effects result because the best faculty can be hired and kept on the cutting edge of new technology through research, and the terminal degree programs produce new faculty who will educate the next generation of engineers and architects.

Industry supports graduate programs through fellowships for graduate students and by sponsoring research projects. Industrial research long has been considered an important element of our land grant mission at Washington State University. At first, this was accomplished by a separate industrial research division of our college.

However, in recent years this effort has been integrated into the academic programs to take advantage of the many synergisms between these activities. Some of the areas in which our research has had major impacts on regional industries have been manufacturing and testing of wood products, modeling and analysis of dams and other large-scale hydraulics projects, studies of air and water pollution and their effects on various life forms, and design and analysis of electric power generation and transmission systems.

Some of the newer areas where we are developing strong relations with industries include manufacturing and automation in the electronics and aircraft industries, processing of genetically engineered biological materials, design of very large-scale integrated circuits for computers, and development of new polymeric and composite materials for use in high technology applications.

In these activities, our faculty and students work in campus laboratories, in the field, and in industrial laboratories. In some cases, industrial researchers come to work in our laboratories.

The total dollar volume of our industrial research was approximately $500,000 this past year, and we expect the level of this activity to increase dramatically next year. One study completed in 1981 indicated that the average benefits to the State of Washington from research projects in the college exceeded $12 million annually.

I would urge that the incentives for industrial sponsorship of research continue, for this is a mechanism whereby new technologies can be developed to help industry maintain competitiveness and academic programs at the universities can be improved.

There are new trends in both industrial and Federal funding of research. As more significant problems in industrial practices are becoming the focus of activity, there are needs for teams of researchers from various academic disciplines and from industry to join forces.

Only schools which have developed the needed research infrastructure can be competitive for some of the large programs now in existence, such as the Engineering Research Centers sponsored by National Science Foundation. We are working hard to develop our capabilities and to cooperate with other universities and industry to submit competitive proposals for future competitions in such areas.

With increases in cooperative research with industry comes some problems that have to be addressed. How is technology transferred to industry in a timely and efficient manner? How are the needs for propriety and dissemination of new knowledge balanced properly? How are the interests of concerned parties protected relative to patents and copyrights? How does one ensure thatl industrial feedback on academic programs does not become industrial control?

These are not new problems for the university, and workable solutions have been utilized for many years. Technology transfer occurs to company sponsors through reports and presentations. This gives the necessary lead time for development, in most cases, as normal publication delays usually average about one year. If it is critical, agreed-to delays can be arranged as well.

Completely proprietary work is not of much interest to universities, although some work of this nature is done. Companies are beginning to realize that in many cases it is a question of survival of entire industries, rather than individual companies, that is at stake.

Patents and copyrights are still a factor that must be negotiated to protect the interests of both parties. Our university policy is to retain patent rights, but to negotiate either exclusive or non-exclusive licenses to sponsoring companies. Industries must have the right to use and profit from the technologies developed, and the universities must have the right to share in the benefits from major innovations. We do not view these as major deterrents to university/industry research ventures.

Senator GORTON. Thank you.

Now, you have indicated at least there is a slight difference in policies at the university on proprietary research. Perhaps you will expand and Dr. Barron will say whether or not it applies to his areas, or under what circumstances you will do strictly proprietary research.

Dr. MILLER. Yes. University policy is that we do not engage in strictly proprietary research. However, we are willing to consider on a case by case basis exceptions to that policy, and if there are situations where a small amount of proprietary work is necessary, as for an example a lead-in to a larger scale project that could be made a public project, we will sometimes negotiate on a case by case basis.

Senator GORTON. But never when the whole project would be proprietary?

Dr. MILLER. No, we would not like to do that.

Senator GORTON. Is that true for Cooperative Extension as well?

Dr. BARRON. We do not do any proprietary work. The only thing that comes close to that would be testing specific products, like pesticides. But the results of that are published so it cannot be used by a single firm.

Senator GORTON. So you are identical to the University of Washington in the sense that everything that you do is subject to being made public with just some delays, which are essentially the time which it takes to put it in order for publication?

Dr. MILLER. Yes. I think that is a fair statement.

Senator GORTON. Also, Washington State University will own the patents, but you will have some arrangements similar to those of the University of Washington with respect to the sharing of any royalties with the actual inventor?

Dr. MILLER. Yes. The details of that arrangement are currently being reworked, but yes, that is correct.

Senator GORTON. Now, what about the corporations or organizations which sponsor or participate in your research programs? Are they generally speaking large businesses or do you have small or medium-sized businesses?

Dr. MILLER. There is a full range of sizes of companies that are involved in joint research projects, and that is true all across campus. That would be true in business and in engineering, veterinary medicine, the sciences, and so on.

Senator GORTON. Cooperative extension?

Dr. BARRON. Very little private sector involvement directly, because our work is with education generally and they tend to fund things in applied research areas. We have received some funds from private foundations for major programs, but those are a different sort.

Senator GORTON. Dr. Miller, are Washington State University's policies uniform across all departments or does each department negotiate on its own?

Dr. MILLER. No, the policies are uniform across the entire campus.

Senator GORTON. Dr. Barron, there was some suggestion in the Congress that Cooperative Extension should serve as a model for many other kinds of technology transfers. Do you have any thoughts about extending your programs and policies outside of the field?

Dr. BARRON. I think in general it can and does serve as a model for some of the things that are being discussed here. It may be a bit less applicable because Cooperative Extension has dealt almost exclusively with very small firms and individuals, rather than with large firms or corporations.

The proprietary issue then becomes more important there, but the educational programs we have used in Cooperative Extension, along with the research establishment in this country, have contributed to the success of American agriculture, and have been very significant. I think some lessons could be learned and some additions to that kind of a program could be included.

Senator GORTON. I want to thank both of you for coming over across the State to share your expertise with us.

The third panel, representing the Washington Technology Center, is Mr. John Fluke and Dr. Edwin Stear.

STATEMENTS OF JOHN M. FLUKE, JR., CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER, JOHN FLUKE MANUFACTURING COMPANY, INC.; AND DR. EDWIN B. STEAR, EXECUTIVE DIRECTOR, WASHINGTON TECHNOLOGY CENTER

Mr. FLUKE. It is a pleasure to have the opportunity to speak before your committee, and I would like to thank you and your committee members for giving us the opportunity to talk about the Washington Technology Center. I would like to emphasize that this subject is so important to me and to the industry I represent that I was willing to leave the San Juans on vacation during one of the 12 sunny days we allowed in this region. So this is a very important subject.

I would like to, instead of reading segments of my written testimony I already submitted, to augment that written testimony with emphasis on a coule of key points. I would like to leave to Dr. Stear the details of how the Washington Technology Center intends to operate with respect to technology transfer and instead comment on what really amounts to a motivation as to why this area of technology transfer from the public research sector to the private development sector, if you will, is so important.

And that brings me to the term "R&D", and I would like to mention briefly who it is that does R and who it is that does D and why it is that way. R goes on extensively in the public sector, and one of the reasons for that is that in order to discover a clearly commercializable technology a great deal of technology exploration is required. A number of blind alleys have to be pursued.

Development, on the other hand, is the province of the private sector, where technologies are commercialialized into saleable products to be used by consumers and industry in this country, as well as consumers and industry overseas. Development necessarily has to go forward with a definite conclusion for a definite amount of money in order to ensure that the commercial enterprises that are commercializing technology can survive and hopefully prosper.

R, on the other hand, as I mentioned, has to go up a number of blind alleys to discover enough variety of technology and discover enough about it that it becomes discernible from the private sector as to just how the technology might be commercialized. Although I will touch on this point in a moment in a little more detail, I think this actually helps to mitigate a great deal of this issue of whether or not research done in a public environment and published publicly really has a lesser utility to private industry because it is so broadly known. I will want to comment on that point more.

The other point I would like to emphasize that was touched on in my written testimony has to do with the issue of commercial enterprises accessing world markets. We ship about a third of our $200-plus million in annual sales outside of the United States.

As it turns out, a brisk market that seems to run counter to the normal economic cycles of the industrialized world can be found in lesser developed or developing nations. As a consequence, we would like very much as a commercial enterprise to acess these markets and, for our mutual benefits—the customers there and our company, that is—take advantage of the opportunities represented by these countries.

A typical example is such a country as the People's Republic of China. India is probably another example that is emerging for us as a potential major market. The nature of these markets, however, is that the governments and the people of those countries are interested in their self-interest, just as we are in this country in our self-interest.

As a consequence, there is a tendency for them not to take our products without taking some other sort of value with them. That is to say, they will not grant us import licenses without us doing something else, and that something else is transferring technology to them.

Now, there are those in our country who suggest that this is risky and dangerous, and I am here to say that, done correctly, it is not. In fact, it is in our best interest, because a number of our high tech products manufactured in this country cannot be used by citizens of many developing nations without some technology transfer so that they can develop their own infrastructure to be able to apply these products, these high tech products and consumer more of them.

So we are anxious to transfer this technology to them. It is a somewhat older technology, maybe 3 or 4 years old, typically, in the form of products that we will license lesser developed or developing countries to manufacture in their country. And generally speaking, in our case, these licenses restrict those countries from exporting our products outside of their borders.

But even if that were permitted, which sometimes it is in our contract, we still do not regard that as much of a threat, and the reason for it is that we get about half of our sales from products introduced over the last 3 or 4 years. So in economic terms, we are replacing about half of our product line every 3 or 4 years.

The fact is that that third of our sales goes overseas; almost half of that would probably be in some jeopardy or other if we did not undertake a transfer of technology. So actually, we would be expanding our markets as a result of transferring technology, not entrapping them. We have been engaging in this technology transfer activity for well over a decade, so by now we should have seen the negative effects were there any for us.

I think that what this points out, therefore, in order to make sure that we have totally negated the risk, os that we have a reliable source of ongoing new technologies being discovered. And of course, you have seen the panelists here this morning. You will probably see more of them. They represent institutions in our society whose responsibility is to discover new technologies and work on them long enough so that they come to be in the form of a commercializable art that the private sector can undertake to turn into useful products.

I think that the point, however, is that not only is the discovery of technology critical, the transfer of it to the private sector for commercialization is also critical. That of course is one of the main purposes for the organization of the Washington Technology Center, not only to accomplish world class research, but to make sure that measures are put in place to ensure that the maximum amount of technology that can be reasonably transferred is transferred to the private sector for commercialization.

Back to that proprietary protection point for a moment. I think it needs to be understood that any successful business enterprise in the high tech area is not all that unlike other businesses, so-called lower tech businesses. That is to say, a product, not only does our business has to have the technology base to make it attractive to our customers, but we also have to manufacture it, we have to sell it, we have to service it, we may have to engage in customer training, we have to attend to the middlemen, should there be any. Some of our products are sold through distribution.

All the elements of the normal business equation are present. Therefore, the notion that somehow a lack of proprietary protection of a piece of intellectual property maturity damages its value to the commercial sector is really not true in any material way.

As a matter of fact, I think from the point of view of the Washington Technology Center, although it will from time to time probably engage in some modest level of proprietary research, in general the orientation of the Washington Technology Center Board is that we want to have a race. If the commercial sector finds attractive a chunk of technology, we do not want it licensed exclusively to some single company who sits on it and languishes it.

We want an expeditious exploitation of that technology, not only for the benefit of whatever employer successfully commercializes it, but for the benefit of this nation in terms of our favorable balance of trade, since technology products tend to be a highly exportable kind of product.

Well, I have droned on long enough. I appreciate your time and attention once more, and I would like to defer to Dr. Stear for a detailed explanation of the Washington Technology Center.

[The statement follows:]

STATEMENT OF JOHN M. FLUKE, JR., CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER, JOHN FLUKE MANUFACTURING CO., INC.

First, Mr. Chairman, I would like to thank you and the other members of this committee for affording me the opportunity and privilege to address the vital issue of Technology Transfer relating to the future stability and growth of our nation's economy, its security, and its leadership role on a global basis.

I am John M. Fluke, Jr., I am Chairman of the Board and Chief Executive Officer of the John Fluke Manufacturing Co., Inc. Our company is engaged in the design, development, manufacturing and marketing of advanced technology test and measurement instruments and systems, which provide measurement solutions to business, industry, science and education throughout the world.

I appear before you today not in that role, although I will relate to it occasionally, but instead as the Chairman of the Board of the "Washington Technology Center."

You will hear later from Dr. Ed Stear, the Executive Director of the Washington Technology Center and Don Balwin of the University of Washington's Office of Technology Transfer. Both of these gentlemen will address in more detail what Washington State is doing to facilitate Technology Transfer from several universities to the private sector. I am, however, as Chairman of the Board of the Washington Technology Center vitally interested in this issue and it is dealt with in quite some detail in the bylaws of the Center.

The role of Technology Transfer is so vital and plays such a significant role both domestically and internationally I feel it cannot be described in such general terms as "good technology transfer or bad technology transfer."

There of course are cases where certain technology is a serious security concern and must be safeguarded; however, the overwhelming majority of technology, particularly that which is commercializable does not fall into this category. When the proper research and development environment exists it makes it possible to continually replace technology in a timely fashion and it becomes an important tool of economic development worldwide, the development of third world and emerging countries and a bridge to better relations and world peace.

In our case (John Fluke Mfg. Co., Inc.) and the case of most companies in our industry, the majority of our incoming orders are for products less than 2½ to 3 years old. We must therefore have an ongoing program assuring us that we will replace old technology with new technology on a more frequent basis to be able to maintain our market share and to grow that market share throughout the world.

My comments here today will relate to the difference between research and development, particularly pure and applied research and basic and applied research, and product development. Who conducts what? Research and Development or Research or Development and where should it be conducted within the public or private sectors.

Unquestionably basic and applied research because of the long term nature of these endeavors is generally carried out best by the public sector whether they be the national laboratories or well known and renown Universities and research centers.

There are of course some large private sector companies which are capable of funding basic and applied research efforts, in their own behalf.

Most smaller private companies conduct little or no basic and applied research. For the most part their development dollars, as opposed to research dollars are expended in applying technology discovered in one or more of the above described facilities. The remainder of what might be loosely termed research and development dollars might be spent not only in applying those technologies in new products, but also in existing products to further improve their quality and/or performance. In other words their primary direction is to turn technology from many sources into commercial products produced and sold at a profit. And in order to maintain market share and market lead these products must be developed and brought to the market in the shortest possible time, which therefore restricts them from carrying out the basic research themselves.

We must have new technology and methods to carry out our product development and to continue to satisfy the needs of our customers, both domestically and internationally.

When the proper environment exists the technological advancements achieved through the efforts of the national laboratories, the various research universities, centers such as the Washington Technology Center and other public and private research labs come at such a pace that we can indeed safely and profitably transfer technology to the private sector at home and the developing nations abroad.

In our case and in the case of most U.S. high technology companies at least 30 to 50 percent of our sales come from markets outside of the United States. This is not only good for our balance of trade, but is fundamental to our economic growth and stability and to our ability to continue to develop new products and to provide new jobs for our people wherever we operate.

When we sell abroad, particularly to underdeveloped countries, we do indeed transfer technology. It is necessary for these immerging nations to have this technology to begin to develop their own economies, to improve the living standard of their people and to become better customers for U.S. products. They also require technology to accelerate the development of the total infrastructure necessary for them to move from the undeveloped state to a nation participating in the total economic and social benefits of the Western developed countries.

We must not only sell in these countries because our competition is there, but because we can grow our develop their own economies. If we are doing our job in terms of technological development we will have replaced the technologies we transfer to these countries much before they can bring that technology on line in their own countries.

Further, the sales of our products in these countries will have a profound effect on the contributions we can make here at home in terms of research, product development, contributions to the educational system, our individual communities and of course to product development for consumption by our domestic markets.

I would like now to discuss how the R&D process that results ultimately in technology transfer works. If you will refer to the slide (a copy of which is included in my written testimony) you will note that I have labeled it "Technology as an Instruction for Domestic and International Economic Development".

First I would like to reiterate that most commercial technology based companies do very little basic or applied research, but are rather more heavily involved in the development side of the equation.

We at Fluke apply technology gained from many sources, both public and private. In our case and that of many other companies most of these technologies may have resulted from both public and private research laboratories, however, there will always be the case where small research facilities, even individuals will either by accident or design stumble on to a technological breakthrough which is capable of being commercialized.

In the main, however, such technologies as that relating to semiconductors and upon which the greatest growth in features and market size for the electronics industry has come from large research facilities, either public or private.

Our experience as a company parallels that of the semiconductor industry, because the technology flowing from that segment of industry has enabled us to make our products more feature enriched and lower in price in order to be able to better compete on a world wide scale.

As we follow the slide the light bulb of course represents and idea, a technology development at some institutions such as those depicted, the University of Washington, Washington State University, the Washington Technology Center and other public and private facilities.

Through adequate interface and dialogue between these institutions and industry certain of these technologies are determined to have commercial value and can indeed be applied in the products of a company seeking to better serve their market segments. Based on market research conducted by the company and the work of those responsible for market and product definition the task of applying that technology to the new or existing products begins as "The Development Phase".

To be a commercially viable product the company must be able to manufacture and sell the product for profit. Thus, the manufacturing people are also a part of the development process as well as responsible for ultimately making the finished product. A very heavy involvement and interface between the design groups and the manufacturing groups is vital and ongoing and not only affects the products being readied, but future product direction and funding as well.

The output of the factory is then sold for profit and as noted earlier technology is therefore transferred at that point, both domestically and abroad and as a result the process of infrastructure development begins in the under developed nations of the world.

The revenues thus generated are fed back to the private sector manufacturer. Those sales and the revenues favorably effect in a positive fashion the Quality, Price and Performance of the manufacturer's products and results in "Technology Transfer". This process makes possible the development of new and improved products and is labeled here "Short Term Competitive Factors".

These revenues in time also help to provide the manufacturer with the ability to do an increasing amount of their own research (see dashed line portion of factory depicted).

For the present however, a significant portion of these revenues/profits thus generated will be channeled back to the public research facilities through the mediums of taxes, contributions of money, equipment and people, and will result in technology discovery, technology transfer and much closer Industry/University involvement. These we have labeled "Long Term Competitive Factors," for the basic and applied research typically involves much longer gestation periods and produce much longer and lasting benefits than those efforts and energies expended in product development.

Again, the commercial producer in the interest of generating profits and reinvesting those profits or revenue must bring new products to market on a much shorter time frame than that normally required or might result from beginning the process with applied or basic research.

With all of the foregoing in mind it must be recognized that in this state, as well as all of the other states technology transfer is fundamental to the stability and growth of our state's economy. If we are to attract new industry to this state to facilitate the start up of new technology ventures and to maintain the health and growth of our present industry there must be world class educational and research institutions, close cooperation between all sectors, public and private, especially industry and education and there must be a working environment which permits technology transfer at it's various stages and as it relates to the development of the technical disciplines in public and private research facilities.

I have alluded earlier to the fact that our company as well as others apply technology from many sources in the development of our own products for commercial sales and of course as commercial products to our own governmental agencies, including the military. We expend our own funds internally generated to apply new technology and develop new products of exceptional quality, performance and cost effectiveness.

Much of the technology we have acquired and utilitzed within our design, development and manufacturing operations has been also acquired from commercial vendors without regard to where the original technology was developed or transferred/sold. Our leadership role in the market segments which we serve results in the main on the ability of our people to apply these technologies to the needs of our company. Over time these technologies are reviewed in light of the market needs of our customers and how they can best be utilized to develop new products for our company that will service our customers. Here the skill, knowledge and experience of our people are key elements in the process of commercializing technology we have obtained in its pre-refined stage are from those sources that have converted it from an idea to a technology method or process that can be applied commercially and producing products which have gained for our company a world wide reputation for quality, performance and cost effectiveness.

In our system through market research, input from our field sales force and the expressed needs of our customers a development project is initiated, a product defined, a project authorized and the resources of the company from the earliest stages of development to the final production and sale are applied to making that product worthy of our trademark and of our country.

As I mentioned earlier, we do very little basic or applied research. We do intensively investigate the possibility of new technologies to the design, development and manufacture of our products. In the process from time to time our needs will dictate our venturing somewhat into the realm of applied research or basic research. I would emphasize again however, this is not the fundamental way that we conduct our business. We do, however, in the process of applying technologies develop such unique applications, process and methods that we are awarded patents for such developments. Certain of these techniques and processes are transferred along with the technology when we sell our products and manufacturing methods to the under developed countries of the world. A significant example is the People's Republic of China where under contract our products are manufactured and distributed for use solely within the People's Republic of China. It is absolutely necessary that we pursue this business in that fashion or we would not be able to sell our products in the People's Republic.

There are several other areas in which we are presently negotiating contracts in which the business environment is similar and probably will result in a similar arrangement to that which we have with several factories in the People's Republic. These areas are namely India and Mexico. both of these countries have coalitions against buying certain types of products if a product which is generically identified

though not technically comparable is produced within those countries. We must therefore negotiate either contract manufacturer or some other means of producing our products in those countries in order: 1) to be able to sell them there, 2) to be able to help them develop their own capability, grow their own economies and improve the standard of living of their own people.

There of course exists a condition throughout our country but most particularly in the State of Washington where there are a number of people, entrepreneur, who have product ideas or who recognize the technology being developed as having a product or market area potential in which they are interested and able to both commercialize. In the case of the entrepreneur, or an early start up company having a product idea but lacks a product definition or the ability to apply the existing technology or to discover the new technology necessary to bring that product to market, the existence of a "Washington Technology Center" will very definitely spell the success or the failure of this particular individual or group of individuals.

The Washington Technology Center and other centers or research facilities involved in the discovery and definition of new technologies and ready to transfer that technology to the private sector to be commercialized represent a major contribution to the development of our coming generation of business leaders and commercial organizations. The ability to access, to contract and receive the necessary technology to convert an idea into a product, to create a company and jobs an to provide that product to satisfy the needs of our State and Nation and our trading partners around the world represents a high order of achievement and the best of our human endeavors.

Mr. Chairman and members I thank you very much for the privilege and opportunity to appear before you today. I will be glad to take any questions you may have.

Senator GORTON. Thank you very much.

Dr. Stear.

Dr. STEAR. Senator Gorton.

It is indeed a pleasure to appear before your subcommittee and to offer some views on the subject of technology transfer and economic competitiveness. For the record, my name is Edwin B. Stear and I am currently the executive director of the Washington Technology Center.

This center is a new statewide joint industry-university research center devoted to: (1) the development of new commercializable technology and its transfer to industry for rapid exploitation; and (2) to the provision of quality education and training of undergraduate and graduate students in high technology fields. My comments are offered based on my recent experience in helping to organize, develop, and manage the center.

Let me begin with a short summary of the background situation that existed both nationally and locally at the time our center, and most other centers of this kind, was established. This will provide some context for my remarks.

It is now widely accepted that the technological leadership and economic competitiveness of the United States is being challenged and seriously eroded by determined efforts of our trading partners abroad to improve their economic competitiveness through the exploitation of technology. Their success is most visibly reflected in the increasingly wide range and large quantity of imports of consumer goods of various kinds which incorporate the latest technology and/or are produced in modern manufacturing plants which themselves incorporate the latest technology.

Most serious at the moment are the challenges of Europe and Japan, but other rapidly developing countries, such as Korea, are beginning to mount increasingly significant challenges of their own. The results of these efforts are just now becoming visible through new imports of various classes of high quality consumer goods which also incorporate the latest technology.

Thus, it appears that the current substantial challenges to U.S. technological leadership and economic competitiveness can be expected to continue, to broaden, and to intensify. These challenges and the accompanying erosion of the U.S. position have created many problems at the national level. The problems include an extremely large and rapidly growing negative trade balance, severe loss of employment in those industries where U.S. competitiveness has significantly declined, sustained historically high interest rates and a resulting very strong dollar in overseas markets, and a declining tax base to support necessary Federal programs in defense and social services.

These national level problems are naturally reflected, amplified, and/or distorted in various ways at the State and local level depending on the local situation and on the nature of the economic and tax base of a given State or local area.

At both the national and local area, these problems have, quite properly, caused concern among industry, government, and academic leaders who have been and continue to be busy trying to figure out how to respond to them. This concern led to a national dialogue/debate on the best way to deal with the problems, and out of this dialogue has come a consensus on what are believed to be some effective ways to significantly attack these problems and hopefully eliminate them.

One area of apparent consensus is that increased emphasis on the development and exploitation of new technology offers one of the best approaches for attacking these problems. As a result, there has developed an intense competition between States and urban areas for the acquisition and development of technology-based industry, including competition to create the most attractive environment for entrepreneurs to establish and nurture new technology-based firms.

Out of this competition finally came the full appreciation of strong research universities as unique potential sources of new technology—derived from large, federally-funded basic research programs—and of the human resources required to exploit it. Unfortunately, over the previous 25 or more years the relationship between most of the nation's research universities and industry had not been nearly as strong or vital as it could and should have been, and as a result most of the potential was not realized.

This situation was clearly illustrated by the positive examples of MIT and Stanford, which demonstrated the very significant impact that close university-industry relations and ties can have on a region's and/or State's economic development and revitalization.

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This completes my summary of the relevant national, State, and local background situation which existed a few years ago and which set the stage for a major new development in relations between industry and the majority of the nation's research universities. It is clear that what was needed was an effective new mechanism for coupling industry to research universities which could and would support the States and/or urban areas in their competition with one another to acquire and develop technology-based industry.

This new mechanism turned out to be state-supported, university-based technology centers. Over the past 6 years, more than half of the States in the United States have initiated programs to develop such centers and many more are in the start-up or initial planning stages. The centers currently in existence vary somewhat in detail as a result of local conditions and a given State's political realities. For example, some are statewide and some are not, some require a higher percentage of matching funds from industry than others, and some are expected to attract Federal funding in addition to State and industrial funding, while others have no such requirement. However, they all share a common set of goals and expectations as centers of excellence in the generation of new technologyy and in the education and training of the personnel resources required to exploit the new technology upon its transfer to industry.

The Washington Technology Center was established in 1983 as the State of Washington's mechanism for achieving a closer coupling between industry and its research universities. As noted earlier, the center is organized as a statewide joint industry-university research center which is devoted; (1) to the development of new commercializable technology and its rapid transfer to industry for exploitation, and (2) to the education and training of undergraduate and graduate students in high technology fields.

The center is operated under the administrative control of the Board of Regents of the University of Washington. It reports to the Dean of Engineering at the University of Washington on administrative matters and to a board of directors on all matters relating to its research programs and research policies.

The board of directors is composed of 14 members from industry and 11 members from the State's universities. The board of directors is composed of several committees which carry out the bulk of its work. They include an executive committee, a research committee, a technology transfer committee, an administrative and fiscal poliicy committee, and a facilities committee.

The operating budget of the center is directly supported by the State of Washington on a matching basis. The center is expected to attract industry funding in an aggregate amount which at least matches the level of State support, and the same expectation also holds for Federal funding. These requirements for

matching support assure that the center's research programs are closely coupled to the new technology needs of industry and that the programs are competitive nationally in terms of overall quality.

The center's research staff consists of regular and research faculty of the participating universities and their undergraduate and graduate assistants, full-time research scientists, engineers and technicians, and industry fellows who are on full or partial leave from their companies at company expense.

The center's long-range research plans are developed in cooperation with the center's participating universities and with a broad spectrum of the State's and the nation's industry and they are approved by the board of directors. Currently, these plans call for the development of research and technology development programs in microelectronics—including microsensors and integrated circuits/optics—computer systems and software, manufacturing technology, advanced materials technology, medical biotechnology, plant biotechnology, and forest products biotechnology.

Major research programs in microelectronics, computer systems and software, and medical and plant biotechnology were initiated in July 1984 and research programs in the other areas are due to be initiated during the current biennium, 1985-87.

Industry and Federal matching funds attracted to date are over $2.5 million, which is almost twice the State contribution to the center's operating budget. This strong support from industry is consistent with the experience of other such centers, and it strongly confirms industry's acceptance of this important new mechanism for strengthening industry-university relations.

Because of the nature of the center and the fact that its board of directors has a technology transfer committee, it should be obvious that technology transfer receives strong emphasis in all aspects of the center's operations. In particular, the center actively supports technology transfer in a variety of ways.

At the most formal level, technology transfer to the center's sponsoring companies is supported through formal intellectual property agreements which are negotiated at the beginning of industry-sponsored projects and which define conditions under which patentable and/or copyrightable technology will be transferred to the supporting companies. If the companies receive an exclusive license, then transfer is simply and directly accomplished.

If the license is nonexclusive to any company or group of companies, which is the usual case, then the patent and/or copyright is developed and marketed to nonsponsoring companies in addition to any sponsoring companies who may have rights to the technology through prior agreements. Such further development and marketing is carried out through a patenting agent such as the Washington Research Foundation, with which the center has an agreement for the performance of such services.

At a less formal, but clearly more effective, level, technology transfer is accomplished directly by the excahnge and/or relocation of technical personnel. This can occur by the return of industrial fellows to their companies, by a company hiring a center staff member or a student who has worked in the center on technology of interest to the company,

and by a company retaining a center staff member or participating faculty member as a consultant if the center concludes that no conflict of interest is involved.

And of course, some degree of technology transfer occurs in the natural course of open publication of the center's research accomplishments. In this connection, all of the center's research results are published after the minimum delays required to protect intellectual property by the filing of appropriate patent and copyright applications.

I hope you will find these comments on the Washington Technology Center and its role in improving the economic competitiveness of the State of Washington and the United States (through the development of new technology and the human resources required to exploit it and through transfer of the resulting technology to industry) to be useful to you in your deliberations.

As I have tried to indicate, it is but one of many centers of its kind now existing and/or being developed throughout the country. Together they can and will play a significant role in the economic future of our country through ongoing programs of technology development and transfer.

Now, John has mentioned R&D and he recognized that a great deal of R goes on at the universities which leads to manuy fundamental results. Moreover, he noted that industry needs to do D, but there is a gap between such fundamental results, and the needs for effective D in industry.

What has been organized and developed to fill that gap has been technology centers. We bridge that gap with industry by involving them in the planning and in the execution of technology development programs, and they are directly involved in the process of assuring rapid technology transfer.

My apologies for reading my written testimony. I wanted to make sure I covered it.

Senator GORTON. Does the Washington Technology Center have a physical place or office or at this time is it simply regular faculty members and others doing work on the university property?

Dr. STEAR. The Washington Technology Center is basically existing or exists in existing space of the participating university campus. We have, though, under design a system of buildings which will house the center.

Senator GORTON. At the university campus?

Dr. STEAR. The preferred location for that building is to be on the University of Washington campus. The basis for this is because we believe that for the future of the center that it is important to in fact be close to the university and the faculty and students so that we can guarantee their participations. A separation of the center away from university campuses has suggested, by other examples in the past, that you do not have to get very far away before the participation falls off significantly.

Senator GORTON. I take it you are still a number of years away from having this?

Dr. STEAR. Yes. Our situation right now is we are operating in something under 20,000 square feet of existing space. We may have to, as we continue to develop, get some temporary space, and we are looking to have a building ready some time for occupancy, some time in 1988 to 1989 time frame.

Senator GORTON. Now, both in reading your testimony and listening to you it sounded to me as though your policies on proprietary research patents and publications are very close to or identical to those which have already been described to us by the University of Washington. Is that true?

Dr. STEAR. Yes. That is basically true because we want to have an intimate relationship with our participating universities. We are in fact a university-based center. We think it is important, therefore, that we operate in ways that are consistent with that university setting.

Senator GORTON. Does your work or your sponsorship extend beyond the borders of the State of Washington in any respect? Is it strictly Washington or are you engaged in research and development on any kind of regional basis?

Dr. STEAR. We have companies involved in the center who are not necessarily located in the State of Washington, but the point that we try to say here is that, while we will accept funding from sources whether or not they are in the State of Washington, it necessarily has to be a benefit for the State of Washington to justify the State's expenditure. So the way I characterize it is that we do work with firms out of the State, but on the basis that we have similar work going on involving firms in the State and that the in-state firms can in fact benefit by the out-of-state projects.

Mr. FLUKE. The primary point is the degree of exclusivity with respect to intellectual property ownership rights. If a company outside the State comes in to fund some activity at the center, we would like to see the arrangement struck so that we get the access to their funds, obviously, on the one hand. But we would also like to have access to intellectual property they have created and make it available to companies in the State.

So usually it is a pretty straightforward situation to establish a relationship with a company outside of the State where they are willing to go along with nonexclusive intellectual property rights.

Senator GORTON. Are there other centers in other places in the Pacific Northwest? Oregon, Montana, and Idaho?

Dr. STEAR. I do not know any that are similar in the sense of being basically State-sponsored in the Northwest region other than the State of Washington. There is the Oregon Graduate Center in the State of Oregon. It has been around for quite a while. They work differently. Moreover, it does not have any significant financial sponsorship from the State of Oregon.

Senator GORTON. John, you said in your oral statement and in your written statement as well that commercially attractive technologies are identified through contact with industry and research facilities and you described what you are doing here. Do you have adequate contact and

relationships with Federal laboratories located near the State of Washington?

Mr. FLUKE. I cannot speak in any great detail to that issue. I know that, from the point of view of our technology people inside the company, that publications of such laboratories, which are relevant to our area are generally speaking, in our technical library.

The person to person kind of interface, though, because of the nature of our business perhaps, has been primarily directed towards the NBS people at Boulder, CO and Gaithersburg, MD.

One of the reasons for that emphasis is that one of our main product lines is the kind of electronic equipment used to transfer the precision standards maintained by the National Bureau out to the private sector, where they use it in turn for their work. So maybe because of the nature of our particular business, we have had a tendency to go to what are basically Federally funded laboratories at places outside the State of Washington.

Senator GORTON. The National Bureau of Standards is obviously not the place, but you have not run into blank walls or dead ends in attempting to get publications or in doing anything else you people have wanted?

Mr. FLUKE. No. Generally speaking, we have had reasonably good experience with the various government communities and technical communities with whom we interact. I can say, however, that through efforts like the Washington Technology Center and some of the other organizations at the University of Washington that we have talked about this morning, things are on an improving trend with respect to the people to people interface end of things.

Ed Stear pointed out that it was important that these kinds of facilities be located on university campuses so that we get industry people coming to those campuses. The university people cannot go everywhere. They necessarily have to pretty much stick to their respective grindstones. It is very desirable to see industry people attracted to the university campuses, not only to take advantage of intellectual property there but to also develop relationships with the university in understanding just exactly how much support and what kind of support is really needed, and the fact that it cannot all come from State and Federal sources.

Dr. STEAR. I might comment that in the process of developing our programs we are developing some relationships with national laboratories, and we have not encountered the kind of problems that CPAC has encountered. Perhaps that is because we are interested in working with them through a different mechanism. Rather than having them join the center per se, we work with them in a collaborative way.

On the other hand, maybe we will encounter problems in the future. I do not know. It is a little too early to be sure.

Senator GORTON. John, in comparison with the description we heard from the University of Washington of how the university relates to its faculty members and other staff members when they have made a development which is patentable, what does John Fluke Manufacturing

Company do? How does it reward innovation on the part of its employees?

Mr. FLUKE. You are talking about the employees of Fluke?

Senator GORTON. Yes.

Mr. FLUKE. Actually, there are a variety of mechanisms. Probably the most frequently employed is a cash bonus. Any technical employee, actually all employees, technical or not, are apprised of a requirement of the company as to basically assign the rights and intellectual property discovered to the company.

This requirement is disclosed to them before they agree to become an employee of the company. That is done technically, from a legal point of view, to make sure that we do not end up with an endless morass of legal problems.

But at the same time the technology discoverers or in our case have to have rewards above and beyond normal compensation. So a cash bonus is one way, in the year in which they have discovered something that clearly became commercializable is one way to provide such awards.

Another way is through grants of shares of Fluke stock.Since the company stock is publicly traded, it has a negotiability to it, sometimes restricted for up to a 3-year period because we do not want that ownership of the company turned into cash prematurely. We like to have that innovator keep innovating and have the motivation to try to protect him from himself, I guess you could say.

But, in any event the innovators must be rewarded, and I think that it goes beyond just monetary rewards. Part of it is also recognition, the esteem that should be accorded these people because they are discovering things that are critical to our long-term future. And our belief that we could give them our dollars and otherwise ignore them—the "we" being industry, the "we" being university administration, the "we" being press, the local press, the national press—our failure to acknowledge the important contributions these people are making would be just as bad as not rewarding them monetarily or not rewarding them in terms of having the laboratory facility they need to continue to work.

Senator GORTON. Thank you both.

Our fourth panel consists of Mr. Farmer of Battelle and Dr. Aron of the National Marine Fisheries Service. Mr. Farmer, we will start with you.

STATEMENTS OF SAM J. FARMER, DIRECTOR, BATTELLE SEATTLE RESEARCH CENTER; AND DR. WILLIAM ARON, DIRECTOR, NORTHWEST ALASKA FISHERY CENTER

Mr. FARMER. Thank you.

My name is Sam J. Farmer and I am director of Battelle Seattle Reseach Center. It is a privilege to be invited to give testimony before your subcommittee, Senator Gorton, and the subject is enormously important to our organization. That is the subject of technology transfer. I would like several impressions to come out of the written transcript provided.

The first is that technology transfer is alive and well. It is happening. While I do not speak for all the Department of Energy laboratories, I think they would say the same thing. There is much evidence of focused activity and creative planning. A considerable expansion of the effort being applied in this area has followed the Stevenson-Wydler Act of 1980 and DOE directives and guidance on this very issue.

You mentioned the Packard report. There is also the Grace report and the Energy Research Advisory Board report, all of which contain very instructive suggestions about how to employ resources of the laboratories in involvement with industry and with the academic community.

The Department of Energy laboratories have had a large, extensive, long-term involvement with the educational community. As you know, a number of them are operated by universities; the University of California, for example, University of Chicago, and other major universities, so that there is an enormous and rather impressive record of interchange of faculty, employment of graduate students and, more recently, access to facilities and that kind of thing.

All this access, of course, is not a passive thing. It takes action and therefore needs support. That kind of activity is in competition with all of the other claims on the resources of these laboratories.

I would like to point out one thing we have learned in the past few years as we have worked in this field. We are learning that there is a great pull from high schools, from junior colleges, from regional universities, to help faculty and students get a picture of what technology looks like: What is technology, what is this thing they call high technology, and how do we teach it?

What should we do, in our teaching, to produce or help our students learn how to create technology, learn how to use it, and learn how to market it and sell it and what is this all about? So that is a kind of new little wrinkle that we think is important to recognize.

When the country looks for a payoff from its involvement in technology transfer to the educational structure, of course, it is not going to be possible to draw a fine profit and loss statement and say here is how much money we have realized in our international trade this year due to the contribution of the educational establishments. But it is strongly indicated that the educational structure of the nation is what really enables our continuously advancing technology and the creation of the highly skilled workers we need in the population, on which the competitive strength of our country depends. That is where the competition is. That is where the battle for competition for international markets is taking place.

The third thing is that different skills are required in working with industry toward the commercialization technology than in the R&D business. The motivations of business and educational communities are different. Business is interested in useful information that is property, such as patents or trade secrets.

So I am saying that the job of seeing that technology is exploited needs to be recognized as a different job from research and development. I think that has been made clear by earlier speakers.

You pointed out that the Federal Government is sponsoring roughly $60 billion of research in the country and that is about half of all of the expenditure. With respect to that half of the research that is done, the government's ownership or control of the output effectively neutralizes the incentive of the patent system to commercialize that technology.

In my prepared statement, I suggested a simple way of overcoming that would be to grant the contractor involved in all cases in the ownership of the invention or patent or whatever the intellectual property is, reserving a right to the government to use it for its own purposes. Probably too simple, and the argument is made that if that is the case are not the contractors getting a windfall?

Why should they be entrusted with it? I say, if you can show how the invention technology or otherwise is going to be commercialized in the present setting, fine. But I just think it is either that or continuing to search for a perfect equity, and I do not think that is going to come about.

On this question of incentives, in my statement I invite attention to Public Law 98-620 amendment the Bayh-Dole. This amendment was to bring the nonprofit operators of the Federal laboratories into the same orbit as universities and small businesses so far as owning a patent. They needed to take patent rights.

This law does have a worthy motive of facilitating the commercialization of valuable Federal technology. While title to inventions may be taken by the nonprofit laboratory manager, there is no means for any contractor to receive any reward from commercializing them. That is, the earnings from these patents or inventions go to the laboratory, for, research and development in the laboratory institution, for education, and to the U.S. Treasury.

It appears that the proposed regulation for implementing this statute expects the contractor to advance his own funds to do this commercialization business in the expectation of being repaid if, as, and when there is income generated by that particular technology.

Speaking from an organization that has had a lot of experience in the commercialization of technology, I would have to say that is not very reasonable. It is true that the contractor may take title, but when you look at the kind of title the contractor gets, it is hung about with an enormous number of conditions and limitations that make such a title very uninteresting to a potential entrepreneur.

I guess I would like to close by simply referring to an ad that was appearing recently in the newspapers of TRW. In it, there is a picture of the director of the Patent Office in 1899 with a quotation from this man, Charles H. Dewall, who says: "Everything that can be invented has been invented."

And then there is a statement from Lord Kelvin, President of the Royal Society of 1895, who says: "Heavier than air flying machines are impossible." And then there is Harry M. Warner, the picture executive

who said: "Who the heck wants to hear actors talk?" And then Robert Millikan, our own Robert Millikan who won the Nobel Prize in physics, saying: "There is no likelihood that man can ever tap the power of the atom."

I think it behooves all of us to recognize that any of these generalizations or categorical positions we put forward are subject to the judgment of the future.

Thank you very much.

[The statement follows:]

STATEMENT OF SAM J. FARMER, DIRECTOR OF THE BATTELLE SEATTLE RESEARCH CENTER

Mr. Chairman and members of the subcommittee, thank you for the opportunity to present views on technology transfer on behalf of Battelle Memorial Institute.

Battelle was created by the Will Gordon Battelle, whose vision was to advance and utilize science for the benefit of mankind. He envisioned technological innovation and education as processes for doing this. Therefore, much of the 56-year operating life of Battelle has centered around research, development, education, and the processes of invention, discovery, and innovation.

Battelle has major research installations in Ohio, Washington, Germany, and Switzerland, with a total staff of more than 7000.

This testimony is based on the experience of Battelle as manager, since 1965, of the Department of Energy's Pacific Northwest Laboratory (PNL) in Richland, Washington.

A few of the many major themes related to the transfer of federally developed technology and economic competitiveness are:

Who should benefit from commercially valuable information developed at the taxpayer's expense?

Can restraints on the publication of scientific and technical information hamper the technological progress of the United States?

How much valuable technology is actually created incidental to or as a by-product of federally funded R&D programs?

Are there feasible measures the federal government can take to stimulate the economic use of federal technology—considering that the commercialization process requires not only technology but an entrepreneur, capital investment, and a planning horizon of about 10 years?

These themes are touched on in responding to the subjects on which you requested my views. Transfer mechanisms is the first of those subjects.

A. TECHNOLOGY TRANSFER MECHANISMS

Technology can be thought of as useful information. The concept of transfer calls up the thought of a thing moving through space from point A to point B. Technology, however, after being transferred to point B may continue to exist also at point A. If the receptor at point B is not very good, the information may not be effectively transferable to point B. It is also possible that useful information may be transferred to point B but not be used because point B does not have the capability or the will to use it.

Useful information becomes more like a physical object when it attains the status of property: The useful information in a patent becomes property by virtue of a federal law that says a patent is personal property. The same thing can be said of useful information that is copyrighted. Information that is a trade secret is also property under various state statutes and decided cases. With respect to these kinds of property, the owner may have the exclusive use and enjoyment of the property and may transfer the property interest to others.

Useful information that has not attained the status of property may be transferred in all of the ways information can be transmitted. Technology that has become property should be transferred under arrangements which preserve the commercial value of the property. The worth of technology exploited as property can be measured quantitatively in terms of licensing income, sales of a patented product or process, cumulative effect of technology property revenues on trade balances, and the like. It is not possible to make such a quantitative determination of the value to the nation's economy of technology that is disseminated as useful information, e.g., the worth of an engineering education specialized in computer technology.

What are the ways useful information is transferred?

1. Education

The educational process is an important way in which useful information is transferred. More will be said about PNL's extensive involvement in educational activities in Section D, below. Battelle recently prepared a report for the State of Washington on "High Technology Employment, Education and Training in Washington State" (Jan. 1984). Every state seeking a high technology future must see that its education system provides the structure to prepare for such a future. The essence of the competitive strength of technology is its key ingredients: constantly advancing knowledge and highly skilled workers. These ingredients enhance the competitive position because they cannot be duplicated easily or over a short time period. The

very existence of these ingredients depends in the first instance on an appropriate educational and training structure.

2. Transfer of knowledgeable people

Staff members frequently transfer to organizations which plan to commercialize technology that has been developed in the R&D lab. An excellent example of this is the transfer of a number of researchers from PNL to Exxon Nuclear Company when that organization began its commercial operations.

3. Publications

Thousands of published reports of research performed by PNL for the Atomic Energy Commission, the Energy Research and Development Administration, and the Department of Energy are available from the National Technical Information Service and technical libraries. Thousands of articles on this work are published in learned journals. Many tens of books based on this work have been published. The U.S. Patent Office is an important repository of technology and a resource for its transfer.

4. Contract research

The performance of scientific or engineering research or studies to meet the needs of an industrial or government sponsor is a technology transfer mechanism. The results of the work are reported. The research organization takes steps as desired by the sponsor to enable the sponsor to utilize the results of the work. This is an action-oriented and focused approach to create a specific solution to meet a particular technological need. The information transfer is pinpointed rather than being broadcast as in education or publications. The object of the transaction is the use of the information.

5. Cooperative programs

When people work together they learn from each other. Staff exchanges between laboratories and industry; working together on cooperative projects; and industry use of laboratory facilities are all examples of situations in which technology transfer takes place. Industry, particularly in the rapidly moving technologies, needs to see immediate benefits from interacting with almost any outside organization.

6. Conferences/seminars/workshops

Well prepared conferences are an excellent way to pass along useful information on a particular topic.

7. Commercial licensing

Technology that is property in the form of a patent or trade secret may be licensed for use by others. The mechanisms for transferring the information may be similar to those listed above, but the communication will be limited to those who need it for the purpose of the licensing agreement. An excellent early treatment of this subject is contained in a 1958 publication of the National Industrial Conference Board (now the Conference Board) entitled "Foreign Licensing Agreement."

Of course one may elect to make, use, sell, or otherwise practice the patented invention for one's own account, sell the patent outright, or otherwise deal with it as property. In any event, if the technology is going to be put to beneficial use it must be communicated to those who are going to carry out the use.

B. BARRIERS TO TECHNOLOGY TRANSFER

A number of obvious barriers might be mentioned:

(1) Bars against publication under classification regulations based on national security.

(2) Controls by the Department of Commerce and the Department of Energy on the export of certain unpublished scientific and technical information.

(3) Delays in transfer related to protection of the Government's proprietary interest.

Your hearings today are not, of course, about technology transfer as an end in itself. You are concerned about technology transfer and economic competitiveness. To this end it is appropriate to look at systemic barriers as contrasted with those we create by law and regulation. As the context for these views I would like to refer to the testimony presented by Dr. Sherwood L. Fawcett to the House Subcommittee on Science, Research and Technology on May 21, 1985. Dr. Fawcett is recently retired as Chief Executive Officer of Battelle. He has had a career-long interest in the subject at hand.

The realities of turning technology or invention into commercial value are these:

During the Battelle Development Corporation's (BDC) first 48 years in business it evaluated about 20,000 ideas; BDC invested in a total of 770 ideas; 105 of those 770 ideas yielded some license income; and only 41 of the inventions yielded a net income.

The time from invention to substantial income is on the order of 12 years, on the average.

Commercial success is dependent on many more factors than the invention itself. Of the cost of getting a new invention to the marketplace, only a small fraction is for R&D. The remaining amount goes for any number of things including preparations for manufacture, investment in manufacturing capacity, marketing, distribution, and advertising.

The bottom line is that having the invention (i.e., the technology) is not enough. An entrepreneur or innovator is also needed. It is not simply that there are artificial barriers to technology transfer, but that there must be an economic incentive to attract entrepreneurs.

There may also be an effect related to the changeability of national policy on the issue of who should really reap the benefit of federally funded inventions. A former Battelle staff member, Dr. Alfred Marcus, discussed several views on the relationship between "Policy Uncertainty and Technological Innovation" in 6 Academy of Management Review pp. 443–448 (1981).

Another widely recognized systemic barrier is the "Not Invented Here" syndrome. There is justification for this in cases where the investor lacks confidence in the technology until he, himself, has replicated the experiment.

Competition for investment capital is assumed. Under E. A. Eschbach's theory of interest rate influence on technology investment, the success rate of a new technology venture is not independent of interest rates. During periods of high interest rates, therefore, relatively less investment will be made in technology ventures than in periods when interest rates are low.

What can Congress do to help with the matter of economic incentive to technology transfer? Congress can provide more support for the technology transfer mechanisms: education, interactions between industry and laboratories, cooperative programs and conferences. As indicated in Section C below, Congress may wish to consider increasing economic incentive under federal patent policies.

The Stevenson-Wydler Act is based on the assumption that there is value in technology that is created incidental to or as a by-product of federally funded research and development. This assumption has not been demonstrated to the extent that one can justify investing any particular amount in the technology transfer process. It seems to me that some potentially valuable technology exists in the laboratories but, like precious metals or gems, it is below the surface and must be dug out, its purported value confirmed, and then it must be treated and polished in order for it to be marketable. This requires qualified investigators to dig out the value. This requires looking outside at commercial needs and doing further work on the technology for the secondary application.

C. IMPORTANCE OF FEDERAL PATENT POLICIES TO TECHNOLOGY TRANSFER

The incentives of our Constitutional patent system remain valuable as a national policy. Abraham Lincoln said something to the effect that the "Patent System provides fuel to feed the fire of genius."

Roughly half of the R&D in our Nation is financed by the Federal Government. Inventions made in this work are governed by provisions which dilute or neutralize in varying degrees the incentive of the patent system. Impairment of this incentive has the effect of slowing technology transfer. It also has the consequence of reducing commercial interest which is the best stimulus of technology transfer.

Without an incentive to turn useful federal technology into salable property, our country faces a future of competing internationally with the very technology it has created. This is most dramatically illustrated in the atomic energy field. With the highest of motives, our nation freely published its nuclear technology. I am not aware that the United States or United States industrial firms have realized significant revenue related to the economic worth of this technology now being used by others that was or could have been property.

The national interest will be served by increasing the incentives to commercialize technology created under federal programs. A simple way to do this is to give contractors full ownership of all inventions they make subject only to the government's non-exclusive license for governmental purposes.

Turning now to a case of disincentive to the commercialization of federal technology that applies to PNL, I would like to invite your attention to the amendments

(Public Law 98-620) to the Bayh-Dole Act. These amendments apply to Battelle as a non-profit organization operating the Department of Energy's Pacific Northwest Laboratory.

Section 401.5(f) of the proposed implementing Department of Commerce Regulation unrealistically limits the reimbursement of technology transfer costs to specified administration costs. The effect of this Section is to require nonprofit operating contractors to incur the principal financial risks, while the primary benefit is to the Government facility. There is little incentive for a contractor to take such risks when the best that can be achieved is to recover only a portion of the costs, and then only (on average historically) seven years after the costs are incurred when income is generated.

Recognizing that any net income may only be expended for specific activities at the originating Government facility, or paid over to the Treasury, original costs necessary for the identification, evaluation, and proving of the inventions should be allowable. Specifically, based on both equitable and practical considerations, we have recommended that allowable costs include evaluation of the inventions for patentability and market potential, experimental proof-of-principle, licensing negotiations, and other directly related expenses. Technology transfer activities are by definition high-risk and difficult, with low probability of return of investment. The statute and regulations require that any net income remain at the facility. If the contractor cannot recover expended private capital, risked for the benefit of others, the incentive for contractors to participate in fostering the development and commercialization of inventions is eliminated.

The recent amendments (Public Law 98-620) to the Bayh-Dole Act allow title to patents on inventions made by the contractor managing a Department of Energy laboratory to be taken by the contractor. While this is technically true, these limits and burdens on the title tend to reduce the commercial interest of entrepreneurs:

(1) The agency retains a non-exclusive, non-transferable, irrevocable, paid-up license to practice or have practiced the invention on behalf of the United States throughout the world.

(2) The Government may ask for the right to assign foreign patent rights to meet U.S. obligations under international agreements.

(3) The agency may require periodic reporting on utilization efforts being made by the contractor.

(4) Non-profit contractors are prohibited from assigning patent rights without approval of the Federal agency (except when assignment is to an invention management firm).

(5) The contractor must share royalties with the inventor.

(6) The Federal agency retains the right to require the contractor to grant licenses to responsible applicants.

(7) U.S. patent assignees and exclusive U.S. licensees must agree that products embodying the invention will be made substantially in the United States.

(8) Government may take title to the invention in countries where the contractor has not filed patent applications.

(9) Licensing probably must be administered by Go-Co employees located at the facilities.

Each of these conditions has a justification. Taken together they present a formidable obstacle to attracting an entrepreneur and capital to the commercialization of a patent burdened with them.

D. BATTELLE'S TECHNOLOGY TRANSFER EXPERIENCE AS OPERATOR OF PNL

Education

PNL has been significantly involved with colleges and universities since its inception. The Joint Center For Graduate Study (University of Washington, Washington State University, and Oregon State University) was created in Richland, Washington, in 1966. PNL staff comprise 65% of its faculty and about 40% of its student body. Please see Attachments A and B.

Formal programs of educational exchange exist at PNL. Through subcontracts, university scientists and engineers support Battelle's research activities. PNL in 1985 is funding about $7.6 million of research under about 50 subcontracts with universities. Technical interchanges are frequently held with university staff.

Science and engineering students and facility from universities nationwide participate in the Laboratory's research programs through the Northwest College and University Association for Science program (NORCUS). In addition, the National Science Foundation's industrial research participation program involves university faculty in research.

Members of the Battelle staff hold affiliate faculty appointments or serve on Boards of Trustees or academic advisory committees of major educational institutions. Dr. William R. Wiley, Director of PNL, is on the Boards of Gonzaga University and the Washington Technology Center. PNL has developed relationships with Gonzaga University and Whitman College resulting in new educational opportunities and programs at these Eastern Washington institutions.

Battelle provides financial aid to the independent colleges of Washington and Oregon, and some funding and equipment for the science programs of local schools. In addition, Battelle has granted funds for university research and has established college scholarships and programs of support for science teaching in the region.

Recently PNL has undertaken important new initiatives to support technology transfer involving educational institutions and the private sector. These initiatives involve educators from elementary school through universities. The initiatives include the expansion of the role of PNL's Office of Research and Technology Applications to include interactions with local pre-college schools and community colleges. University and Industry Relations staff have been located in Seattle.

University involvement

Recent technology transfer activities at PNL involving the universities and colleges include the encouragement of better utilization of federal technology and capability by inviting university faculty and students to PNL for tours and seminars and to conduct research. PNL scientists and engineers participate in teaching and research activities at the universities. Development of joint research projects and staff exchanges take place.

Expansion of these activities will help increase outside awareness of the latest Laboratory research and will help PNL research staff transfer their results to the academic community and make better use of PNL and university capabilities. As part of the expanded activities, contacts have been established and discussions initiated on mutual areas of research between PNL staff and faculty at Northwest universities. For example:

PNL management met with the deans of the schools of the University of Washington, Washington State University, and Oregon State University; and in separate meetings with Northwest College and University Association for Science (NORCUS) representatives to discuss approaches and areas for developing additional interactions.

Seventy-six deans and department chairmen of colleges and universities in the Northwest region were notified about the availability of the "User's Guide to DOE Facilities."

Opportunities for faculty and students of Historically Black Colleges and Universities to participate in PNL projects have been identified.

PNL staff participated in a University of Washington Science Affiliates symposium. Science Affiliates is an experimental approach toward facilitating contacts between industry and the university sciences.

Involvement in work study programs has been expanded to include the Oak Ridge Associated Universities, in addition to the NORCUS and Associated Western Universities programs.

Visits have been made to several regional and state universities in the Northwest including University of Washington, Washington State University, Western Washington University, Central Washington University, University of Idaho, Portland State University, and Oregon State University.

The needs and capabilities of the universities determined through these visits and other contacts will be used to identify federally developed technologies which may be of interest to the university programs. One example involved a graduate student at the University of Washington in Materials Science and Engineering. The student's thesis research was enhanced by the use of special surface science analytical equipment at PNL.

Another example of technology transfer to academia is teaching at universities by PNL staff members. In addition to teaching at the Joint Center for Graduate Study, PNL staff also teach at nearby locations such as Walla Walla College, Whitworth College, Washington State University, and Central Washington University. Last summer a PNL engineer taught a special engineering course at Walla Walla College, presenting ideas and concepts that were developed as part of PNL programs. Another engineer is teaching an evening course in plastics technology and helping with the plastics laboratory at Central Washington University.

The University-DOE Laboratory Cooperative Program administered by the NORCUS provides an opportunity for technology transfer directly to academia and indirectly to the private sector. The NORCUS program makes it possible for many

faculty members and students to gain valuable experience in working with researchers at PNL. After their appointment at PNL, faculty and students return to the university or private sector with new knowledge and experimental techniques based on federal developments. In addition to NORCUS funding, R&D programmatic funding is used to meet needs under the NORCUS program for bringing faculty, student, and post-doctoral appointees to the Laboratory.

Pre-university involvement

A higher education committee has estimated that by 1990 enrollment of 18- to 24-year-olds in colleges and universities will have decreased by 25%. Thus the fraction of students graduating in science and technology could decrease proportionately. To keep the number of science, mathematics, and technology specialists graduating the same as now, there has to be a significant increase in the fraction of total students going into those areas. PNL is working to help improve educators' capabilities to make those areas relevant to the student's interest and to maintain that interest and science program continuity.

PNL staff members met numerous times with administrators, science curriculum directors, principals, and elementary science teachers in the region in response to requests from school districts in Pasco and Richland, Washington. The purpose was to contribute to curriculum decisions such as how to supplement existing textbooks and supplies; how to make science more relevant to students' interests; and how to develop continuity in the science program from grade to grade.

An effort called "Sharing Science with Schools" based on input from local educators was funded and launched in the local schools in October, 1984. Six topics were selected as subjects to be "shared" with local schools. The topics are technologies with a high potential for application in the private and public sectors. These are: Nuclear Waste Management; Food Processing Using Irradiation; Robotics (high-speed inspection); Engineers in Energy Research (catalytic biomass gasification); Artificial Intelligence; and Biotechnology.

PNL staff have been meeting regularly with Academic Division Leaders from the local community college, Columbia Basin College (CBC), to recommend ways PNL can assist the science and mathematics faculty in curriculum development; specifically, in using writing as a way of learning. PNL provided a workshop, during school hours, for the CBC faculty on strategies for integrating writing into teaching science. As a result of these meetings, other ideas of mutual interest are surfacing which will allow PNL technologies to be shared with community colleges. Many potentially fruitful areas of collaboration between PNL and the academic community have been identified.

PNL has supported a state-wide conference of 30 High School Teachers sponsored by the American Nuclear Society. This week-long program was directed to learning about energy sources. PNL for a number of years has supported the annual six-week conference for High School Teachers sponsored by the Washington Council on International Trade. The purpose of this conference is to interest and teach high school teachers especially about international trade.

Attachment C is a summary of participants in education programs at PNL in FY1983.

Office of Research and Technology Applications [ORTA]

A technology transfer focus at PNL is provided by the Office of Research and Technology Applications (ORTA). The Manager of ORTA: Assesses PNL R&D efforts for applicability to the needs of the private sector and state and local governments; is a catalyst for application and/or adaptation of PNL research or technology to processes, products, solutions, and services for use by the private sector and state and local governments; and handles requests from state and local governments and industry for applications of DOE technolgy.

The ORTA approves activities under DOE Order 5800.1 and is responsible for meeting DOE requirements under the Stevenson Wydler Act. Activities include assessing technology applications; referring inquiries to appropriate staff; providing technical assistance; and establishing criteria, priorities, and schedules for responding to requests.

The Manager of the Office works with the R&D staff and obtains support from PNL's patent office, public information staff, library reference staff, and small business liaison office. In addition, one member from each research department is identified to provide guidance, to help coordinate the effort, and to suggest appropriate people to handle requests.

PNL staff also cooperate with technolgy transfer brokers such as the Federal Laboratory Consoritum (FLC) for Technology Transfer. The Regional Coordinator for the Far West Region of the FLC is a PNL staff member. This region covers 8 states

and includes 45 laboratories representing 6 federal agencies. The cooperation helps PNL focus activities in the Northwest and provides additional contacts for transferring technology.

Many PNL programs involve technology transfer efforts directly. Other R&D programs are being reviewed to identify those that may be appropriate for technology transfer efforts. Visits to Northwest industries to identify needs that match PNL technology also occur regularly. Results of these activities suggest fruitful areas for DOE/industry cooperative programs and guide dissemination of information on new technologies.

Research efforts sponsored by DOE are reviewed by PNL for transfer potential. New direct or indirect applications of Laboratory discoveries and capabilities are sought; and information about them is disseminated through publications, demonstrations, direct training, and utilization. For efforts that appear to have immediate transfer potential, a plan for making the technology available to an appropriate audience is developed. The Office of Industry Relations, through extensive contacts with industry, is developing a detailed understanding of industry needs. This activity is an essential part of the creative path, providing the means to link federally developed technology to needs which could not be foreseen without knowledge of both the needs and the technology pool. In both cases, arrangements are made to assist producers or users in appropriate use of the technology.

In FY 1985 and beyond, the resources committed to an expanded role for ORTA and the Offices of Industry Relations and University Relations will amount to four full-time professionals and technical and secretarial support.

Recent Technology Transfer Highlights at PNL include:

Marking paint

In 1977, a readily identifiable marking product was developed for reducing pilferage of government hand tools and other property as part of Hanford site support programs. Fluorescent dyes and metal ions are added to an epoxy-based paint which is used to mark the item to be identified. The combination has resulted in a paint with properties that make it an attractive and viable marking product.

Food processing

In cooperation with the U.S. Department of Agriculture's Research Service laboratories in the Washington cities of Yakima and Wenatchee, the Oregon State University Experiment Station at Hood River, and the Washington State Fruit Commission, PNL is studying irradiation as a disinfectant and preservative of Northwest agricultural products such as cherries and apples. Increasing restrictions on various chemical treatments are making disinfestation and preservation of food products by irradiation more important.

As part of a planned technology transfer process, information on this technology was presented at a forum sponsored by the Institute of Food Technologists. A total of 85 requests was received for assistance and for arranging cooperative studies.

Uranium bioassays

In a technology chosen for a planned technology transfer effort, instrumentation and methodology for using kinetic phosphorimetry to measure uranium concentrations in bioassays has been shown to both potential users and producers. Development of the technique was funded as part of the Environmental Research and Development Program.

Corrosion control

Corrosion protection technologies developed for the Geothermal Energy Program and nondestructive testing (NDT) techniques are being evaluated and suggested for spin-off applications in the pulp and paper industry and the agriculture industry. A cooperative program directed to saving energy through corrosion reduction in continuous digesters was prepared which involves several pulp and paper industry representatives, PNL, and DOE.

In the agricultural area, a proposal is being prepared for a cooperative effort to reduce irrigation pumping energy requirements by reducing corrosion in pumps and piping using the corrosion control technology developed at PNL.

Photovoltaics product guide

A consumer's guide and directory on photovoltaics product information has been prepared by PNL as part of the Solar Energy Program and published by Van Nostrand Reinhold Publishing Company. The guide includes information on the use and availability of photovoltaic products, examples of operating systems in the United

States, implications of tax credits and a listing of product prices, manufacturers, and contacts.

Special awards

Two PNL staff members received 1984 Special Awards for Excellence in Technology Transfer from the Federal Laboratory Consortium for their efforts in transferring laboratory-developed technology to private industry.

Recovery of noble metals

For the third consecutive year researchers at PNL have received an IR-100 award from Research and Development magazine. The 1984 award, for one of the 100 most significant new technical products of the year, was in recognition of a process for treating fission waste for recovery of noble metals. The laboratory-scale process developed under the Defense Waste Management Program removes valuable and strategic metals from what would otherwise be considered waste, spent nuclear fuel. The development could result in a new domestic source of ruthenium, rhodium and palladium—metals which occur rarely in nature but are produced as fission products in nuclear reactors.

Portable blood irradiator

A portable blood irradiator developed under the Life Science and Nuclear Medical Applications Program shows promise of suppressing early rejection of tissue or organ transplants. The patented device uses radiation, in the form of a thulium isotope, to lower blood levels of lymphocytes, the white blood cells that initiate the cell and tissue rejection process. Research with the device has shown that lymphocyte counts can be lowered to less than 10% of pretreatment levels without a significant change in red cell numbers or evidence of lowered resistance to diseases.

Controlled-release chemicals

A controlled-release herbicide device has been developed for protecting waste burial sites from root intrusion under the remedial Action Program. One laboratory prototype designed for feasibility testing is a polyethylene device which releases the herbicide trifluralin at low uniform rates over an extended period of time, estimated to be about 100 years. The device prevents longitudinal root growth but does not affect root and shoot production.

Some research programs have technology transfer accomplishments as part of the programmatic work such as:

Industrial energy conservation; Building systems; geothermal energy processes; thermochemical conversion of biomass, atmospheric fluid dynamics; civilian nuclear waste management; and energy conversion technology.

In FY1984 PNL issued Energygrams and Technology Transfer Bulletins on the following subjects:

Energygrams

Intergrating wind turbines into a conventional utility; Sampling aquifer thermal energy storage systems; LNG fire and vapor control system technologies; portable blood irradiator; lung cancer risk from radiation exposure; an improved technique for uranium bioassays; coolant-level sensors for nuclear reactors; LNG release prevention and control systems; liquid-petroleum-gas safety; and In-situ vitrification—technology for waste treatment.

Technology transfer bulletins

An improved technique for uranium bioassay; In-situ vitrification; computer-assisted geochemical prospecting; catalyzed gasification of biomass; high-speed inspection; food irradiation; advanced technologies in nondestructive evaluation; research and technology applications; sharing science with schools; biobarriers for waste site protection; remedial action technology for waste disposal; evaluating material and structural integrity through advanced nondestructive evaluation; and technologies opportunity list.

In FY1984 PNL held conferences with private sector participants covering the following technologies:

Hazardous waste stabilization; improved separation processes; materials reliability, technological indicators; geochemical prospecting; catalytic biomass gasification; controlled release chemicals; high-speed inspection; corrosion control; coating technology; uranium bioassays, and food processing using irradiation.

Numerous presentations were made at other conferences and meetings including: Small Business Innovation Research Program workshop; Geothermal Resources Council; DOE/Motor Vehicles Manufacturers Association; Symposium on DOE's Uranium Mill Tailings Remedial Action Program; Buildings Innovative Concepts

Fair; Food Technologists Forum; Annual Meeting of Federal Laboratory Consortium for Technology Transfer; and Washington Small Business Development Center (National Innovation Workshop).

E. TECHNOLOGY TRANSFER EXPERIENCE UNDER THE DOE-BATTELLE USE PERMIT

The closing of AEC's plutonium production reactors at Hanford in the early 1960's created the prospect of economic hard times in the Southeastern Washington area. The AEC, with the support of the President and Congressional Joint Committee on Atomic Energy, undertook a program to induce Hanford contractors to develop, with their own resources, business activity in the region. For example, ARCO built a new hotel and started a large cattle-feeding operation; Douglas established a high tech products lab; Douglas and United Nuclear invested in a zirconium manufacturing plant; and Battelle Memorial Institute undertook to create a contract research business and invest substantial resources in the Northwest for this purpose.

The AEC's 1964 Request for Proposals for management of the Hanford Laboratories offered the use of AEC laboratory facilities to the successful R&D contractors for work on its own account, including work for industry and other Government agencies. This permit to use Government property is, in essence, the "Use Permit."

As implementation of the Use Permit has envoled since 1965:

Battelle, the R&D contractor, has invested $49 million in research facilities and equipment in Washington State.

Battelle has performed $237 million of R&D for industry and government agencies other than AEC, ERDA, and DOE. This work is pre-financed with Battelle funds.

An average of 470 full-time equivalent employees per year have been employed in Use Permit work over the past five years.

And $15.5 million has been paid or credited to the Government by Battelle for use of Government facilities and equipment from 1965 to October 1, 1984.

Significant employment relatable to Use Permit programs has been created in the community (Exxon Nuclear Company, Nortec, Holosonics, Automata).

The Use Permit is regarded as a useful mechanism for technology transfer of DOE's technology to industry and form industry into DOE's Pacific Northwest Laboratory.

Attachment D is a summary of patent activity at NPL since 1965.

In summary, multiprogram laboratories such as PNL can help improve our national competitive strength:

(1) By appropriate involvement with educational institutions at all levels. This involvement appears to be desired by the educational institutions. In this way current and developing technologies can be made real. The skills needed to work with technology can be seen and appreciated.

(2) By digging out and appraising technology and taking other necessary steps preliminary to attracting commercialization efforts of entrepreneurs.

This activity calls for skills and interests that differ from those applied to research and development. Therefore this activity needs to be recognized and supported according to its particular purpose and objectives.

These activities will be facilitated if the incentive of the Constitutional Patent System is allowed to operate with respect to technology that has commercial value. This might or might not result in basic innovations, i.e., new technologies or methods of operating that can potentially offer employment to a large group of people. It is more likely to produce lesser improvement innovations. I know of no easier way to test the validity of the assumptions that are being made about the value of federal technology.

We hope that the information and opinions presented here will be useful to your Committee.

Senator GORTON. Thank you very much.

Dr. Aron.

Dr. ARON. Senator Gorton.

I am William Aron, the director of the Northwest Alaska Fishery Center. It is on one hand a great pleasure to appear before you. And also, it is with a considerable amount of trepidation. I think I am to

some degree at an unfair advantage in terms of other witnesses to talk to Senator Gorton about the fishing business. It is not totally reasonable.

The Northwest and Alaska Fishery Center is a research center and a large one. It is a research center within the framework of the Federal Government. As such, we are vey strongly mission oriented.

To be effective within our mission means that we must understand and work closely with the constituency we serve. This constituency includes a full spectrum including consumer, recreational fisherman, commercial fisherman, processor, and marketer of fish. I would like in my comments to you to provide some perspective for the written testimony which I have submitted.

We work very closely with our community and at the present time I perceive two broad areas of great concern: one, where we stand with the United States and Canada in our treaty obligations towards salmon; the second, which I will cover first really, is the very rapidly developing United States, and in particular the Northwest and Alaska, ground fish fishery.

At the present time, the United States is the world's leading importer of frozen processed ground fish products. We import two-thirds of the world's supply. Ninety percent of the frozen ground fish products of the United States at the current time are imports.

The sustainable yield from the Gulf of Alaska and Bering Sea and the turf for which our center has the research responsibility can completely support the ground fish needs of the United States and at the same time provide substantial opportunities for export, unless of course, as I hope, the United States and its citizens will come to recognize the truth that: one, fish are awfully good to eat; and two, they are also awfully good for you to eat.

And certainly in recent days, recent years, we have seen a growing demonstrated and statistically proven fact that those people who eat fish at least three times a week are far more healthy and less vulnerable to cardiovascular disease than those who eat fish less frequently. We have begun to understand the medical background for this, we understand how eating fish works on on the circulatory system.

I do anticipate we will see an increased use of fish in this country. Certainly, as our ability to handle the fish in a way which will allow the consumer to buy a quality product improves, we will see increased use of fish. However, we do see a very real shortfall in terms of our import/export ratio. I think that what we are doing in the fishing industry today will help provide a balance to the trade.

Within this framework, the center has a major responsibility in terms of providing the kinds of stock assessment data which are critical to an industry that faces very heavy capitalization and wildly fluctuating stocks. Normally, fish and other wildlife resources will undergo natural large-scale fluctuations.

Within the past decade we have seen, for example, a tenfold increase in the population of cod fish. We have seen a tenfold increase in the population of pollock. Simultaneously, we have seen very severe

reductions in the populations of king and tanner crabs. We are also seeing severe reductions now in both the northern fur seal and the sea lion.

It appears to me that virtually all of these changes are attributable to still unexplained natural alterations in the environment which have reasonably unexplained impacts on the populations. Even though we cannot explain these changes, we are in a position, by virtue of our ability to assess stocks in the wild, to predict these changes.

In fact, we do provide the industry rather long-term predictive capacity. For someone who is interested in building a fishing boat, the time between construction of the boat and the time that boat is fishing could be as much as 3 years. It is important to a man today who wants to invest in a codfish boat, indeed, that 3 years from now he will have a source of supply of fish.

The center provides, in fact, the kind of information to the community, both to the managers and to the users of fish and to the purveyors of fish products, the kinds of insight which will allow reasonable marketing. For example, there is little benefit to introducing new recipes to "Ladies Home Companion," to the other newspapers and other sources of recipes, for recipes on fish that will not be available. We try to provide that kind of insight.

Likewise, we have also been very successful in identifying to our fleets the areas where fish and products can be taken in which they can develop appropriate target species.

On the other hand, the problem we are facing in terms of the management of our salmon. The salmon resources of the Northwest are very important. We share those resources between a number of States and a number of countries. Canada, Japan, fish on stocks of salmon that are generated in North American streams.

The fishermen of Alaska, for example, in their troll fish catch of chinook salmon, take about 80 percent of their catch from fish born in streams to the south, in Canada, Washington, and Oregon. It is clearly a classical common property resource. It is clearly a resource which faces severe jeopardy because of a number of environmental shifts.

But there is little point, in fact, without sound management for the people of this State, for the people of British Columbia to invest large amounts of money in mitigating environmental damages, if in fact the profits from that investment go to the fisheries of

other countries or of other States.

I think now the President and the Senate have concluded a sound treaty with Canada that will allow wise management. Wise management now implies, however, a number of things: one, an ability to mitigate damage that has already been done; two, it implies an understanding of the geographic location and an ability to identify at sea the different stocks of fish.

Our center has played a key role in developing the kinds of mitigation necessary to solve problems generated by dam construction on the Columbia River, by logging practices, both in Alaska and Washington and Oregon. We also have developed the kinds of

technology that allow, through genetics, electrophoretic techniques, to separate stocks of fish.

Out at sea, in very precise ways we are able to tell if fish taken in the Gulf of Alaska are destined for North American or Asiatic streams. We are able to tell what streams they are destined for, all of which are crucial to both the fisherman and to the managers of these resources.

I think we have been effective largely because we have been able to work very closely with the community, who have provided the kind of signals to us that gives us a hint as to what we should work on and also provides us an ability to take that material and translate it in ways which are useful to communities.

Thank you.

[The statement follows:]

STATEMENT OF DR. WILLIAM ARON, DIXETA, NORTHWEST ALASKA FISHERIES CENTER, NATIONAL MARINE FISHERIES SERVICE

The Northwest and Alaska Fisheries Center (Center) is one of four research centers of the National Marine Fisheries Service (NMFS), NOAA. As a public, research organization the mission of the Center is to:

(1) Plan, develop, and manage programs designed for better comprehension of the living marine resources of the sea, such as fishes, shellfish, seals, and whales, and the environmental quality essential for their existance and continued productivity;

(2) Describe and provide to management, industry and the public, options for the utilization and conservation of living marine resources and maintenance of environmental quality which are consistent with national and regional goals and needs, and international commitments.

As a mission oriented research agency the successful accomplishment of our functions and responsibilities rest not only with development of scientifically sound information but also with timely relay of that information to appropriate constitutent groups. From experience we have found that transfer of information in the printed form needs to be augmented by frequent personal contacts. Center staff are in daily, personal contact with members of the industry (at the Center or at the waterfront), other federal and state research organizations, academic institutions, fishery commissions, and management bodies, such as the fishery management councils.

Depending on the type of information and user a variety of mechanisms and media are used for technology transfer. They are: (1) guides, directories and briefs prepared in response to the Stevenson-Wydler Technology Innovation Act or 1980; (2) scientific publications, reports, brochures, handouts, and charts; (3) seminars, symposia, and workshops; and (4) face-to-face communication.

To transfer technology to industry, a technique practiced at the Center is to identify and work closely with the innovators, or "high liners", i.e. those individuals we perceive as willing to try (risk) a new gear, equipment, or method and by their successful application influences others in the industry to adapt the new technology. We utilize this approach because experience has shown that in many cases the printed word alone, although widely circulated, does not necessarily result in adoption of the technology. Where possible, we also try to include preliminary estimates on cost and potential benefits of the technology. This information assists the interested party in making informed investment decisions.

Examples to follow show that technologies and technical information developed at the Center and transferred to the outside cover a broad spectrum of activities.

TECHNOLOGY AND TECHNICAL INFORMATION TRANSFER

Survey and stock assessment

During the Fifties and Sixties the primary information developed and transferred to industry and other constituents were on location, distribution and abundance of utilized and underutilized fishery resources in the North Pacific Ocean and Bering Sea. Federal commitment and lead is a necessity considering the structure of the harvesting sector of the U.S. fishing industry (thousands of independent vessels/owners).

Comprehensive surveys on groundfish, pelagic fish, shrimp and crabs (king and Tanner) were carried out along the West Coast to the Bering Sea. This technical information was transferred to industry and governmental agencies in the forms of reports, charts, and direct contact. In most cases, members of the industry personally visited the Center to obtain information and advice. It is generally acknowledged that much of the development and growth in U.S. West Coast and Alaska fisheries were aided by these surveys—(1) the resource survey was instrumental in starting a new fishery or (2) the resource survey made possible the subsquent efficient development of a fishery as new processing technology was developed (e.g., shrimp peeling machine) or as the market and demand for its products began to grown.

Since the Seventies the primary purpose of surveys has shifted to that supporting stock assessment; however, information from these surveys on distribution and abundance of resources are still valuable to industry. Requirements under the Magnuson Fishery Conservation and Management Act accelerated the shift to stock assessment. Information on stock condition is relayed to management councils for decisions on quotas, allocation (domestic and foreign) and regulatory measures. The same information is used by industry to assist them with investment and operational decisions. Some selected examples on this technical information area and transfers are:

Chart overlays that show survey results in graphic form.

Fishing logs that list results for each station fished.

"Reports to Industry" for crab. The report presents results from surveys to fishermen before the season opens each year.

Special reports to industry. For example, on Pacific cod we provide projection of change in abundance and yield to result from occurrence of the unusually abundant 1977 year class (ten times as abundant as average year class).

Status of Stocks report which each year evaluate the condition of stocks and short term changes to be expected on major fishery resources such as pollock, rockfish, flounders, Pacific cod, sablefish, Atka mackerel, Pacific whiting (hake), king and Tanner crabs.

Tailored products that present any subset of data from our survey record (data base) of 31,000 trawl hauls. For example, maps and tables of all results for sablefish (blackcod) for locations within 200 miles of Kodiak, Alaska.

Provide industry with comparative longline and pot gear tests for blackcod harvest.

Biological/fishing factors affecting blackcod flesh quality are being evaluated to provide industry information needed to market quality product.

Fishing gear technology

The primary purposes of federal research on fishing gear technology during the Fifties and Sixties were: (1) increasing the efficiency of commercial harvesting methods; (2) reducing mortality of incidentally caught animals; and (3) developing improved sampling gear for stock assessment needs. On commercial fishing gear/technology, federal commitment and lead was a necessity considering the structure of the fishing industry and infancy of the U.S. fishing gear industry. Fundamental research activities underlying these are studies on animal behavior, on fishing and sampling system designs, and on performance evaluation. The immediate client of information on efficient commercial harvesting methods was the fishing sector of the industry. The immediate clients of information on effective harvesting methods (e.g., reduce catch and mortality of incidentally caught animals such as in the tuna-porpoise situation) were the industry as well as management agencies.

The following technologies developed at the Center have been utilized by industry and research agencies. Many have become the standard fishing gear of the industry as well as sampling tools of research agencies.

Deepwater trawl system and gear; midwater trawl system and gear; universal trawl; sablefish trap; Columbia River smelt trawl; high-opening shrimp trawl; double trawling system; king crab bait trawl; selective shrimp trawl and one-man, small-boat beam trawl.

With the advance in the fishing technology industry, internationally and nationally, our efforts have shifted to the (1) continuing improvements of research sampling gear, (2) continuously updating our reference collection on international efforts in fishing gear research and development, and (3) maintaining expertise and capabilities for modifying fishing gear to meet special or specific situations. Recent examples include:

Development of an escape panel to allow porpoises to escape from tuna purse seines. This technology has been adopted throughout the U.S. tuna fleet.

When interest grew in the potential for a squid fishery in Washington and Oregon the Center was involved in a wide range of transfer activities. Automated squid-jigging machines were furnished to a demonstration project off the Washington coast. Plans and reports on squid-catching techniques such as trawls, lamparas, seines, jigging machines, pumps, and night-lighting operations were furnished to interested fishermen and regulatory agencies.

The California Department of Fish and Game sought advice from the Center on possible alternative fishing techniques for California halibut gillnet boats. Construction and operation plans were furnished for longlines, beam trawls, and pair trawls suitable for operation from small boats.

When fishermen in southern Oregon expressed interest in harvesting spot prawns and other large shrimp found in their area, the Center furnished construction loans for traps used in southeast Alaska for the same species along with reports on the use of such gear, and put the fishermen in touch with trap manufacturers.

When other Oregon fishermen began harvesting scallops, the Center provided them with loans for commercially-scaled scallop dredges and gave plans for a smaller dredge suitable for research to a management group.

The Center disseminated information on automated jigging machines developed in Europe to interested rockfish fishermen from Alaska and coastal Washington. This technology presented an alternative to the less efficient traditional way of fishing by hand lines. The jigging machines are now in use.

Resource Utilization, Product Quality and Safety

Fishery resources available along the West Coast and Alaska offer vast opportunities for expansion of our domestic fishing industry. The pollock resource alone represents a potential addition of 1.5 million tons to domestic catch and products.

The Center provides a focal point and source of knowledge on:

(1) Chemical and physical properties of fish and seafoods.

(2) Methods of handling, preservation and processing, including iced storage, freezing, canning, curing, smoking, freeze-drying, and irradiation.

(3) Methods of quality control, quality measurement, and quality improvement.

Major research efforts of the Center include:

Minced fish and surimi. Methods of preparation, species differences, quality control, and effect of storage on functional properties.

Underutilized species. Storage properties and special handling requirements, proximate chemical composition, use concepts and properties that affect acceptability.

Research on Clostridium botulinum (botulism). Methods to prevent outgrowth in seafoods, guidelines for assuring safety in smoked fish and other seafoods, identification and prevention of botulism in fish hatcheries.

Fish waste research. Characterization of fish processing wastes, treatment methods to prevent fish wastes from becoming pollutants, and use of fish wastes to prepare fish and animal feeds.

Some recent examples of developments transferred to industry are:

Method of reducing thaw time by use of acoustical energy. Patent was issued and the system is being developed further by a private engineering company.

Automatic scallop shucker. Patent was issued. Machine was built and operated by a private company.

Injection of solutions into fish. Developed a high-pressure injection unit to uniformly treat fish flesh with various solutions such as salt. Commercial model was built by private company.

Removal of carotenoids from shellfish wastes. Developed method of extracting carotenoids from shellfish wastes. Commercial plant was built based on the technique.

Cooperative industry, Federal, and State of Alaska study to assess the distribution, abundance and quality of subtidal surf clam in the Bering Sea.

Joint research project with a fisherman's association and a consulting firm to determine the feasibility of preparing minced pollock at sea.

Joint research project with Smoked Fish insustry and National Fisheries Institute in developing processing parameters to assure the safety of smoked fishery products.

Fishery enhancement

Much information has been transferred to the public and private sectors on enhancement of biological productivity of resources and protection of resource habitat. Examples are:

Developed relationship between river flow and downstream migrant survival that was used by fishery agencies to establish minimum flow criteria for the Columbia-Snake River system.

Developed the comprehensive smolt monitoring program being used by the power entities and the fishery agencies to allocate spill at dams in the Snake-Columbia River system to enhance salmonid survival.

Developed the concept of significantly increasing survival of juvenile salmonids by transporting them from upstream collector dams to release sites in the lower Columbia River—being used by COE and fishery agencies to enhance survival of salmonids.

Developed the submersible traveling screen and bypass concept being used by the COE to protect juvenile salmonids from turbines.

Developed the radio-frequency fish tag for adult and juvenile salmonids being used by a multitude of agencies to monitor fish behavior.

Developing the comprehensive radio-tag automatic monitor system which will allow acquisition of definitive data on juvenile salmonid passage routes and survival at hydroelectric dams without the need to mark and handle vast numbers of smolts.

Development of vaccines to control disease in cultured salmon stock, e.g., vibrio—being used by fishery agencies, industry, and Indian tribes.

Developed salt (NaCl) feeding technique to promote smolting in hatchery fish—being used by fishery agencies, industry, and Indian tribes.

Developed the technique using Na+ −K+ ATPase and hyroid hormones as indicators of smolting for hatchery fish—used by fishery agencies, industry, and Indian tribes to adjust release times.

Developed the Genetic Stock Identification (GSI) method for identification of stocks within mixed-stock fisheries—used by fishery agencies for real-time management and will be a major part of the U.S./Canada treaty work.

Developed the marine net-pen concept for rearing salmonids during the marine part of their life cycle—being used by fishery agencies, industry, and Indian tribes in both enhancement and culture activities.

Developed information on salmon interceptions in southern Alaska that contributed to successful negotiations on the Pacific Salmon Treaty with Canada.

The information being developed on chinook salmon enhancement and restoration at the NMFS Little Port Walter Field Station is transferred annually to State of Alaska agencies and Regional Aquaculture Associations. These groups depend heavily on results of this research.

Worked with the State of Alaska and industry in developing a comprehensive chinook salmon restoration and enhancement plan including a detailed annual annex update for Southeast Alaska.

Developed information that led to substantial reduction in the numbers of U.S. salmon intercepted by the Japan gillnet fisheries from more than 5 million fish in 1970 to less than 1 million fish in recent years.

Develop information needed by industry and management agencies on effects of oil on fishery resources to assess the impact of development on fishery habitats.

Develop information on logging effects to the timber industry in Alaska leading to best utilization of timber resources while protecting salmon stream habitats.

EXCHANGE OF PERSONNEL

The Center utilizes a variety of formal and informal arrangements in bringing about personnel exchange. These exchanges are international, national, regional, and local in scope and cover disciplines in fishery biology, oceanography, economics, computers/systems, marine mammal biology, genetics, quantitative science, and survey technology.

We have active personnel exchange programs with fishery institutions/agencies of Norway and Japan. This exchange keeps our staff better informed on new technologies and scientific advances taking place in leading foreign fishing nations. Our staff transmits appropriate information to governmental agencies, academic institutions, and industry.

Under the Intergovernmental Personnel Act (IPA) we usually have 2–3 scientists from state and academic institutions. In turn, we place Center scientists at state or academic institutions on an opportunity basis.

We usually have 1–2 scientists (Post Doctoral Fellows) from academic institutions under the National Research Council's Research Associateship Program. This exchange brings scientists with up-to-date knowledge on advances in his/her field to the research project at the Center. In turn, these Fellows take back to the academic community the latest advances and information on applied research.

Each summer we have 1–3 professors from minority colleges undertaking fishery projects at the Center. This program helps to expose the college faculty (and subsequently their students) to public fishery research organizations—its programs, objectives, and disciplines involved.

Many of our facilities are shared with state agencies and academic institutions. Examples are:

The co-location of the groundfish research personnel of the Washington Department of Fisheries with our survey and stock assessment personnel at the NOAA Sand Point facility.

The shared use of our electron microscopes at our Montlake facility.

The shared use of our marine net pens and fishery enhancement research facilities at Manchester, WA.

The shared use of our salmon enhancement research facility at Little Port Walter, Alaska with the state of Alaska and Regional Aquaculture Associations.

Joint operation and management of our experimental hatchery at Auke Creek with Territorial Sportsmen of Juneau, State of Alaska, and University of Alaska-Juneau to enhance recreational fisheries in northern Southeast Alaska.

The shared use of our utilization research facility and pilot plant at our Montlake facility.

The shared use of our Kodiak, Alaska facility with the University of Alaska's food/fish technology scientists.

TECHNOLOGY TRANSFER PHILOSOPHY

As an indication of the importance we attach to the concept of "technology transfer," the Northwest and Alaska Fisheries Center has established an annual award to honor individuals who have made significant contributions in this area. The award, which may go to a person inside or outside the government, is presented at the biennial Fish Expo in Seattle, Washington. The recipient is selected by a panel representing both the fishing industry and the National Marine Fisheries Service. It is presented in the name of the late Jerry Jurkovich, a long-time NMFS employee. Jerry came from a fishing family and was himself a master-fisherman prior to his military service and academic training. Although formally trained as a fishery biologist, he dedicated his knowledge and skills to the design, construction and operation of improved fishing gear. During the quarter century, he served the NMFS, tens of hundreds of fishermen, students and colleagues "dropped-in" to his office of net-loft to talk about fishing gear. He always gave of his time and knowledge and over those years, this kind of personal technology transfer made a positive impact on many areas of the fishing (harvest) industry. This practice, or legacy, is continued today by the people he trained and who follow in his footsteps in the NMFS Northwest and Alaska Fisheries Center.

Senator GORTON. Thank you. That was a fascinating description of what you do and how you go about doing it.

In an agency such as yours, how are innovative employees rewarded? Are they allowed to engage in outside consulting?

Mr. ARON. Well, addressing rewards first, within the Federal Government there is a standard reward scheme in terms of: one, promotion; two, cash awards; and three, (which a previous witness, John Fluke, talked about and which I think is very important), clear recognition.

I would mention, and it is part of my testimony, a very close friend of mine, Jerry Jurkovich, who passed away several years ago. Jerry was the classic example of a man dedicated to technology transfer. Jerry spent much of his time on the waterfront, was a master fisherman, and worked with the fleet in terms of transferring his knowledge to the users of fishing technology.

We have honored Jerry by creating a Jerry Jurkovich Award. That award is presented at each fish expo that takes place in Seattle. It is an award given to a person who best typifies the transfer of scientific technical information from the Federal Government to the private community. This kind of recognition is very important to the individuals who receive it.

As a manager of Federal employees, one's hands are often fairly restricted by rules and regulations. But within the center, those people who are the true innovators find themselves with a greater degree of freedom in terms of the pursuit of work, which in fact excites them and keeps them at the center.

Senator GORTON. What about outside consulting? Are they permitted to do that?

Dr. ARON. In terms of outside consulting for personal profit, really no. We are paid by the Federal tax dollar. I think our responsibility is to the community at large. I encourage our people to work with that community, but however this is on a gratis basis.

Senator GORTON. What about Battelle?

Mr. FARMER. Battelle tends to graduate its staff to commercial enterprises who will take technology out of the laboratory. I would say a hundred of quite excellent people went with Exxon Nuclear Corporation when they went into commercial activity. Richmond Hogh, Dr. Hogh, is the founder of Sigma Research Corporation and a successful graduate, and a number of our good people have joined Flow Industries and take technology there and work on it.

When people are working in the research laboratories, working in the research and development mode, we do not permit outside consulting, and this is for a number of reasons. The principal one was the concern on the conflict of interest that was mentioned by an earlier witness. One can imagine many horrible kinds of things that would happen.

There is the question of the where and how to pick the entrepreneur who is going to get this valuable technology which will make him rich. There is the question of absolutely unbiased judgment and in making program decisions within the lab about which programs to support and the directions to go if one is also taking money from industry.

Battelle faces a somewhat different type of problem that also leads to the same conclusion, namely that for 50 years a large part of Battelle's activity has been selling contract research to industry and other government agencies. In that case, you see, we are coincident in our interest with the interests of the sponsor. For that particular project, we are like an extension of his business. He is entitled to everything that comes out of that.

Now, if you allow staff to consult for someone else who is in a similar business and it turns out that in that context he makes a very powerful invention, a question is raised. So this is purely for assuring a lack of bias. It is also for the purpose of making sure that research sponsors effectively substantially get the results of whatever it is they are bargaining for in terms of the research sponsorship.

Senator GORTON. Are patent ownership issues handled differently under your use permit than they are at Pacific Northwest Laboratories?

Mr. FARMER. Yes. The sponsors of research under the use permit get all of the patent rights that we can give them, which is essentially all rights except for inventions that depend on unpublished Federal information.

Under the operating contract, the U.S. Government owns all of the inventions, and I think that is the case in all of the DOE labs, going back to the early days when they were created in the context of the atomic energy program, and in that case the government began owning everything and that continues.

Senator GORTON. Do you think it is critical? What are your recommendations for an ideal Federal patent policy?

Mr. FARMER. Well, I think that a policy under which inventions made in the course of Federally sponsored research belong to the contractor with a nonexclusive royalty-free license reserved in the government for use in government purposes is not a bad way to go.

That policy served the Department of Defense very well for many years and it has the advantage of being simple. It has the advantage of enabling the contractor to dispose of something that may or may not have commercial value. But at least it provides a way of getting the technology out of the government system, out of the government's patent bureaucracy.

I do not say that in a denigrating way. Those people are very valuable. And believe me, I have seen in industry the difficulties that an inventions committee and the corporation faces, that the employee brings forth an invention, well, he takes it to the inventions committee. It is very difficult for that inventions committee to say: Well, yes, we are not sure; let us defer action on this. And it is very difficult for that inventions committee to say: Yes, we will give this back to you because we are not going to do anything with it.

In an industry that is difficult because you may be giving away Xerox or Polaroid or something that could be a basic innovation that changes the course of the economics of the world. And the same is found in government. So if you are going to get out of that bind, you give it to the contractor, who at least, there are a lot of them and some are going to do it very well and some are not.

Also, I think it has the advantage of lowering to the lower decision centers and defusing other important questions about publication of the technology that underlies this invention, which is a different line of inquiry.

Senator GORTON. Dr. Aron, how does your laboratory handle patent rights, for example, for the acoustical thawing system?

Dr. ARON. This is handled through normal Department of Commerce channels that when patents are investigated, we go through the Department and the policy we have is in fact a departmental policy. The information contained in the patents, I believe are available to the public at large.

Senator GORTON. Do you have a full-time ORTA staffer?

Dr. ARON. Full-time, excuse me?

Senator GORTON. ORTA staffer, Officer of Research and Technological Applications.

Dr. ARON. Not an individual. I am the point of contact for that.

Senator GORTON. Do you participate in the Federal laboratory consortium?

Dr. ARON. Yes, we do, sir.

Senator GORTON. Do you foresee any possible problems with cooperative research in which you engage with industry?

Dr. ARON. We have not had any up to this point in time. When people come to us with material that might be proprietary we explain the conditions to them, the conditions under which we are allowed to work, and the fact the information derived from such proprietary material is public information.

One area where we do maintain confidentiality deals with the individual's statistics from specific fishing boats. That is in fact protected or we would not get those data in any kind of an accurate

way. But in terms of instrumentation that we from time to time test on behalf of food processors, they know the test results will be a matter of public record.

Senator GORTON. Again, I would like to thank both of you.

Our last panel will consist of Dr. Tam of the Washington Research Foundation, Mr. Brix of the Technology International Exchange and Mr. Simpson of Physio-Control Corporation. Dr. Tam, I will start with you.

STATEMENTS OF PATRICK Y. TAM, PH.D., PRESIDENT, WASHINGTON RESEARCH FOUNDATION; A. T. BRIX, PRESIDENT, TECHNOLOGY INTERNATIONAL EXCHANGE; HUNTER SIMPSON, PRESIDENT AND CHIEF EXECUTIVE OFFICER, PHYSIO-CONTROL CORPORATION

Dr. TAM. Thank you, Senator Gorton.

My name is Patrick Tam and I am serving as the president of the Washington Research Foundation. The Washington Research Foundation is a privately funded nonprofit organization to help the universities within the State of Washington to transfer technology to private industry. From my experience, I would like to share with you some of the issues that we have faced in transferring technology.

We use three major formalized mechanisms to transfer technology: by the most traditional route, licensing; by forming up startup companies; and/or in a generic way, research and development partnerships.

Licensing has long been practiced, that you take a technology and license to a company for complete development and bring it to the marketplace. Most of the ideas that are so-called product ideas end up being licensed to a company. Whereas technologies that are of fundamental value, that has broad applications, this might be economically feasible to start up a company to exploit the technology. This will end up creating employment in the local region and/or attracting venture capital funds to come into the State where the technology is developed.

In the situation where we deal with university technologies, a lot of them are rather raw in the sense that they are not going to be packaged in six weeks and go to the marketplace. They need quite a bit of additional development. Most of the companies are not willing to look at a technology that is so raw in that stage, where the proof of concept or reduction to practice has not been carried out.

A mechanism through which we can bring the technology to a bit more maturity is through the research and development partnership type situation, where we can get some additional funding to carry the technology a bit further, making a few prototypes, drawing a business plan, and so on, to attract interest from companies so that they will see that the technology is not simply an idea, it is something that they can begin to think about the product development stage.

On all three mechanisms, it is very important that when we market the technologies, we do not simply just transfer the technical information to a company. We need to convince them, as well as ourselves, that such technology has commercial value, and that is an important part of technology transfer in which you estimate and determine the market situation of a new technology.

This can be done in a small, simplified business analysis, where you can determine what products can come out of a certain technology, what competition is out there, who are the key players, and, more importantly, to find out which companies are eager to get into that particular product line. These companies are the likely licensees, because they are willing to get into the marketplace quickly and pay quite a bit of money to buy the technology.

All of these technology transfer mechanisms are premised on three things: one, new technologies are disclosed; second, that the technologies to be transferred are protected so that you have something that you license for commercial value; and thirdly, the willingness of the innovators and the institution to cooperate with the commercial firms to complete the development.

The disclosure of new technologies is a very important area. You have nothing to transfer if there are no disclosures. How do you get meaningful disclosures? How do you get sufficient disclosures? These are problems that we all face, both within the university and other research institutions.

One can make regulations to ensure routine disclosures. You are going to face a problem in that situation where people just make a perfunctory disclosure and makes the evaluation of those technologies very difficult.

Earlier, other witnesses have alluded to incentive programs that you provide both recognition and monetary rewards to entice investigators to think along the line of making disclosures on technologies they are working on, and I think a combination of having a policy requiring invention disclosures together with an incentive program, would be a very effective way of getting new technologies out.

For example, the Washington Research Foundation is considered a licensing agent for the University of Washington, and in that capacity we work very closely with the university to actively seek out new inventions, rather than waiting for investigators to make a disclosure to us. I think very often people who are highly technically oriented are not the best person to judge the commercial value of an invention and it is really up to us to try to make that match between what we see as needed in the commercial sector and to find the appropriate technology within those research settings and then to bring the technology out.

Regarding the protection of technologies, earlier speakers have alluded to patentable positions. Most of the nonprofit public research institutions are committed to sharing information, so they are obliged to publish. In that sense, then, any licensable technology must be patentable so that we have something that is an intellectual property to license out, that can bring an enconomic return to the license.

That raises a number of issues in terms of when the disclosures are made, how do you make sure that the recordkeeping is sufficient for patent application purposes, and also the cooperation between the investigators, the company, and the institution regarding the timing of the publication to protect the patentable ideas.

Thirdly, that any technologies that are transferred will have to go through a product development stage, and that product development within a company can be very much enhanced by the participation of the inventors and the institutions.

This raises a number of policy questions, in terms of whether an institution allows the individual employees to serve as consultants and to what extent can they serve as consultants to a company that has licensed a technology developed by them.

Another subtle issue that has come up quite often recently within the university settings is that, especially with startup companies, consultants are rewarded with shares of the company. A lot of institutions have policies against employees holding significant shares of companies or serving as officers of a company. This could be a significant issue for the Federal labs in terms of the development of the technology.

Also, the institutions, having the facilities that have been used to develop the technology, can help part of the total development.That assistance can be a research and development contract from the company to the institutions. Again, there needs to be guidelines and policies regarding that kind of contractual relationship.

Other barriers that we have run across in transferring technology is the necessity for an exclusive license for technologies. Mr. Fluke has talked about earlier that, yes, the transfer of a technology to the marketplace involve a number of steps, the product development, the marketing capability, and the manufacturing capability of the license.

However, if you are asking companies to invest significant sums of money to complete development of the technology, they would require a very well protected position. This would often mean an exclusive license to them. It is the responsibility of the licensing agent to make sure that a technology is not licensed to be killed within a company. Those can be taken care of in terms of due dilligence clauses in the licensing agreement.

Also, there are concerns about licensing technology to foreign companies and therfore are an export of the technology, which then come back and compete in the U.S. marketplace. These are concerns that have to be addressed.

There are some specific questions, for example, should a foreign licensee be permitted, nonetheless, if they restrict their activities within that foreign marketplace? Should a foreign licensee be allowed if the licensing agent has exerted his best effort to find a U.S. licensee and not come up with one?

These are some of the questions and issues that we have encountered in our short life. We were formed 4 years ago to basically help the universities within the State of Washington to transfer technology. We have worked with the universities in the following way: when a

technology is administered by WRF, the titles and rights are signed to us, and in return for that we share a percent of the royalty stream with the university or the institution with which we have the agreement.

In the past 2 years, we have successfully licensed about 16 technologies, and the total in our 4 years history is about 21 technologies licensed. We continue to see an increase in the disclosure activities, as well as in licensing activities, because of our active seeking of invention as well as active promotion of the technologies to the companies.

Thank you very much.

[The statement follows:]

STATEMENT OF PATRICK Y. TAM, PH.D., PRESIDENT, WASHINGTON RESEARCH FOUNDATION

The Washington Research Foundation is a privately funded nonprofit organization to assist the universities in the state of Washington to transfer technologies for commercialization. We were established about four years ago. We have licensed twenty-one technologies to private industry in Washington State as well as nationwide.

There are three major mechanisms through which technology developed at the university could be transferred for commercial development: first, licensing; second, forming start-up company and third forming research and development partnership.

To attract private sector interest in commercialization of university technologies requires active marketing and promotion of these technologies. A market analysis and scientific highlights of the technologies must be presented to ascertain quick response from potential licensees or partners. The market analysis should include a definition of products based on the technology, the potential market size for the products, existing competition in the market place and the projected need for resources to complete the product development.

The market analysis serves three functions: first, to assist us to identify potential licensees; second, to provide basic economic information for licensee's assessment; and third, to obtain a valuation of the technology.

Most university technologies are raw, requiring significant additional development. Most companies are unwilling to take the high risk to license such technologies without proof of concept or reduction to practice. Research and Development partnerships provide a mechanism to further develop technologies of significant commercial potential. The more nature technology is subsequently licensed with substantially enhanced value.

A small percent of university technology is of fundamental value in that there are broad applications for the technology. The market analysis will indicate that it is desirable economically to start up a company based on the technology. A detailed business plan is then drawn up to attract investors to capitalize the company. A management team has to be assembled to operate the company. The success of the start-up company depends on many factors which may not be anticipated or are not controllable by the principals, such as difficulties in raising the required capital, technical road-blocks in product development, or changing market needs. Through this mechanism, the university takes an equity position in the company thereby benefitting not only from the technology transferred from the university, but also from others which might be acquired by the company. This is the most labor-intensive of the three approaches. However the rewards can be many times that of licensing.

The successful transfer of technology is premised on at least three factors: the disclosure of new technologies by the investigators; the sufficient protection of the technologies to provide a licensable product; and the willingness of the investigators and their institutions to assist in product development by the licensee.

Invention disclosures are usually initiated by the investigators. However, researchers are often not good judges of the commercial potentials and needs for new technologies. Their busy schedule can result in delay in a disclosure until the statutory time limit for patent application has passed. An alternative is to require the investigators to routinely disclose the technologies under development. This will necessarily place a burden on the technology transfer office to effectively evaluate the large number of disclosures which may not be completed with the best effort nor with the necessary information. Another alternative is to provide incentives to encourage "good" disclosures. Most universities have a royalty sharing policy. Those with a generous policy have witnessed a comparatively larger number of disclosures. A rule of thumb is one disclosure per one million dollars of research funds for an institution with a generous plan. The most effective approach is the combination of an incentive program together with the technology transfer agent actively seeking out new technologies to match market needs.

Universities and other non-profit research institutions have a commitment to share new knowledge with the public. This necessitates any licensable technologies to be patented. This requirement sometimes presents problems such as the timing of disclosures, as mention before, proper record keeping and delay of technical publications. There is also the need for funds to file patent applications. Typically it costs about four to five thousand dollars to prepare an application and an additional two to three thousand dollars for the prosecution depending on the complexity of the technology. Filing patent applications in foreign countries such as the western Euro-

pean countries, Japan and Canada could very well cost an additional ten to fifteen thousand dollars.

The investigators and their institutions play an important role in assisting the licensee in rapid product development once a technology is licensed. This assistance usually takes two forms. The investigators serve as consultants to the company and/or a research and development contract to the institution. While most institutions have policies regarding accepting contracts from private sector, rules on employees serving as consultants are not always in place. Does the institution allow employees to be consultants for private gain? How much of an employee's time is allowed for consultancy? Sometimes a consultant is paid with shares of a company. Does an institution permit an employee to be a significant share holder of a company?

Other barriers to technology transfer would include a policy to grant only non-exclusive licenses and/or licensing only to domestic companies. When a technology needing significant additional development is licensed, the licensee requires an exclusive license to protect his investment and to ensure that he can obtain healthy profit margins. A non-exclusive license would mean a low barrier to entry. Few companies are prepared to invest significant sums of money only to find others to follow his step and harvest from his investment.

While licensing only to domestic companies may not be a severe limitation to technology transfer, there must be clear guidelines to address some operational realities. Is the wholly owned subsidiary of a foreign corporation considered a foreign licensee? Should the sale of licensed products be restricted to only the domestic market? Should a foreign licensee be permitted, but only to market the licensed product in the foreign markets? Should foreign licensees be considered only after best effort search for a domestic licensee? What is best effort?

The Washington Research Foundation provides one model for effective transfer of university technology. This model may be useful for federal laboratories. Titles and rights to technologies are assigned to WRF when they are administered by the Foundation. In return, the WRF shares a percentage of all proceeds with the institution from which the technology is developed. Being independent of the universities, we have less administrative contraints when considering various arrangements for licenses, R & D partnerships and start-up companies. We have a regional focus which allows us to work closely with the investigators and institutions to better understand and therefore represent the technologies. This is very important to the proper and active marketing and promoting of a new technology. In the past eighteen months we have licensed sixteen technologies, mostly to companies in Washington state. We anticipate that due to our active seeking of new inventions, we will review about one hundred new technologies in calendar 1985.

Senator GORTON. Mr. Brix.

Mr. BRIX. Thank you, Senator Gorton. It is indeed a pleasure to be able to give testimony today on behalf of private industry. I would like to, like several of the other people that have given testimony today, I would like to augment my written description today and to focus on how technology transfer can enhance our U.S. competitiveness in and out, coming to and from the United States, and most importantly, how technology transfer has and could impact the State of Washington and some of the problems we have seen with this.

For the record, my name is Terry Brix. I am President of Technology International Exchange. We are a privately held for-profit corporation that has been in business since 1977. We do approximately 95 percent of our business internationally between Europe, Japan, and the United States.

Our major role is to help take the technology and create a business and jobs therefrom. As Patrick has already alluded to, there is only three things you can do with technology: You can study technology, i.e., market research, cost benefit studies, et cetera; you can license

technology, which is moving it from one place to another legally; and last but not least, as Patrick has indicated also, some technologies are worthy of starting a company around because they are what we call in our business a divergent technology, that they can go multiple directions and not just one product-oriented.

So we have structured our company to basically take advantage of these three basic functions to help businesses get organized and move them around the world. I cannot emphasize enough the role of information. As Patrick has alluded to, one of the problems with what we call orphan technology is we have excellent technology, we do not know where it should go.

In market research, not only in the United States but particularly in Japan and in Europe, it is crucial to the process of understanding: A, the value of a technology; and B, what you can do with it.

In terms of problems, we see several problems, several of which have already been alluded to, but I would like to give my comments. One is what we call the packaging of technology. This is particularly in reference to some of the government laboratories. We have had the pleasure of being involved with Los Alamos Laboratory and a publicly traded company called Benedict Nuclear Pharmaceutical in Golden, Colorado.

Benedict has developed a new drug that offers the prospect of a radioactive diagnostic of brain strokes. Unfortunately, this is a radioactive drug and they need huge quantities of iodine-123. Interestingly enough, here is a case, Senator Gorton, where industry, Benedict Nuclear, has a post Los Alamos because Los Alamos has the accelerator technology to produce copious quantities of iodine-123.

This agreement is now being negotiated on an exclusive basis, because it does not benefit Benedict Nuclear to invest $40 million in a cyclotron facility if everybody in the world could come in and buy that technology. So this is a perpetual problem we find of taking a technology and packaging it into a marketplace.

Let me comment further about another problem in this proprietary aspect. Patrick again has alluded to the problem. In the industrial sense, we do somewhat the reverse of what has been talked about today. It is our job to take public available information and make it proprietary such that private industry will invest money to make it become a commercial reality.

I do not want to be lengthy, but I would like to give two local examples or several local examples to document how this has impacted the State of Washington and the competitiveness of these respective companies that have been a beneficiary of the technology.

Microrim is a software company located in Bellevue, WA. Three years ago, they did not exist. They developed a product from the NASA-developed RIM product, which was a Relational Information Manager software program. They put it on a microcomputer.

We assisted them in licensing this technology to Japan, and at the culmination of those two events, i.e., the initiation of their company and the license agreement with Japan, they were successful in raising

$2.5 million of venture capital. And now, as of this date, they have raised $10 million and from a period of 2 years they have gone from practically 2 or 3 employees to approximately 200 employees. This is an example where the Japanese and the Americans, in a cross-lateral exchange rights and obligations, created a very substantial company for the State of Washington.

As a secondary example, we have a company that is also publicly traded in the Seattle area called Sianotec. This technology originally came out of—Sianotec specializes in making chemicals from micro-algae. Interestingly enough, this original work was somewhat sponsored by the National Science Foundation and internal work done at Battelle Memorial Institute.

In 1982, this company was formed and in 1984 the company went public. They now employ approximately 20 people here in Woodinville and have production facilities in the State of Hawaii. They are also entertaining, through some introductions from our firm, major investments by Japanese and European concerns.

So in terms of proprietary, we just do the reverse. Our trick is and in the industrial sense is taking public information and trying to make it proprietary, because no sponsor, no industry, would accept it unless it is.

Last but not least, I comment about patentability because this is something I think the U.S. Government can do a great deal about. Patrick again alluded to this. In foreign countries patents are sacrosanct. If you do not have a patent, particularly in Japan, the Japanese have a very difficult time culturally, legally, even talking to you, even though we recognize fully in the United States the value of know-how.

One program that the government could initiate is to assist small, medium-sized and institutions like the University of Washington in providing resources to patent worldwide from this technology as soon as it is appropriate.

In terms of solutions to the never-ending problem of how do you get more technology transferred to industry, unfortunately I come with not an open bag of easy tricks. It seems to me, as you can probably understand, this technology transfer business is a very people-intensive business. And how do you get more Picasso's? You do not.

You provide basically an incentive system, and the incentive system is best provided by I however feel in the State of Washington's case there are two things we should keep in mind:

The University of Washington, the Washington Research Foundation, are logical epicenters around which we can train more people on how technology transfer actually operates, not just the theory but practical, how you go about actually creating a business from a piece of technology.

The second thing is, in the State of Washington we should not lose sight of the fact that, as Hemingway said in his book "The Movable Feast,' if you take the analogy for the technology business, technology is a movable beast. The Japanese have more engineers as a nation than the United States does, and on a per capita basis so does West Germany and France.

But the point is there are technologies in those respective countries that can be brought into the United States. So as we consider these issues of technology transfer, let us not forget that technology transfer is a two-way street.

In summary, I would like to thank you very much for the opportunity of expressing some of our comments, and I would be glad to answer any questions.

[The statement follows:]

Statement of A.T. Brix, President, Technology International Exchange

1. INTRODUCTION

Technology International Exchange, Inc. (TIE) has been engaged in the formation, organization, and transfer of technology in and out of the U.S. since 1977. TIE, the parent company, has three wholly-owned subsidiaries: Temar, Limited (Market Research); Tectran International (Technology Licensing); and Pitex Inc. (Venture Formation).

A.T. Brix, founder of TIE, has over 15 years of business experience in the Far East and Europe. He worked for Battelle, Pacific Northwest Laboratories from 1967 to 1979 as a senior staff engineer and director of international marketing. During his years at Battelle Northwest, Mr. Brix marketed and directed more than 60 contracts for Japanese industrial clients. General research areas for the projects included process development and evaluation, market studies, company diversification, new applications, product assessment, and technical assistance in the areas of materials, electronics/optoelectronics, chemicals, agriculture and food products, and biotechnology.

This paper summarizes key examples that illustrate the process of technology transfer, with specific emphasis on ways to stimulate technology transfer in the Pacific Northwest.

2. THE NATURE OF THE BEAST: TECHNOLOGY TRANSFER NOT DEFINED, BUT AT LEAST CORNERED

Talk to 100 people and you'll get 100 different definitions of technology transfer. In fact, I don't think it's possible to crisply define technology transfer in a bottom-line, ten-words-or-less statement. However, for discussion purposes, let's assume a simplified definition and work around it for a better understanding:

"Technology transfer is creating business from ideas." I like this definition because: creativity and people are at the core of the whole process; business is an open-ended concept with both domestic and international prospects; and ideas (albeit a fuzzy concept), are the basis of all business and/or social activities.

I like to think of technology as a big fraction in the arithmetic sense: business and technology are the denominator, and people are the numerator. Regardless of how big the technology and the business, without people your prospects are small. On the other hand, good people can make successes out of little technologies with niche markets.

2.1 A starting point: where you can get technology and what you can do with it

Let's get to the core of technology transfer, which is technology itself. Technology is basically "know-how." In our business, we largely focus on the technology generated from science (i.e., the series of processes that describe how to do something, whether it is making a new adhesive or a semiconductor chip).

To help understand and focus in on technology sources and uses, just visualize a pair of dice showing double threes.

There are only three ways to get technology. First, make it yourself. Second, steal it. Third, license it. Needless to say, we focus on making it and licensing it. This is the first die.

The second die represents the three things you can do with any viable technology:

First, you can study the technology to determine uses and applications. This is why market research and technology assessment are critical to the process of technology transfer.

Second, you can move the technology from one place to another. The whole licensing industry is based on this process. Licensing here means legally tranferring the rights to a technology from one entity to another.

Third, you can create a functioning business around a technology as the most expeditious way of getting the technology to the marketplace.

Our company has developed three wholly-owned subsidiaries to address the practical needs of the technology transfer business, namely:

Temar Ltd.—Essential Information.

Tectran International—Technology Licensing.

Pitex, Inc.—Venture Formation—Start-Up Companies.

In short, you can't play technology transfer baseball without all three bases covered. Adaptability and flexibility are prerequisites to being a good player.

Robert Heinlein, the famous science fiction writer, can proably give you a flavor of what's needed for technology transfer better than I can. Heinlein described the need for a universal, adaptable man. I'll misquote profusely, but you'll get the drift.

"A man must be able to write a sonet, feed a baby, make a souffle, plan a battle, and say last rites for a friend." How do you apply this to technology transfer? You have to be able to juggle several balls at once.

To further the analogy, market research can be likened to juggling numerous ping pong balls. Some products make sense, some don't, some will fly, some won't; but in any event the failure of a given study (if they come crashing down) is not catastrophic. The ping pong balls will keep bouncing.

Licensing is like juggling eggs—there are fewer of them, but they go up higher, and if you drop them, you end up with a mess. If you do it right, you end up with a souffle.

Starting new companies around a technology is like juggling watermelons. Once you get them lifted off, you have a great sense of relief and accomplishment. However, if they come down and you don't catch them, you still get some consolation—a lot of seeds for thought.

In summary, technology transfer involves never-ending market research in order to gather, study, and pass the technology on to the end user.

2.2 Where's the cornucopia? Under what rocks do we look for technology?

First of all, you can't create any business without some kind of technology. Thus, our first concern is the source. Washington is blessed with a variety of technology sources. The major ones that spring to mind include (with some of their offspring):

University of Washington (Advanced Technology Laboratories (ATL), Physio Control, Lawrence Laboratories).

Boeing (Flow Industries, Aerogo).

Battelle (Sigma Research, TIE, Inc., Cyanotech).

Fred Hutchinson Cancer Research Institute, and Virginia Mason Clinic (Genetic Systems, Immunogenics).

The University of Washington and Battelle also have mechanisms to stockpile technology (i.e., the Washington Research Foundation (WRF) and Battelle's Development Corporation (BDC) where proprietary and patented technology is inventoried).

2.2.1 Campbell's canned vs. homemade

As Dr. Patrick Tam (Director of The Washington Research Foundation), the people at Battelle Development Corporation, and we at TIE can attest, having an inventory of technology is the starting point, but not necessarily the end point. Most people tend to think of technology transfer as walking into a supermarket. The prospective corporate licensee, venture capitalist or budding entrepreneuer thinks of going up and down the aisles with a shopping list.

Unfortunately, technology is not like Campbell's soup, it doesn't come in a nice container, properly barcoded for easy pricing. It cannot be rendered delicious by merely adding two cans of water and simmering it on the stove.

Technology transfer can more realistically be likened to going into a supermarket and finding ingredients for soup interspersed with detergents, bakery goods, and pots and pans. In short, here are some herbs, potatoes, and onions; now make your own soup.

2.2.2 We've seen the enemy—and they are us

I'm leading up to a not-so-startling conclusion. Knowledgeable people make the difference in technology transfer. One person looking at a technology may see a fit. The next person might see a dog that needs to put out of its misery. In short, beauty is in the eye of the beholder. We need more people who are capable of linking pieces of technology into a business whole. We need these talented people now more than ever, as many technologies waiting in the wings for commercialization have already been taken.

What has typically happened to date is "cherry picking." Cherry picking is defined as picking the immediate winners and leaving the rest to fate. There is nothing wrong with cherry picking, but something needs to be done with the remaining intellectual property to transfer it to the business community.

In short, all the 21-year-olds are gone. We now have to invest the time, money, and patience with the promising teenagers. We have to invest now, and wait for them to grow up.

Technology transfer is technology- and people-dependent, and as is the case for all things of interest, beauty can be more subtle and demanding than meets the eye.

3. WHERE'S THE BEEF? EXAMPLES OF LOCAL TECHNOLOGY TRANSFER FOR CREATING BUSINESSES

To illustrate the competitiveness, impact, mechanisms, and need for technology transfer in the Pacific Northwest, several examples may prove useful. I don't wish to present exhaustive case studies, because this is not what is important for this presentation. I apologize in advance for deletions which may not give credit where credit is due. As in all cases where multidisciplinary teams are needed, success is due to teamwork. Furthermore, we have selected these examples because we are involved with them. Again, we don't mean to slight other successes.

3.1 MicroRim

MicroRim, a privately-held company, serves several purposes for our discussion. It illustrates the role of domestic as well as international technology transfer. Wayne Ericson, the founder, worked with NASA's (public domain) RIM database management program. Mr. Ericson correctly surmised that a microcomputer version of RIM would enjoy a large market. In short, MicroRim created a PC version of RIM. Our firm met MicroRim during its infancy and contractually agreed to take the technology to Japan. Approximately one year expired before a master distributorship/license agreement was completed between MicroRim, Mitsubishi Corporation (Japan's largest trading company), and B-Con (one of the top Japanese software firms). This Japanese mini-consortium assisted MicroRim to:

Attack the Japanese market.

Create momentum for its own capital formation activities. After the agreement was announced, Dain Bosworth successfully raised $2.5 million for MicroRim in private placements.

Open the door for equity purchase discussions, resulting in a $500,000 investment by Mitsubishi in MicroRim common stock.

The success of MicroRim is, of course, largely due to the leadership of Kent Johnson and Wayne Ericson. Technology transfer, however, played a critical role in the early stages of the company's growth and in establishing an international image and market for MicroRim. Today, MicroRim employs several hundred people, has raised in excess of ten million dollars, and is enjoying acceptance of its RBase 5000 products. MicroRim illustrates how U.S. government technology can be used to create products, and how these products in turn can be transferred to other parts of the world.

3.2 NyPlan

In comparison to MicroRim, NyPlan's evolution illustrates several additional major aspects of technology transfer. NyPlan, although much smaller (15 people) is publicly traded, locally. NyPlan's major product is financial modeling software, and its forte is developing vertical packages (i.e., where small machines can talk to big machines) and developing versions that can operate on virtually every major operating system (i.e., TI, IBM, DEC, Fujitsu, NEC, and Prime). Unlike MicroRim, who hit a major market in the IBM PC and Apple microcomputer world, NyPlan focuses on the minicomputer world. Interestingly, of the 1000+ copies of NyPlan sold so far, 60% have been to international customers.

In 1982-83 TIE began technology transfer activities to Japan, on behalf of NyPlan. In the immortal, yet facetious words of W.C. Fields, "There I was, prostrate—face to face with terra firma." There was no initial interest in NyPlan—we fell flat on our faces. In the early 1980s, Japan had no interest in financial modeling. Kanji (Japanese language-characters) word processing was in vogue, and database management was a hot item. Unlike the U.S., where financial spreadsheet products made the software market, Japan was somewhat the reverse (at least from our perspective).

Now, however, NyPlan is negotiating several Japanese joint venture license arrangements as the Japanese market becomes more aware of the need for modeling in their new business activities. In addition, a recent major conversion of NyPlan to a Control Data machine in Italy has opened up major discussions with Control Data. Successful international JVs or licenses could cause a dramatic increase in NyPlan staff—from 15 to perhaps 45 employees.

NyPlan is a classic example of the importance of timing in technology transfer. A three-pitch, strike-out inning in 1982-83 has turned into a three-balls, no strikes ball game.

In NyPlan's case we've been at it for three years. The moral to the story is: "If at first you don't succeed, to hell with it, but I'll be back anyway next month!"

3.3 International Polyol Chemicals, Inc. (IPCI)

Of all the technologies I'm familiar with, IPCI is probably the most dramatic. IPCI started with a group of sophisticated Eastern Washington farmers (Messrs. Larry Richardson and Bob Hollway) who were tired of having limited market options for their potato crop. Washington potato farmers normally have only three options—selling to french fry producers, fresh produce markets, or cattle feed.

Battelle, Pacific Northwest Laboratories did some initial work (proof of concept) on converting potato starch into petrochemicals. Approximately $450,000 later, Hydrocarbon Research Inc. of Princeton, New Jersey had completed process work and received patents worldwide.

Let me summarize what IPCI has and what they're trying to transfer.

IPCI has five patents, worldwide, to convert lowly starch (currently worth $0.10/lb. in the U.S. and $0.04/lb in Thailand) into polyols. Polyols include ethylene glycol (the ubiquitous antifreeze with a U.S. market of about 5 billion lbs/year); propylene glycol (your polyester shirt and tie) with a market of 1 billion lbs/yr; glycerol (used in Oil of Olay and by terrorists as nitroglycerine) with a market of 300 million lbs/yr; and sorbitol (market of 300 million lbs/yr), used in everything from cough syrup to sugar substitutes for diabetics, to the raw material for Vitamin C.

The cheapest ethylene glycol is worth $0.30–35/lb and glycerol is worth $0.80–0.85/lb. The cost of making polyols is $0.12–0.15/lb.

IPCI has a non-OPEC petrochemical process. A way of making countries like Taiwan, Thailand, Brazil, the Union of South Africa, and Argentina into "petrohaves" instead of "have-nots."

All of this, ladies and gentlemen, is brought to you by 30 Quincy, Washington farmers, aided by a cast of scientific advisors, including chemical engineering professors from the University of Washington, Montana State University, Westinghouse, and Union Camp.

This process is not a panacea, but wouldn't it be interesting if Washington had a $1 billion/yr polyol industry fed by Washington potatoes and corn starch. We've been trying for years to attract a corn processing industry to Washington State to replace the dead sugar beet industry.

Unfortunately, Taiwan, not the U.S., has signed the first letter of intent to build a pilot plant facility. To me, this is very ironic. The technology was developed because of a need by the farmers of Washington, yet it finds its first home in Taiwan, to be followed by the Union of South Africa and Israel.

The impact of one major polyol plant would create one to two thousand jobs, not counting those generated in the agricultural community.

IPCI dramatically illustrates the irony of technology transfer and yet its universal nature. "Farmers in Washington Develop Petrochemical Substitute." A nice headline for the Wall Street Journal.

3.4 Cyanotech

Cyanotech is one of the only companies in the U.S. engaged in the production of specialty chemicals from microalgae (we call microalgae the slime business). Yes, microalgae is the green stuff in swimming pools and lakes. In fact, there are 10,000 species of microalgae, all waiting to be tapped to produce unusual product components ranging from Vitamin E to fluorescent pigments for lipstick.

In the Northwest, Battelle was one of the first firms to get seriously involved in microalgae by building a team headed by Dr. Gerald Cysewski. (Dr. Cysewski left Battelle in 1980 and started Cyanotech, which was jointly founded by Cysewski and our company.) The addition of a tremendous CEO spark plug in the form of Dr. Karuna-Karan created the high octane mixture necessary to organize, start production, and become public in a record of two years.

In this case, the concept of microalgae as a source of chemicals came with Dr. Cysewski. To date, the technology has been generated internally but not transferred. Interestingly, the company has its headquarters in Woodinville, yet relies on the State of Hawaii to support the production of its products. Ultimately, this technology will be transferred internationally, today it's all in-house.

In summary, the cited examples illustrate the somewhat labyrinthic route that technology transfer can take—getting from the idea stage to the business stage. To review:

MicroRim, based on a NASA public domain software program, transferred into a private company, then expanded to Japan.

NyPlan, based on a mainframe modeling package, developed industrially and shrank to fit minis and micros. NyPlan has major technology transfer activities with Japanese and European companies in progress.

IPCI, with proof-of-concept developed at Battelle and catalyst details worked out by petrochemical processing exports, now has development work centered in Seattle with the first technology transfer aimed at Taiwan.

Cyanotech, with the team and idea originating at Battelle, the product being developed over several years, with technology being internally generated.

4. THE MOVEABLE FEAST: DIVERSIFICATION BY INCREASING TECHNOLOGY TRANSFER

Historically, the U.S. has been viewed as a practically limitless source of technology. In fact, U.S. companies have led the world in licensing technology abroad, and forming JVs to exploit technology. As the world's technology mix changes from heavy, thick, wide, long, capital-intensive to light, thin, short and modest capital requirements, many international companies have developed technology that can be licensed into the U.S. In the past, technology has been immovable (steel plants and chemical facilities come to mind). Now technology is like Hemingway's "Moveable Feast." You can find it in many locations.

We see licensing-in as an extremely cost-effective way of creating new jobs and expanding business opportunities. To illustrate that opportunities exist in the rest of the world, consider the following:

4.1 Fireproof the world

Dainichi Nippon cable is a leading producer of fireproof putty and tape products in Japan; necessitated by the stringent Japanese building codes to help prevent fire started by earthquakes. In 1980, the MGM fire in Las Vegas brought the fire code problem to national attention. We assisted DNC in licensing the fireproof technology to Nelson Electric, a $10 million subsidiary of General Signal. This one technology will double the size of that division in approximately three years. Since the Japanese firm was already producing the product, initial imports generated cash while a commercial plant was being constructed.

This case simultaneously opened a market (via licensing) previously closed to DNC and dramatically diversified the fireproofing technology base of Nelson.

4.2 The world's cheapest roof structures

National Shieldweld, a Canadian firm, has developed a rectangular geodesic structure. Just imagine a Buckminster Fuller geodesic dome as a rectangle and you have the basic idea. Two shapes, a diamond and a triangle, will create a roof structure that is one-fourth the cost of an ordinary roof. With a declining forest products industry in the Pacific Northwest, the availability of aluminum, and our tremendous export facilities, this technology should have been adopted locally. It wasn't. Mainland China now has an agreement with National Shieldweld, and the Japanese are negotiating for Pacific Rim manufacturing rights.

These two brief cases illustrate that foreign technology is available. If properly introduced to a receptive company or state, this technology could immediately impact our economy. The U.S. can no longer be considered the only source of technology.

5.0 AN EXAMPLE OF THE ROLE AND IMPACT OF GOVERNMENT TECHNOLOGY

The examples cited above center around industry-derived technology, and technology directly or indirectly transferred, to some degree, by government research and development.

Let's take a look at a potentially pure technology transfer action between a major government laboratory and private industry. As most of you know, there are several pieces of legislation which affect the transfer of government-owned technology to private industry. Let me cite an example.

Benedict Nuclear Pharmaceuticals (BNPI) is a NASDAQ publicly-traded company, headquartered in Golden, Colorado. BNPI is one of the few American companies engaged in the production of radio-pharmaceuticals on a large scale.

BNPI currently manufactures Iodine 123 capsules which are employed in thyroid diagnosis. In the last several years, BNPI has also acquired exclusive rights on a worldwide basis to radio-pharmaceutical chip called HIPDM, which is used in stroke diagnosis. Currently, 500,000 people per year suffer from strokes, and an additional 2 million patients per year need some form of brain barrier diagnosis.

Iodine 123 is critical to the production of HIPDM. Currently, small cyclotrons can produce only limited quantities of HIPDM (enough to treat perhaps 20,000 patients per year). To serve the market, BNPI needed an advanced cyclotron system.

To capitalize on this market potential, Los Alamos Laboratories (DOE) has completed a letter-of-intent, and is currently negotiating a contract with BNPI. With

this contract, proprietary government linear accelerators and radioactive isotope separation technology will be transferred exclusively to BNPI. The Los Alamos technology will allow an order of magnitude increase in the production of HIPDM, which in turn will serve the entire U.S. market.

The Los Alamos technology, combined with the existing BNPI product technology and FDA approvals, could create a five hundred million dollar/year business and catapult BNPI into a pharmaceutical and industrial cyclotron/accelerator leadership position.

Were it not, however, for the understanding of the DOE and the cyclotron technology by Malcolm Benedict (the founder and chairman of BNPI), and over three years of negotiations, this government-industry relationship would have been improbable.

In summary, government technology focused by large or small companies with long-term patience could create a new industrial technology base. The key factors are the understanding and resources of private industry and the willingness of a government agency to work a deal.

6.0 ENHANCING COMPETITIVENESS OR "SHARPENING OUR SWORDS"

Technology transfer can be viewed as both an inflow and an outflow, and each situation requires a different approach. The following are some of the opportunities interested parties in the State of Washington might explore to enhance awareness and develop skills for increasing technology transfer to Washington business entities. In turn, implementation of these ideas will help transfer other technologies abroad.

6.1 A Ph.D in technology transfer

The entrepreneurship program at the University of Washington (Dr. Karl Vesper) is a logical starting point. One could imagine a cram course or seminar on the "how to's" of technology transfer with emphasis on selecting technologies, markets, and structuring businesses. My only concern is that technology transfer in general sounds trendish and exciting. One conjures up visions of Longacres and rapid-fire Thoroughbred horses. In actuality, the technology transfer business is at best at Clydesdale, and at worst a donkey. Nevertheless, technology transfer starts with qualified, interested people—and these people need to know the ropes, as thin as they may be. The Washington Research Foundation would be a logical co-sponsor of such an activity. The State could also fund such a program.

6.2 Technology transfer is a breakfast of champions

All successful technology transfer (i.e., taking a technical idea and reducing it to practice) starts with an individual and ends with a team. Maybe Don James, the Husky football coach, would like to get involved during the off season. I've looked at the entrepreneurs I know well, and I don't know how to train them. If I had to pick a class of individuals to develop a core of technology transfer expertise, I'd look for engineers and/or scientists with business backgrounds. This suggests Battelle, Physio Control, ATL, Fluke, Sigma, Flow, Boeing, and others as logical starting places.

Since technology transfer is both one step before venture capital and one step after venture capital, technology transfer can be extremely risky—both financially and in the amount of time involved. In order to reduce the risk exposure, companies might employ a sabbatical approach, putting one or more people on leave with the idea of creating a business concept from a technical base.

These two examples are simple in scope, educational, and could have a slow, systematic impact (company by company). However, they don't captivate the imagination. It's just business as usual.

6.3 Cross Currents

A more exciting, proactive alternative might be "Cross Currents", a concept developed by TIE to focus on the economic needs of a given area, such as Washington State, with the full power of technology transfer. Cross Currents would be a combined private-industry/state or local government project. Its purpose would be to (1) select 10-20 manufacturing and technology-based service organizations each year, and (2) start transferring their technology internationally, and (3) bring "fit" technology from abroad and transfer the technology into these firms.

Each participating firm would pay a small initial fee, to be matched by the state. The technology provided by the firm can be transferred internationally, thus generating revenue in the following ways: License or royalty fees; additional income from export sales; possible investors from abroad, and/or joint ventures.

Simultaneously, an international search could be initiated, particularly in Japan and Europe, to find licensable technology that could be transferred into the state.

When success is achieved, the Cross Current team members share in the revenues generated for sales, licenses, and/or obtain a small fee based on the joint venture or investment amount. The process would then be repeated for more companies.

A quick downside analysis will show that the participating firm and the state have little or no financial risk, yet would achieve an awareness of the competitiveness of their products and diversification prospects from abroad. An upside analysis would show the prospect of new sales, jobs, licenses, and investment in joint ventures.

Technology International Exchange is involved with more than 100 companies on three continents. We are currently engaged in technology transfer dialogue illustrating the concept on an international basis.

We believe a program such as Cross Currents, focused on the State of Washington, could significantly improve the state's competitiveness and economic health.

7.0 CONCLUSION

The business and financial community needs to have more awareness of the technology transfer basics. Our experience has proven that technology transfer plays an essential role in fostering the commercialization of technology—both technologies sourced from private industry or government-sponsored R&D laboratories. Each commercialization process is completely unique—creating a road map is not possible. But, some of the commonalities include: A team effort—flexibility and creative thinking; continuous market research; and good timing.

A major impact can only be achieved through a combined effort by the financial, industrial, and governmental institutions.

Senator GORTON. Thank you.

Mr. SIMPSON.Thank you, Senator Gorton.

I am Hunter Simpson, President and Chief Executive Officer of Physio-Control, located in Redmond, WA. We manufacture, design and develop medical electronic instrumentation.

Those who preceded me have probably, Senator, covered much of the ground regarding this remarkable term called "the transfer of technology." Patrick basically went through some of the m

echanisms by which one can become involved in, such as sponsored research between an institution and a private company or research organization, consulting agreements between individual investigators and a private company, licensing agreements on patented technology, or, all of the above.

The important thing that ought to come out of this hearing, Senator, is that these agreements should remain uncluttered or unencumbered by Federal guidelines, and there should be a free atmosphere in negotiating these arrangements between investigators, institutions, and interested companies.

I think that the Washington Research Foundation is a classic example of that kind of arrangement, having been involved with it from the onset. There were three things that had to happen: There had to be value created to the investigator; there had to be value created to the institution; and there had to be value created to the recipient. Those three things have to exist and they cannot be encumbered by any kind of Federal guidelines.

One of the things that the whole world of transfer of technology essentially lacks, although I think that the research foundation is a very meaningful step, is the ability to either market an idea or research how good an idea is. It would seem to me that whenever there is a research grant given, that a modest percent of that research grant must be earmarked towards a study: Is the product ever going to fit? Is the outcome of the research ever going to make a meaningful contribution to our society?

There are a number of examples that I personally have been involved with where millions were spent, much was learned, but when you got right down to it the market did not exist. And if Federal grants are going to get mileage because brilliant individuals are pulled together, then part of that grant money must be earmarked for research to determine if the end product, the end concept, the end system, whatever it may be, fills a need.

We are doing some good things in the State of Washington. Number one, we have the most precious asset in the State called the University of Washington. The Washington Research Foundation relates very closely to it and other research institutions. I think it is pretty obvious that about 90 percent of what comes out of the research foundation will come from that university.

Another very positive step and the only other—there are only two facilities like it in the United States today—of course is the Washington Technology Center. It is a fine start. It accomplishes many good things. It encourages, a great accumulation of very talented people, and one of the primary focuses of it will be, microsensor technology, which cuts across all lines, not only medicine but agriculture, metalurgy, aerospace, and other fine endeavors.

A little bit of insight, Senator, into how a commercial company translates its investments into commercial products might, in broad terms help establish guidelines so that funding to institutions or to private investigators might operate more effectively.

First of all, you have got to understand that if somebody is developing something, whether it goes through this foundation or any other vehicle, that it has got to fill a need. We have spent a lot of money doing research and have gotten involved in this great world of technology transfer on things that may not fill a need.

You have to avoid funding projects for technology's sake. There is a great disease out there called "creeping elegance" and it has to be avoided at any cost. As I said, you have got to be able to determine in this great world, regardless of whether it is aerospace, medicine, or agriculture, that it will work and it will not be encumbered by possible future Federal restraints.

There has to be some element in funding research that says, do not be afraid to stop and employ the resources someplace else if along the way the world changes. Grants are given for long periods of time. It is like of like taking a drink out of a fire hydrant. As long as the water is there you are probably going to sip.

In the intelligent mode if the world changes, the market changes or physiology changes, whatever it may be, do not be afraid to stop and say, we will apply these resources in another direction, and follow the instincts of people who understand the market and know what the research will end up doing for society.

This is a broad field, Senator. There are many people involved in evaluating what is best done in this great world of transfer of technology to the world of private industry. This is a meaningful hearing and I am delighted to have been asked to briefly convey a few ideas that have come from the school of hard knocks.

Thank you very much, Senator.

[The statement follows:]

STATEMENT OF HUNTER SIMPSON, PRESIDENT, PHYSIO-CONTROL

Views on mechanisms by which technology is transferred from government funded research to the private sector:

MECHANISMS

(A) Sponsored research agreement between University and private company; (B) consulting agreement between individual investigators and private company; (C) license agreement for patented technology; and (D) combinations of the above three.

Mechanisms usually include combinations of A, B, and C. These agreements should remain unencumbered by federal guidelines and be negotiated between the University, principal investigator and the interested company.

The Federal Government should foster and encourage small companies access to government-funded technology and its transfer to the private sector.

BARRIERS

Lack of (shortage of) organizations to "market" the technology developed to the private sector (such as Washington Research Foundation).

WHAT THE STATE OF WASHINGTON IS DOING

Washington Technology Center—a good start, but needs to be established as a long run commitment to Washington's future in high technology.

Funding of state research institutions such as University of Washington and Washington State University to attract top caliber faculty talent that brings research money into state and eventually transferred to the private sector.

INSIGHTS INTO HOW PHYSIO RESEARCH IS TRANSLATED INTO COMMERCIAL PRODUCTS

Understand your customer's needs and keep focused on satisfying that need.

Avoid "technology for technology's sake" temptation; i.e., creeping elegance of research.

Get some early version of your research into actual clinical use as quickly as possible to get "real world" feedback to guide continuing research effort.

Don't be afraid to kill some projects to provide funding for others.

Follow the intuitions of your experienced people as well as market research activities.

Senator GORTON. Thank you.

We have gotten a really good orientation here from all of you, from some of the earlier thoughts, about the relationships between our universities and various bridge organizations within the private sector.

What about Federal laboratories and the technologies which they develop? Are you all familiar with the Federal lab consortium and center the for utilization of Federal technology, and do they form the kind for bridges of technology transfer that we have here in this State?

Any or all of you.

Dr. TAM. I would just like to comment on one aspect of it, and that is there have been successful dissemination of information, For example the NASA technical briefs. However, those are still left up to the devise of the company to figure out whether there is commercial value and to what extent does technology have a commercial value, what is the market size, what kind of product can come out of it. It will be greatly beneficial to the companies in terms of really helping enhance the transfer, is to have that sort of market analysis done.

Senator GORTON. There is no Federal equivalent of your organization?

Dr. TAM. No, not that I know of.

Senator GORTON. Should there be?

Dr. TAM. I think there should be if there is the intent of really enhancing the transfer of technology, because from a commercial company's point of view they look at technology not strictly from a technical view point. They look at it from a market point of view as well.

Mr. Brix. Absolutely correct. From a private industry's standpoint, if you talk to Los Alamos or Sandia, first of all you have to be very, very precise in terms of what you want. You have to know exactly and sometimes if technology transfer goes, it is an interactive process, so if you do not know exactly what you want you would have a hard time getting in.

In the various levels, since under the Stevenson-Wydler Act they have not got their act completely together in terms of simplified procedures, they still have to go non-exclusive in many events. So there is no appropriate good mechanism You have to get technology in and out of their laboratories.

Senator GORTON. Mr. Simpson.

Mr. SIMPSON. I have nothing to add to that, Senator.

Senator GORTON. Dr. Tam, what kind of rates does the university obtain in its inventions? Do they cause problems in commercialization? Are they negotiable?

Dr. TAM. The technologies that are disclosed to the foundation are mostly the ones that are sponsored or developed under Federal sponsorship, so they fall under the guidelines of the recent public law, so that the university has the right to or can elect to retain rights to those inventions.

After our assessment and we determine to administer to a certain technology, we will then request the university to retain those titles and then assign those to the foundation.

Senator GORTON. You have good results?

Dr. TAM. Yes.

Senator GORTON. Are universities as a general proposition good owners and managers of their technology?

Dr. TAM. Our experience has been very good with the University of Washington in particular.

Senator GORTON. Mr. Simpson, what does your own organization do to reward innovation on the part of its employees? What kind of specific recognition?

Mr. SIMPSON. We invest about 10 percent of our revenue in R&D, Senator. Most of that goes towards the D side. Most small companies are not equipped to handle the R side, which is why we give major grants to selected institutions because they are qualified to do that. The reward to the men and women who develop ideas that have proprietary strength is the fact that their company grows and prospers and they all share in the growth and profitability of the company. This seems to satisfy them and has been very successful through the years.

We do, of course, give scholarships to higher education, to make sure that we are fulfilling our corporate responsibility to higher education. We also provide significant grants for research. But the individual reward in the business is strictly remarkable opportunities to watch something grow and then they grow with it.

Senator GORTON. Would Physio-Control sign even more contracts with the universities and similar organizations if it had any way of getting excusive rights to the production of results?

Mr. SIMPSON. The exclusivity is very important, Senator, as both these gentlemen pointed out. It is very difficult for a commercial organization to invest in a technology or an idea when anybody can utilize it once that organization has brought it to a position of fruition.

It is interesting, however, to note that we as a company do not believe in patents. We feel that technology is the best patent, and if we can continue to leapfrog the technology with various products, in our case in the life sciences, that is the best protection you can have.

The only things that we patent are our designs, meaning what our products look like. Those are the only patents that we normally receive. There are very few exceptions to that. But in the developmental stages, it is important to have some kind of an exclusive right.

Senator GORTON. Thank you all. We learned a great deal today. I hope we can take some of these lessons back to make them work better with respect to our Federal investments in research and development. I appreciate your helping and the information given. Thank you.

[Whereupon, at 11:50 a.m., the subcommittee was adjourned.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF ROBERT ABBOTT, PRESIDENT, NEORX

Mr. Chairman, this administration has made great strides in supporting small innovative research companies with research and development tax credits, R&D limited partnerships, changes in the anti-trust laws, changes in patent law and encouraging the entreprenural spirit of investors. But, while these initiatives have helped greatly, there are enormous hurdles remaining.

My company is a bio-technological firm emphasizing research in monoclonal antibodies. My experience is that small companies have virtually no avenue to obtain funding at the levels necessary for scale up technology. There is under-funding of generic applied research; the U.S. biotechnology industry is significantly handicapped in its technological ability to apply basic research developments, especially due to lack of mass production technology. Other nations, notably Japan, the United Kingdom, Switzerland, and the Federal Republic of Germany, are actively supporting generic applied research which will capitalize on our country's basic discoveries. The earliest example of this is occurring in the U.S. pharmaceutical industry, where product introductions involving lymphokines and monoclonal antibodies are imminent over the next several years.

The research shortcoming is especially evident in mass production technology for monoclonal antibodies for the *in vivo* detection and treatment of cancer. Monoclonal antibody development plays a significant role in cancer research programs. This is the arena where the global fight for dominance in technology is being fought. The vast majority of start-up companies welcome the Innovation Center concept of Stevenson Wydler. These Centers would be where the United States invests its scientific and technological growth. I believe in a few years they would become self-sufficient, producing numerous scientific break-throughs benefitting all mankind. These Centers would likewise become centers for economic growth as manufacturing and distribution of the scale up technology proceeded.

Mr. Chairman, the Congress has focused on the question of transferring the benefits discovered in Federally supported research and development into commercially viable industries. The Congress has found that there is no system. Centers such as we are discussing today could become the magnets for those involved in research and development, taking the ideas and producing and marketing products.

Although the United States is currently the world leader in both basic research and commercial development of new biotechnology, continuation of this initial American preeminence in the commercialization of biotechnology is not assured. In the next decade, competitive advantage in areas related to biotechnology may depend as much on developments in bioprocess engineering as on innovations in genetics, immunology, and other areas of basic science. U.S. government funding of generic applied research, especially in the areas of bioprocess engineering and applied microbiology, is currently insufficient to support the rapid and competitive commercialization of this country's biotechnology efforts. This needs to be done if the United States is to maintain its role as the world's most eminent scientist and its most efficient economic engine.

STATEMENT OF DAVID T. MOWRY, ASSOCIATE DIRECTOR, NTIS

Thank you for the opportunity to place in the Record of these hearings this progress report of the technology transfer activities of the National Technical Information Service (NTIS) since the enactment of the Stevenson-Wydler Act in 1980. I am responsible for the Center for the Utilization of Federal Technology (CUFT) which was created by Section 11 of this Act. Documented results of this effort support the thesis that Federal technology should and can play a much greater role in the economic growth and international competitiveness of this country.

The Stevenson-Wydler Act created the CUFT which the Department of Commerce (DOC) located within NTIS to enable a synergistic relationship with the NTIS centralized technical information dissemination operations started over thirty years ago

and the multiagency patent licensing program which started in 1976. Six functions for CUFT were authorized by the Act and further detailed in H.R. Report 96-1199, pp. 36, 37 which accompanied S-1250. These include serving as a clearinghouse for the collection, dissemination and transfer of information on federally-owned (e.g. patented) and federally-originated (available know-how) technology; coordinating the activities of the Offices of Research and Technology Applications at the Federal laboratories which supply technology assessments to CUFT; working cooperatively with the National Science Foundation and the Federal Laboratory Consortium (FLC); relaying requests from State and local governments to appropriate laboratories; using appropriate transfer mechanisms such as computer-based systems; and providing funding to laboratories for special State and local government requests. The last function has not been carried out because transfer funding has not been available. However, considerable progress has been made on the other five programs.

CUFT's emphasis has been on the announcement and promotion of Federal technologies available for licensing and transfer; the consolidation of these activities has enhanced efficiency and facilitates greater commercial use of this technology. On behalf of all agencies we have expanded a weekly newsletter "Government Inventions for Licensing" and the monthly publication "Tech Notes" by adding a series of annual catalogs to facilitate identification, location and evaluation of the technology. Another new best selling publication is the Directory of Federal Technology Resources identifying some 800 world-class R&D programs with points of contact to enable personal discussion of new developments. The costs of these publications are recovered directly through sales.

Additionally, directories of net-working personnel and catalogs of governmental regional technical centers providing assistance to innovators are supplied gratis to all Federal laboratories, and State and local governments. Group visits of technology scouts from industry to national laboratories have been arranged. Biennial reports of technology transfer progress have been received from all agencies in accordance with Section 11(e) of the Act, merged into a Federal report and distributed. CUFT has implemented a 1982 agreement between the DOC and the FLC by providing a data base of laboratory technical activities and contact points. CUFT has also negotiated another agreement with the FLC to provide training, marketing information and an interface with state economic development centers.

CUFT's Office of Federal Patent Licensing operates an intensive program on behalf of agency laboratories generating about 10% of the Government-owned patents. This is a pilot program to demonstrate the value of the incentive provided by licensing to the adoption and use of Government technology by the private sector. Licensee reports also document the actual development and commercialization. Under cooperative agreements with the Departments of Health and Human Services, Agriculture, Interior, Commerce, Transportation, Army, Air Force, the Veterans Administration and the Environmental Protection Agency, NTIS has negotiated over 140 royalty-bearing licenses since passage of the Stevenson-Wydler Act. NTIS evaluates new inventions for commercial potential, files for patents on selected inventions in foreign countries, and promotes those inventions to industry.

In FY 1983-1984, NTIS negotiated 77 patent licenses, about 50% with small businesses. Source agencies (excluding DOD, DOE and NASA, which have their own licensing programs) contributed 251 patent applications of which 44 were licensed for the first time. In addition, CUFT efforts supplemented licensing done by source agencies on their own inventions and raised the total licensing rate to the 25-30% range, approximating the rate of patent utilization by the private sector and universities. This is a substantial improvement over the much quoted 4 to 5% licensing rate based on data generated prior to 1976.

Of the 44 new inventions, 72% were licensed on an exclusive or co-exclusive basis, thus maximizing the incentive the Government can offer the private sector to invest its funds in further R&D, regulatory approvals, and commercialization. In exchange for the 77 licenses, licensees provided development plans which aggregated $173 million.

There is normally a three to eight year lag between invention and commercialization, so the NTIS licensing program has not nearly reached its potential in royalty income. However, in the two year period, fees and royalties returned to Treasury totalled $1.78 million, or 53% above appropriated program costs. The return to Treasury is projected to reach several million annually based on licenses signed but not yet commercialized.

An important aspect promoting the value of recognizing and patenting inventions is provided by incentive awards to inventors based on licensing revenues from their inventions. In 1985 awards in excess of $40,000 will be paid to 118 inventors whose licensed patents generated revenues in 1984.

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