APPENDIX A
INTERVIEW QUESTIONNAIRE

1. **Role of Laboratory Researchers and Other Personnel:** Please comment on the contribution and background of the involved laboratory personnel in terms of the technology transfer that occurred. Besides the person/team who received the award, were there other laboratory personnel involved? Is this a large group, in terms of the overall size of the laboratory? In terms of support to the transfer of the technology, could you compare your (research) activities with those of other parts of the laboratory (management support, help from the lab’s Office of Research and Technology Applications, etc.)? In terms of the chief scientist and laboratory researchers involved in the transfer of the technology, what was the level of professional technology transfer experience before this case?

2. **Technology and Applications:** Please describe the technology and its applications.

3. **University Involvement:** If there was a university partner involved, are you aware of any university benefits such as student or faculty benefits due to university partnering?

4. **Funding, Financing:** Did the funding come solely from the laboratory or also from cost-sharing with a partner or another source? Was other outside funding or financing involved in the transfer of the technology? This could include, for example, SBIR funds or other government technology funding programs (Technology Reinvestment Project, Advanced Technology Program, etc.), corporate allocations or matching private capital, venture capital, public offerings, loans, or other sources.

5. **Intellectual Property:** What were the results of the formal invention disclosure in the laboratory? Did it lead to patents being granted (or applied for), the technology being licensed, and/or articles being published? If the technology was licensed, what were the terms (e.g., exclusive, non-exclusive, etc.)? What is the annual income in fees or royalties?

6. **Technology Transfer Mechanisms:** What mechanism(s) was used to transfer the technology? Possibilities include: publications or presentations at professional or trade association meetings, laboratory-sponsored conferences, cooperative research/CRADAs or other strategic alliances, licensing, work for others (reimbursable), use of facilities, technical assistance, informal collaborations, education and training, researcher exchange, etc.

7. **User Group:** What was the technology’s intended primary and/or secondary user or user group? Was the technology applied commercially, or was it used to solve a state or local government problem or some other more specific application area?
8. **Barriers to Commercialization:** Were there any barriers to transfer that were particularly evident or troublesome? Also, are you aware of why such barriers existed?

9. **User Benefits/Economic Impact/Outcomes:** Are you aware of any benefits to the users resulting from the technology being developed and transferred? For example, an increase in any private company’s market share in the way of product sales or jobs generated. Are you aware of any costs being cut or intangible gains (competitive information gained, unique patent/intellectual property position secured, etc.)?

10. **International Activity:** Was there any international activity on the technology? For example, overseas patents or sales.

11. **Government Gains:** Were there any unanticipated government gains (other than the directly-intended R&D results). For example, technological spinbacks to the laboratory or agency, R&D costs saved or avoided, resources shared, etc.

12. **Economic Development, Technical Assistance:** Did the transfer involve outside assistance (management, legal, etc.) such as from a state Small Business Development Center, NASA regional technology transfer center, or other university-based technical assistance center?

13. **Elapsed Time:** What was the time frame involved in transferring the technology? This can be stated in terms of the stage of development, in terms of specific years, etc. What was the technology’s stage of development as technology marketing efforts were initiated -- conceptual, technical feasibility, development, prototype, production, support, etc.?

14. **Other Factors:** Were there any other factors not discussed that would be important to understanding this transfer of technology?
APPENDIX B
LIST OF AWARDS - LEVEL I ANALYSIS

* = Documented in the Federal Laboratory Consortium’s *Winners in Technology Transfer*¹

1985

1 Agricultural Research Service (Beltsville, MD) - Robert M. Hendrickson, Jr. - For leadership in the development and introduction of a unique method of biological pest control which saved Agriculture $13 million in 1982 and at least that amount in each subsequent year.

2 Air Force Engineering and Services Center (Tyndall AFB, FL) - Joseph L. Walker - For success in aggregating the critical resources needed to significantly advance and transfer fire fighting agents, protective clothing and equipment for fire fighters in the United States.

3 Argonne National Laboratory (Argonne, IL) - E. Philip Horwitz, Louis Kaplan - For leadership and initiative in transferring to the private sector a new chemical extractant which has application in nuclear industry and in separations research.

4 Argonne National Laboratory (Argonne, IL) - Jack M. Williams - For development and transfer to private industry of the Synthesis of the Synthetic Metal Precursor (TMTSF).

5 Brookhaven National Laboratory (Upton, NY) - Jack Fontana, Lawrence E. Kukacka, Meyer Steinberg - For developing and assisting in the commercialization of polymer concrete materials used by industry for producing construction materials; used by States and municipalities for bridge and highway repair; and used by the United States Air Force for runway repair under damp and cold conditions.

6 Brookhaven National Laboratory (Upton, NY) - Eric B. Forsyth, Albert C. Muller - For efforts in developing polymeric tape insulation for power cables as an American-produced alternative to paper/polymer laminated insulation (the currently dominant material) produced exclusively by the Japanese.

7 Forest Products Laboratory (Madison, WI) - Erwin L. Schaffer, Roger L. Tuomi - For design and patenting of the Truss-Framed System for residential construction, and an aggressive technology transfer effort resulting in national acceptance by the public and

private sectors.

8 Lawrence Livermore National Laboratory (Livermore, CA) - Robert Godwin - For his efforts in facilitating collaboration with U.S. industry in the development of the Nova Laser System.

9 NASA Lewis Research Center (Cleveland, OH) - Tito Serafini - For the development of PMR-15 polyimide matrix resins and transfer of the technology to advanced aerospace composite applications.

10 NASA Marshall Space Flight Center (Huntsville, AL) - John R. Richardson - For significant biomedical engineering contributions in the development of a precise Ocular Screening System used to detect eye abnormalities in children.

11* National Institute of Standards and Technology (Gaithersburg, MD) - Dennis M. Gilbert, Albert T. Landberg, Jr., Lynn S. Rosenthal, Charles L. Sheppard - For outstanding achievement in creating and operating microcomputer-based electronic bulletin board systems that support technology transfer to individuals in industry and government.

12* National Institute of Standards and Technology (Gaithersburg, MD) - Robert Loevinger - For key efforts in establishing a national network of radiation therapy measurement calibration laboratories in cooperation with AAPM, government laboratories, and industry.

13 Naval Civil Engineering Laboratory (Port Hueneme, CA) - Robert L. Alumbaugh, Spencer R. Conklin - For the transfer of the large amount of data generated on sprayed polyurethane foam roof systems to state and local government and into the private sector using a variety of technology transfer procedures.

14 Naval Command Control Ocean Surveillance Center (San Diego, CA) - John Reindel - For technical innovation in the printed circuit technology, and leadership in transferring this technology to industry.

15* Naval Oceanographic Office (Stennis Space Center, MS) - Carey Ingram - For conceiving and coordinating development by Louisiana State University of a prototype Expendable Bottom Penetrometer System for automatic sea bed classification and measurement of sediment shear strength.

16 Naval Underwater Systems Center (New London, CT) - Ronald G. Heroux - For his tireless and creative efforts to assist state and local government in Rhode Island to implement cable television and other telecommunications systems.
17 Oak Ridge Institute for Science and Education (Oak Ridge, TN) - Audrey T. Schlafke-Stelson, Michael G. Stabin, Evelyn E. Watson - For developing new technologies, disseminating information, and providing radiation dose assistance to government agencies, industry, laboratories and physicians.

18 Pacific Northwest Laboratory (Richland, WA) - Richard P. Allen, Leland K. Fetrow, Michael W. McCoy - For transferring advanced decontamination techniques successfully to the commercial nuclear industry where they are in widespread use.

19 Pacific Northwest Laboratory (Richland, WA) - Rudolph T. Allerman, Benjamin M. Johnson, Ellwood V. Werry - For transferring power plant dry cooling technology to the commercial power industry.

20 Sandia National Laboratories (Albuquerque, NM) - David S. Ginley, Janda K. Panitz, Carleton H. Seager, Donald J. Sharp - For development of a process to increase the efficiency of solar cells using ion-beam hydrogenation, and transfer to the manufacturing industry.

21 Sandia National Laboratories (Albuquerque, NM) - Peter B. Rand - For development of a stabilized aqueous foam material, and transfer to the security system and fire fighting industries.

1986

1* Agricultural Research Service (Beltsville, MD) - William J. Connick, Jr. - For effective dissemination of the alginate process technology which incorporated chemical and biological pesticides in granular formulations to industry and research organizations.

2 Agricultural Research Service (Beltsville, MD) - Joseph F. Flanagan, Dr. Eugene F. Guy, Dr. Virginia H. Holsinger, Dr. George A. Somkuti, Dr. Marvin P. Thompson - For transfer of science and technology resulting in the commercial production of lactose-reduced milk and milk products for lactose intolerant individuals.

3 Air Force Wright Laboratories (Wright Patterson AFB, OH) - Paul J. Erbland, Richard D. Nuemann, Jerold Patterson, Neil J. Sliski - For their leadership in developing and transferring state-of-the-art computer programs with very special application.

4* Air Force Wright Laboratories (Wright Patterson AFB, OH) - David L. Judson, Devin A. Satz, Gerald C. Shumaker - For establishing, demonstrating and transferring a major break-through in computer system integration manufacturing technology.

5 Ames Laboratory [DOE], Iowa State University (Ames, IA) - John McClelland, Linda Seaverson - For development and commercialization of a new photoacoustic cell for
Fourier transform infrared spectroscopy.

6 Argonne National Laboratory (Argonne, IL) - Robert F. Domagala, James E. Matos, James L. Snelgrove, Henry R. Thresh, Armando Travelli, Thomas C. Wiencek - For developing a proliferation-resistant nuclear fuel for research reactors and transferring the fabrication technology to commercial fuel element producers.

7 Army Construction Engineering Research Laboratory (Champaign, IL) - Timothy D. Ables, Capt. Wylie K. Bearup, William F. McCleese, John M. Scanlon - For development and implementation of a comprehensive technology transfer plan for the U.S. Army Corps of Engineers' Repair, Evaluation, Maintenance, and Rehabilitation (REMR) research program.

8 Army Construction Engineering Research Laboratory (Champaign, IL) - William H. McAnally, Jr., William A. Thomas - For design and development of a powerful state-of-the-art numerical modeling system for predicting flow and sedimentation and for leadership in making the system available to practicing engineers.

9 Army Natick RD&E Center (Natick, MA) - Armand V. Cardello, John Kapsalis, Owen Maller, Patricia Prell - For the development and application of a unique system for the sensory and objective description and classification of edible fish species for use by government laboratories and the American Fishing Industry.

10 Army Natick RD&E Center (Natick, MA) - Tedio Ciavarini - For pioneering efforts to establish and foster the ASTM Retort Pouch Subcommittee F-2.4 and for providing singular technical support to contractors on all aspects of packaging and packing for the Meal, Ready-to-Eat combat ration.

11 Army Close Combat Armaments Center (Dover, NJ) - John H. Underwood - For leadership in the technology transfer of new fracture analysis methods.

12* Brookhaven National Laboratory (Upton, NY) - Russell N. Dietz - For leadership and initiative in developing and commercializing an air infiltration measurement system that will result in more comfortable homes and energy efficient buildings.

13 Energy Technology Engineering Center (Canoga Park, CA) - Nathan J. Hoffman - For promoting technology transfer between academic and Federal laboratory sectors by suggesting graduate thesis topics of mutual interest to the Department of Energy and university research departments.

14 Federal Highway Administration (McLean, VA) - Charles R. Stockfisch - For outstanding effort in the transfer of traffic engineering technology to the public and private sectors at the national and international level.
15 Lawrence Livermore National Laboratory (Livermore, CA) - Hans Bruines - For the transfer of the LLNL-developed Cray Time Sharing System to firms in private industry seeking to provide less costly supercomputer environments.

16 Lawrence Livermore National Laboratory (Livermore, CA) - Dr. Douglas R. Stephens - For his success in using cooperative agreements to transfer underground coal gasification technology to industry and foreign countries.

17 Los Alamos National Laboratory (Los Alamos, NM) - James D. Doss - For transfer of an optical keratoplasty device to Radtech, Inc.

18* NASA Langley Research Center (Hampton, VA) - Terry L. St. Clair - For development of POLYIMIDESULFONE (PISO2), a thermoplastic, high modulus polymer, and transfer of production technology to the chemical, electronics and aerospace industries.

19 National Institute of Standards and Technology (Gaithersburg, MD) - James F. Ely - For leadership and innovation in the development and transfer of computer codes and data to allow the rapid implementation of large scale enhanced oil recovery and supercritical solvent separation projects in the United States.

20 National Institute of Standards and Technology (Gaithersburg, MD) - Staff Members - For development of the Automated Manufacturing Research Facility and unusual creativity and innovation in transferring federally developed technology to industry, universities, and the general public.

21 Naval Civil Engineering Laboratory (Port Hueneme, CA) - Richard W. Drisko - For creativity in the transfer of important technology on maintenance painting to state and local governments and the private sector.

22 Naval Command Control Ocean Surveillance Center (San Diego, CA) - Dr. Jerry D. Stachiw - For his outstanding performance while providing initiative, management and leadership in the area of non-metallic materials technology transfer.

23 Naval Research Laboratory (Washington, D.C.) - Howard Lessoff - For establishment of the Liquid Encapsulated Czoohralski (LEC) gallium arsenide growth and wafer finishing technology.

24 Naval Surface Warfare Center; Carderock Division (Bethesda, MD) - Eugene C. Fischer - For distinguished leadership in the development of chemically controlled release technology and the subsequent transfer and adoption of this technology worldwide.

25 Oak Ridge Associated Universities (Oak Ridge, TN) - Cheryl F. Allred, Shirley A. Fry, Harold Hodges, Judy S. Lambert, Clarence C. Lushbaugh, Robert C. Ricks, Ann H. Sipe -
For developing new treatment techniques, providing technical assistance, and disseminating information to government agencies, industry, and hospitals to improve the handling of radiation accidents.

26 Oak Ridge National Laboratory (Oak Ridge, TN) - Michael S. Blair, E. Jonathan Soderstrom, Dr. Tuan Vo-Dinh - For noteworthy contributions toward the commercialization of the fiber optics luminoscope resulting in a licensing agreement with Environmental Systems Corporation of Knoxville, Tennessee.

27 Oak Ridge National Laboratory (Oak Ridge, TN) - Chain T. Liu, Anthony C. Schaffhauser, Vinod K. Sikka, E. Jonathan Soderstrom - For noteworthy contributions toward the commercialization of aluminide alloys and, specifically, toward the achievement of a licensing agreement with Cummins Engine Company, Inc.

28* Pacific Northwest Laboratory (Richland, WA) - Frederick G. Burton, Dr. Dominic A. Cataldo, Dr. Peter Van Voris - For their initiative and uncommon creativity in transferring a biobarrier technology into products that prevent unwanted root growth and vegetation from roadways, septic tanks, sewer lines, buried gas lines, and irrigation heads.

29 Pacific Northwest Laboratory (Richland, WA) - Dr. Steven R. Doctor, Thomas E. Hall - For their initiative and uncommon creativity in transferring the "SAFT-UT Signal Processing for High Resolution Imaging" to private industry for its application at electric utilities.

1992

1* Agricultural Research Service, National Center for Agricultural Utilization Research (Peoria, IL) - George E. Inglett - For developing and successfully transferring OATRIM technology thereby providing a new fat substitute which improves health by lowering blood cholesterol.

2 Air Force Armstrong Laboratory (Dayton, OH) - Daniel W. Repperger - For efforts in transferring technology from DOD to the private sector involving local industries. A joint program involving DOD, industry, and a university was developed.

3 Air Force Armstrong Laboratory (Brooks AFB, TX) - David N. Erwin, Johnathan L. Kiel - For demonstrating uncommon creativity and initiative in the transfer of technology and winning national recognition of an unprecedented technology in a very short time.

4 Air Force Phillips Laboratory (Kirtland AFB, NM) - James C. Lyke - For his contribution to new forms of advanced electronics packaging for applications inside and outside of the military.
Argonne National Laboratory (Argonne, IL) - Richard Hitterman, David Kupperman, Saurin Majumdar, Jim Richardson, Jitendra P. Singh - For the transfer of neutron diffraction techniques which have been developed to determine strains and stresses in engineering composites for validation of analytical models and optimization of fabrication procedures.

Army Construction Engineering Research Laboratory (Champaign, IL) - Vincent Hock, Ashok Kumar - For completing the transfer of ceramic coated anode technology through publication of the design guidance contained in the engineering technical letter dated January 1991.

Forest Products Laboratory (Madison, WI) - John M. Considine, Dennis E. Gunderson, Theodore L. Laufenberg - For outstanding efforts in technology transfer and paper industry implementation of the paper restraint for paper testing.

Forest Service, Northeast State and Private Forestry (Radnor, PA) - Edward K. Pepke - For identifying the ready-to-assemble furniture market for wood products, developing a business plan, and transferring technology leading to increased employment and economic development.

Idaho National Engineering Laboratory (Idaho Falls, ID) - John E. Flinn - For outstanding achievement in the development and successful implementation of cooperative research and development agreements (CRADAs) for transfer of rapid solidification technology.

Jet Propulsion Laboratory (Pasadena, CA) - William T. Callahan, James A. Rooney, James E. Schroeder, James B. Stephens - In recognition for excellence in technology transfer using the unique and innovative process designed into the JPL/NASA technology affiliates program.

Lawrence Berkeley Laboratory (Berkeley, CA) - John Clarke - For development and transfer of a highly sensitive device, the squid magnetometer, using the new high temperature superconducting materials for medical and geophysical applications.

Lawrence Berkeley Laboratory (Berkeley, CA) - Shih-Ger Chang - For transferring the LBL Phosnox process for combined removal of SO2 and NOX from flue gas.

Lawrence Berkeley Laboratory (Berkeley, CA) - Wayne R. McKinney - Synchrotron-radiation research depends upon optics formed into complicated shapes with unprecedented precision. McKinney and industry collaborators made several breakthroughs in manufacturing and characterizing these devices.

Lawrence Livermore National Laboratory (Livermore, CA) - Anthony F. Bernhardt, Robert J. Contolini, Steven T. Mayer - For the transfer of electrochemical planerization
and electropolishing technology to a computer manufacturer.

15* Lawrence Livermore National Laboratory (Livermore, CA) - Lloyd A. Hackel - For outstanding development and transfer of state-of-the-art solid state laser technology to Hampshire Instruments for use in the HI model 3500 X-ray lithography system.

16 Los Alamos National Laboratory (Los Alamos, NM) - George I. Bell, James H. Jett, Richard A. Keller, Babetta L. Marrone, John C. Martin, Brooks E. Shera - For transferring the rapid DNA sequencing technology to industry, resulting in a patent issued, a patent applied for, and a CRADA with Life Technologies, Inc.

17 Los Alamos National Laboratory (Los Alamos, NM) - Betty Jorgensen, Howard Nekimken - For transferring the technology of their optical high-acidity sensor to industry which may result in the transfer being completed in one year's time.

18* National Institute of Standards and Technology; Boulder Laboratories (Boulder, CO) - Gordon W. Day - For the transfer of optical fiber current sensor technology from NIST to the 3M Company.

19* National Institute of Standards and Technology; Boulder Laboratories (Boulder, CO) - James E. Faller - For transferring the fundamental optical, electronic, and mechanical technology in the jila absolute gravity measurement device to Axis Instrument Company.

20 National Institutes of Health; National Heart, Lung and Blood Institute (Bethesda, MD) - W. French Anderson - In recognition of pioneering research and development that has brought NIH technology from the theoretical realms of the laboratory to clinical applications.

21 National Oceanic and Atmospheric Administration; Environmental Research Laboratory (Boulder, CO) - Alfred J. Bedard - For displaying initiative and creativity in transferring new static pressure probe technology to the private and public sectors, making a significant contribution to aircraft safety.

22 Naval Command Control Ocean Surveillance Center (San Diego, CA) - Graham A. Garcia, Isaac Lagnado - For persistence, dedication and marketing effort to develop and transition the thin film silicon on sapphire (TFSOS) technology which could impact the fabrication of advanced microelectronics products of the late 1990s.

23* Naval Research Laboratory (Washington, D.C.) - Teddy M. Keller - For his exceptional creativity and initiative in the effective technology transfer of phthalonitrile monomer/prepolymer technology for a broad spectrum of applications.
24 Oak Ridge National Laboratory (Oak Ridge, TN) - A. L. Compere, J. M. Googin, W. L. Griffith, W. P. Huxtable - For significant contributions to the invention, development, licensing, and commercialization of the Cl₂EAN OUT™ process for dechlorination of waste streams.

25* Pittsburgh Energy Technology Center (Pittsburgh, PA) - Mahendra P. Mathur, Franklin D. Shaffer - For their outstanding efforts in transferring an advanced flow diagnostic technique developed for fossil fuels to assist the medical community in improving artificial heart pumps.

26 Pacific Northwest Laboratory (Richland, WA) - L. Roy Bunnell, Frank P. Hungate, William F. Riemath - For determination in transferring the portable blood irradiator technology to an international center for treatment of leukemia and blood diseases, where it can help save lives.

27 Pacific Northwest Laboratory (Richland, WA) - John W. Cary, Glendon W. Gee, Randy R. Kirkham, John F. McBride, Carver S. Simmons - For their vision and persistence in transferring the electro-optic liquid soil sensor, a simple, inexpensive device with environmental and agricultural applications.

28 Pacific Northwest Laboratory (Richland, WA) - L. Loren Eyler, Donald S. Trent - For dedicated and innovative technology transfer of the tempest software for three-dimensional transient hydrothermal analysis.

29* Sandia National Laboratories (Albuquerque, NM) - Theodore A. Dellin - For combining the vision, industry needs, and laboratory resources into a microelectronics quality/reliability center to transfer quality technologies to the IC industry.

1993

1 Agricultural Research Service (Beltsville, MD) - Edward M. Dougherty, Dwight E. Lynn, Martin Shapiro - In recognition of the transfer of technology in development of the first commercial in virtobaculovirus biological pesticide system.

2 Agricultural Research Service, Southern Regional Research Center (New Orleans, LA) - Paul S. Sawhney - For effective international dissemination and commercial licensing of a new core-spinning technology for producing unique composite yarns of predominantly cotton content and almost 100% cotton surface.

3 Air Force Rome Laboratory (Griffiss AFB, NY) - Brian S. Ahern - For creativity and initiative in the transfer of Lanthanum Hexaboride thin film coating technology for use in improving efficiency of flourescent lamps and X-ray medical equipment.
4*  Air Force Rome Laboratory (Hanscom AFB, MA) - Luigi Spagnuolo, Terrence G. Champion - For initiative in the transfer of robust speech compression technique designed to provide reliable, high quality speech communications while increasing the capacity of narrowband channels.

5  Air Force Wright Laboratory (Wright-Patterson AFB, OH) - G. A. Beane IV, Lynne M. Nelson - For initiative in transferring "smart dipstick" technology for measuring remaining useful lubricant life to industry and implementing broader applications in transportation and food processing industries.

6*  Ames Laboratory [DOE], Iowa State University (Ames, IA) - Edward S. Yeung - For unusual devotion and effort in transferring a new laser-based method for indirect fluorescence of biological samples.

7*  Army Construction Engineering Research Laboratory (Champaign, IL) - William Goran, Jim Westervelt, Michael Shapiro, Mark Johnson, Marjorie Larson, Mary Martin, Jean Messersmith - For initiative in the development of support structures and mechanisms to transfer GRASS technologies to government, private sector, and educational institutions throughout the U.S. and around the world.

8  Army Research Institute for the Behavioral and Social Sciences (Alexandria, VA) - Beatrice J. Farr - For exemplary activities in transferring the Job Skills Education Program. A commercial version of this Army-developed program could help millions of American workers improve their job performance.

9  Forest Service, Forest Products Laboratory (Madison, WI) - Robert J. Ross, Earl A. Geske - For the development and rapid adoption of economical and innovative techniques to improve the quality and reliability of structural wood products.

10  Forest Service, Pacific Northwest Experiment Station (Portland, OR) - Larry Bryant, Jack Ward Thomas, Michael J. Wisdom - For the transfer of the IMPLAN system (economic impact assessment technology) to federal, state and local government agencies, academic institutions and private businesses.

11  Forest Service (Ft. Collins, CO) - Gregory S. Alward, L. Eric Siverts, Kenneth G. Walters, Susan A. Winter - For the transfer of the IMPLAN system (economic impact assessment technology) to federal, state and local government agencies, academic institutions and private businesses.

12  Lawrence Berkeley Laboratory (Berkeley, CA) - Dariush Arasteh, Stephen Selkowitz - For development and transfer to the U.S. building industry of the technology base for "superwindows," windows with better thermal performance than insulating walls.
13 Lawrence Berkeley Laboratory (Berkeley, CA) - Mark Bednarski, Matthew Callstrom - For the development of a new polymeric material which can significantly extend the active lifetime of enzymes and allow their use in harsh industrial environments.

14 Los Alamos National Laboratory (Los Alamos, NM) - Anthony A. Amsden, T. Daniel Butler, Peter J. O'Rourke - For the nominees' efforts in the transfer of the KIVA software, which has lead to the widespread use of the technology by U.S. engine manufacturers such as General Motors, Ford, Chrysler and Cummins Engine Company.

15* Los Alamos National Laboratory (Los Alamos, NM) - Albert Migliori, George Rhodes - For the nominees' efforts in the transfer of the resonant ultrasound inspection technology, which resulted in a license agreement between Los Alamos National Laboratory and Quatro Corporation, and in a product that is now being marketed.

16 NASA Lewis Research Center (Cleveland, OH) - Richard T. Barrett - For transferring to the aerospace and construction industries the first comprehensive Fastener Design Manual directed toward the design engineer.

17 National Institute for Occupational Safety and Health (Cincinnati, OH) - John W. Sheehy - For reducing lead exposure in radiator repair shops through effective technology transfer.

18 National Institutes of Health, National Institute on Aging (Bethesda, MD) - Josef Pitha - In recognition of pioneering research and development and an unsurpassed commitment to transferring NIH/NIA technology to benefit mankind.

19 National Oceanic and Atmospheric Administration, Environmental Research Laboratories (Boulder, CO) - Warner L. Ecklund, David Carter, Kenneth S. Gage, Robert T. Frost, William Neff, James R. Jordan - For creativity transferring the 915 MHz profiler technology to the private sector through use of a Cooperative Research and Development Agreement (CRADA).

20* Naval Air Warfare Center, Weapons Division (China Lake, CA) - Herbert Richter, Ronald Henry, Joseph Johnson - For efforts in transferring technology from DOD to the private sector resulting in two license agreements.

21* Naval Civil Engineering Laboratory (Port Hueneme, CA) - Richard Drisko - For outstanding dedication and initiative in transferring paints and coatings expertise to the private sector via direct technical consultation and assistance.

22* Oak Ridge National Laboratory (Oak Ridge, TN) - D. W. Bible, R. J. Lauf - For significant contributions to the invention, development, licensing and commercialization of the Variable Frequency Microwave Furnace.
23 Pacific Northwest Laboratory (Richland, WA) - Larry A. Chick, Larry R. Pederson, Gregory Exarhos, J. Lambert Bates, Gary D. Maupin - For using the CRADA mechanism to revitalize the licensee's interest in commercializing the glycine nitrate process.

24 Pacific Northwest Laboratory (Richland, WA) - James G. Droppo, Jr., Karl Castleton, Gene Whelan, Bonnie L. Hoopes - For transferring MEPAS\textsuperscript{e} environmental assessment software to Mesa State College, thereby improving Mesa's curriculum, training workers for DOE, and enhancing MEPAS' marketability.

25 Pacific Northwest Laboratory (Richland, WA) - Evan Jones, L. John Sealock, Jr., Wayne Wilcox - For personal effort and innovation in forming a new company through an alliance with an existing business to transfer and commercialize Waste Acid Recovery Systems.

26 Pacific Northwest Laboratory (Richland, WA) - Michael K. White, Janet L. Bryant, Gregory M. Holtzer - For their insight, initiative and persistence in trailblazing the rapid technology transfer of ReOpt software, the first scientific approach to identifying technologies for waste cleanup.

27 Pittsburgh Energy Technology Center (Pittsburgh, PA) - James T. Yeh, Henry W. Pennline, James M. Ekmann, Charles J. Drummond - For leadership, creativity, and initiative in effecting the first transfer of a process patented by a DOE Energy Center to private industry.

28 Sandia National Laboratories (Albuquerque, NM) - Randy R. Lober, Johnny H. Biffle, Ray J. Mayera, Teddy D. Blacker - For initiative in the transfer of technology from Sandia's Mesh Generation Consortium which is providing U.S. industry with engineering software to reduce the time required for design iterations using advanced mesh generation algorithms and adaptive analysis techniques.
APPENDIX C
INTERVIEWEES FOR THE SELECTED CASES - LEVEL III ANALYSIS

Penetrometer for Seabed Classification/Measurement

Mr. Carey Ingram, Supervisory Oceanographer
Special Support Division
Naval Oceanographic Office
Stennis Space Center, Mississippi

Dr. Joseph N. Suhayda, Professor
Civil Engineering Department
Louisiana State University
Baton Rouge, Louisiana

Advanced Thermoplastic Polymer Material

Dr. Terry St. Clair
NASA Langley Research Center
Hampton, Virginia

Ms. Rosa Webster
Technology Transfer Office
NASA Langley Research Center
Hampton, Virginia

Mr. Milton Evans, President
High Technology Systems, Inc.
Clifton Park, New York

Substance Tracer Technology

Dr. Russell N. Dietz, Head
Tracer Technology Center
Brookhaven National Laboratory
Upton, New York
Slow-Release, Alginate-Based Herbicide/Pesticide

Mr. William J. Connick, Jr., Research Chemist
Southern Regional Research Center
Agricultural Research Service
New Orleans, Louisiana

Dr. Ramon Georgis
Biosys, Inc.
Columbia, Maryland

Mr. James Walter, Director
Research and Development
Thermo Trilogy Corporation
Columbia, Maryland

Controlled-Release, Chemically-Imbedded Herbicide/Pesticide Material

Dr. Peter Van Voris
Pacific Northwest National Laboratory
Richland, Washington

Mr. Harry E. Barnes, Biobarrier Manager
Reemay, Inc.
Old Hickory, Tennessee

Mr. Rodney Ruskin, CEO
Geoflow, Inc.
Sausalito, California

Radiation Therapy Quality Assurance

Dr. Robert Loevinger
Radiation Physics
National Institute of Standards and Technology
Gaithersburg, Maryland

Dr. Geoffrey S. Ibbott, Asst. Professor and Director
Department of Radiation Medicine
University of Kentucky
Lexington, Kentucky
Laser-Based Method to Light Up Biological Samples

Dr. Edward S. Yeung, Program Director
U.S. Department of Energy - Ames Laboratory
Iowa State University
Ames, Iowa

Mr. Craig Ranger, President
Lachat Instruments, Inc.
Milwaukee, Wisconsin

Voice Coder for Telecommunications

Mr. Luigi Spagnuolo, Acting Branch Chief
INFOSEC Technology Office
Electromagnetics and Reliability Branch
Rome Laboratory
Hanscom Air Force Base, Massachusetts

Dr. John C. Hardwick
Digital Voice Systems, Inc.
Burlington, Massachusetts

Paper Quality Tester

Mr. Theodore L. Laufenberg
Forest Products Laboratory
U.S. Department of Agriculture
Madison, Wisconsin

Mr. Peter Davis
Isthmus Engineering and Manufacturing Co-op
Madison, Wisconsin

Variable-Frequency Microwave Oven

Dr. Robert J. Lauf, Senior Development Staff Member
Metals and Ceramics Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee
Mr. Don W. Bible, Development Staff Member  
Instrumentation and Controls Division  
Oak Ridge National Laboratory  
Oak Ridge, Tennessee

Mr. Richard S. Gerard, President and CEO  
Lambda Technologies, Inc.  
Raleigh, North Carolina

**Gravity Meter**

Dr. James Faller  
Joint Institute for Laboratory Astrophysics  
University of Colorado/National Institute of Standards and Technology  
Boulder, Colorado

Dr. Steve ONeil, Director of Technology Transfer  
and Industry Outreach  
University of Colorado  
Joint Institute for Laboratory Astrophysics - Industry Liaison  
Boulder, Colorado

Dr. Tim Niebauer, President  
Micro-g Solutions  
Erie, Colorado

Dr. Mike Winters, President  
Winters Electro-Optics  
Longmont, Colorado

**“Oatrim” Fat Substitute**

Dr. George E. Inglett, Biopolymer Materials Specialist  
National Center for Agricultural Utilization Research  
Agricultural Research Service  
Peoria, Illinois

Mr. Stephen B. Grisamore, General Manager  
Mountain Lake Specialty Ingredients Company  
Omaha, Nebraska
Mr. Mark Freeland, Director of Textural Technologies
Rhone-Poulenc, Inc.
Cranbury, New Jersey

Mr. Lanny Babbitt
Quaker Oats Company
Chicago, Illinois

Chemiluminescent “Light Sticks”

Dr. Herbert Richter, Supervisory Research Chemist
Naval Warfare Center - Weapons Division
China Lake, California

Ms. Martha Harrington
Technology Transfer Office
Naval Warfare Center - Weapons Division
China Lake, California

Mr. Fred Kaplan, President and CEO
Omniglow Corporation
Novato, California

Artificial Heart Flow Diagnostics

Mr. Franklin D. Shaffer, Mechanical Engineer
Pittsburgh Energy Technology Center
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Dr. Harvey Borovetz, Professor of Surgery and
Director of Biomedical Engineering
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APPENDIX D
PRE- AND POST-LEGISLATION FINDINGS SUMMARIES

PRE-LEGISLATION FINDINGS SUMMARY

This appendix summarizes the findings for the selected pre-legislation cases in Chapter III organized according to the questions addressed in the interviews. The topic, “Other Factors,” is incorporated into the concluding section of this dissertation. The cases appear in the following order:

a. Penetrometer
b. Thermoplastic Polymer
c. Substance Tracer
d. Alginate Herbicide
e. Root-Control Barrier
f. Radiation Measurement Standards.

Role of Laboratory Researchers and Other Personnel

a. For the river bottom penetrometer, Mr. Ingram worked with state and local government officials on a county problem, serving as lead scientist for a team of intergovernmental personnel surveying the river bottom. He developed the concept for a new surveying tool and consulted with a nearby university as they developed the prototype.

b. Dr. St. Clair, who invented the thermoplastic material, developed both the material and a process for producing it. Then he proactively sought industry partners to further develop and manufacture it by speaking at a number of workshops and conferences co-sponsored by industry trade associations, particularly aerospace-related ones.

c. Dr. Dietz at Brookhaven demonstrated the tracer technology to a wide range of potential user communities both in this country and overseas, and even produced a video showing the technology’s capabilities. Dr. Dietz has worked with all types of user groups; in fact, his tracer technology center performs tracer services for some fifteen to twenty user groups each year. He has also conducted experiments with other federal agencies, such as EPA and NASA, and with the Commission of European Communities. In addition, he has written scientific papers and spoken at conferences.

d. Mr. Connick, inventor of the alginate process, was sought out by others, rather than undertaking proactive technology transfer approaches. He published a number of scientific papers and made presentations over the years that “caught on” in the scientific community. His work has been cited by other scientists nationally and internationally.
e. Upon coming up with their idea serendipitously at a social bridge game, the team of PNNL researchers working on the root-control technology tested a variety of chemicals and materials for the applications they had in mind. For one of the applications, they designed and constructed the prototype themselves; for two other applications, they worked with private companies involved in those product lines. They wrote a number of scientific papers and teamed with private sector partners for a number of these papers.

f. For the radiation therapy quality assurance case, Dr. Loevinger at NIST proposed to the American Association of Physicists in Medicine (AAPM) that national methods were needed in the area of ensuring radiation therapy dosage measurements. He also wrote scientific papers in this area.

Technologies and Applications

a. The river bottom penetrometer was a sophisticated instrument developed by combining parts from different off-the-shelf instruments with a computer and printer to create a new river surveying instrument.

b. The PISO2 thermoplastic material is advanced in its thermal properties. It would be relatively inexpensive to mass-produce and would have a variety of potential uses in industry and space programs if commercialized.

c. Part of the interest of the perfluorocarbon tracer technology is that it has so many applications. The technology’s commercial possibilities include: building ventilation analysis, underground cable leak detection, utility applications, underground storage tank leak identification, explosives detection, petroleum reservoir analysis, pre-fire warning, environmental monitoring, and disaster emergency management. The instrumentation involved in tracer systems could also be commercialized.

d. The alginate-based herbicide/pesticide is unique because it can incorporate either chemical or biological control agents that attack only their intended targets and do not affect their surrounding environments. Also, they work slowly over a period of time, rather than having to be re-applied. The alginate technology can be applied to a variety of “undesirables”: plant diseases like root rot, unwanted water and soil-based weeds, young insects and other pests, and fungi that attack grains and crops. It is being used in bioremediation of toxic chemicals underground.

e. The PNNL chemical slow-release technology fights plant roots extending down into radioactive waste sites. In the commercial arena, the same technology can be applied to control plant roots ruining underground watering systems, tree roots “uprooting” sidewalks, weeds overtaking gardens and landscaped areas, or roots intruding into sewer pipes. Longer-term applications being developed include insect and rodent control and protecting decaying telephone poles, railroad ties, and buried power and gas lines.
f. In the case of NIST establishing a radiation therapy quality assurance program, the technology that was transferred was the traceability of x-ray dosimetry (measurement) systems to national and international standards. Before this was transferred to other sources in this country, these measurements were performed in a “vague, uncontrolled, and amateurish” way in many institutions. Although NIST performed calibrations for some institutions, there was no systematic process in place for other institutions to be calibrated. With this technology, these other institutions can be calibrated by other organizations besides NIST. The calibrations have traceability to NIST for ensuring their accuracy.

The Laboratories

a. The laboratory for the penetrometer was the Naval Oceanographic Office located with other agencies at the Stennis Space Center. Stennis is known for its outreach to local governments in the state of Mississippi. Stennis was one of the earliest FLC members to initiate a formal technical assistance project with the counties in the state. With this type of reputation, it is not surprising that the substance of the case had to do with helping a local economic development organization.

b. The thermoplastic material was developed at the NASA Langley field center which had an interest in this material for aircraft structures.

c. The tracer technology was developed at Brookhaven National Laboratory (BNL). Although the technology has not materialized as a commercial venture in any of its application areas, it is consistent with BNL’s culture to provide this service to outside users on a fee per service basis. BNL’s culture is based on a reputation for providing access to its unique facilities for both proprietary work as well as basic research.

d. The alginate-based herbicide/pesticide started at the USDA Crop Protection Research Laboratory in New Orleans, but eventually it branched to a variety of other USDA and university laboratories. The federal laboratories included the USDA Southern Weed Science Laboratory in Mississippi, the USDA Aquatic Weed Research Laboratory in Florida, and the Agricultural Research Service headquarters in Beltsville, Maryland’s Biological Control of Plant Diseases group. Ultimately, the technology involved the USDA Subtropical Agricultural Research Laboratory in Texas and joint work with some university laboratories.

e. The technology involving chemically-imbedded herbicide/pesticide materials was invented at Pacific Northwest National Laboratory (PNNL). Although the technology was tested in Colorado, it was intended to help solve the problem posed by the laboratory’s next door neighbor, the huge DOE Hanford Site. The technology was needed to control underground plant roots threatening major underground storage tanks full of nuclear wastes.

2Interviews with Dr. Loevinger, August 27, 1996, November 12, 1996, and December 9, 1997.
f. The radiation therapy quality assurance technology was conceived by a scientist at NIST. NIST was the perfect agency for initiating such an activity. Its missions include assisting associations and groups to establish standards and funding research related to standards. NIST also provides calibration services linking customers’ equipment to national standards.

**University Involvement**

a. For the penetrometer technology, the Naval Oceanographic Office contracted with a nearby university to develop a prototype and test the new instrument. The university, in turn, worked with a company intending to commercialize the technology.

b. In the case of the thermoplastic material, the small firm obtaining the NASA SBIR contract conducted the R&D jointly with a professor at a nearby university.

c. Universities laboratories that do environmental testing are occasionally customers for BNL’s tracer technology-based service.

d. Universities have utilized the alginate-based process for a great deal of laboratory testing work because it is suited for obtaining accurate results in that type of work. In addition to independent university research, Mr. Connick has been conducting joint research with the University of Arkansas which has resulted in a joint patent and publications. Also, USDA’s company partners in this area have used a number of university researchers as consultants to test their products.

e. There was no university involvement in the root control technology.

f. For the NIST radiation therapy quality assurance program, some of the hospitals in the national quality assurance system were university hospitals.

**Funding, Financing**

a. Naval Oceanographic Office funds supported the conceptualization, prototype/testing contract, and procurement contract for the prototype copies.

b. The work at NASA Langley on the thermoplastic material was funded through NASA. There was little interaction between the NASA inventor and the private-sector licensees. Laboratory funds were not involved with commercialization with one exception: the small firm still working on further developing the technology received NASA SBIR funding and state R&D funding. However, the firm does not have any outside funding for its work on the technology.

c. The tracer technology demonstrations, tests, and experiments have been, for the most part, jointly funded by the organizations involved in them. BNL covered Dr. Dietz’ time and that
of other BNL researchers involved. These projects are viewed as a way to prove the feasibility of the technologies resulting from the R&D being performed at the laboratory.

d. All of the work on the alginate-based technology at the USDA centers and laboratories was covered by USDA funds. In addition, the USDA Beltsville center provided cooperative research funding to the Grace-Sierra Crop Protection Company for its work in this area.

e. Initial funding for the chemically imbedded herbicide/pesticide material was provided by PNNL, Rockwell International (the contracting operator for the nearby Hanford Site), and the Office of Nuclear Energy at DOE headquarters. The PNNL research team currently devotes only five percent of its time to this project, which is funded by companies and military services interested in the pest control applications.

f. In the radiation therapy quality assurance case, Dr. Loevinger’s work with the AAPM committee was considered part of his NIST job responsibilities, and therefore was covered by his NIST salary. NIST’s charge for its primary level, national standards calibrations for radiation therapy instruments averages $500. Each of the five certified secondary level regional calibration laboratories are voluntary and not federally subsidized. They remain self-sufficient or near break-even by charging for the calibration services they provide to tertiary-level institutions involved in radiation therapy. (There are other benefits of being certified as a regional calibration laboratory, but they are more intangible.)

**Intellectual Property**

a. The Navy chose not to apply for a patent for the two versions of the penetrometer.

b. Two patents were jointly filed by NASA and MIT for the thermoplastic material, with the inventors being the NASA scientist and an MIT graduate student.

c. The only application area that was patented for the tracer technology was the pre-fire warning system. Dr. Dietz commented that, until recently, the laboratory researchers tended not to patent.

d. The alginate technology has been patented for many applications: two patents for use with chemical herbicides, two for biological control of plant diseases, two for weed control, and one for bioremediation. USDA has applied for a patent for its use with nematodes. In the meantime, Biosys has developed proprietary knowledge on its formulation and production. The company has a patent application in process in the United States and patent applications filed in four other countries.

e. For the chemically imbedded material, there have been no less than seven invention disclosures at the laboratory and seven patent applications filed by DOE. In addition, the partnering companies have filed patents.
f. This topic was not applicable to the radiation calibration services.

Technology Transfer Mechanisms

a. The transfer mechanism with the Navy’s penetrometer was the contract with the university for developing the prototype.

b. NASA licensed its thermoplastic material to two companies. The small company with the SBIR contracts also has ownership rights to the technology through the Bayh-Dole Act.

c. A variety of mechanisms have been involved in the transfer the tracer technology from BNL to outside users. These mechanisms have included such diverse means as:

- BNL sale of equipment with an exclusive license to a trade association,
- a CRADA with a small ventilation company,
- successful early demonstrations and subsequent transfer of a proprietary knowledge-based system to a public/private electric power consortium which offers the service commercially,
- unsuccessful joint tests between BNL and a utility,
- successful joint tests between BNL and a commercial laboratory,
- the loaning of equipment to an instrument company,
- a collaborative BNL/company procurement project,
- fee-for-service provision to the petroleum industry, and
- traditional marketing of a patent license for a pre-fire warning system.

d. For the alginate-based herbicide/pesticide case, in the late 1980s the cooperative research funding USDA provided to Grace-Sierra evolved into one or more CRADAs, since the company was interested in protecting its intellectual property rights. Because there were company changes, it is difficult to sort out the point when the various CRADAs started and ended, and how they corresponded to the company takeovers. Biosys, Inc. did not have a formal collaborative arrangement with Mr. Connick’s center, but eventually signed a CRADA with one of the USDA laboratories in Texas. Mycogen Corporation signed an exclusive license with USDA for all the alginate-based patent applications.
e. For the chemically imbedded material, Agrifim Irrigation International obtained an exclusive worldwide license from PNNL’s contracting operator, Battelle. Agrifim sub-licensed the technology to Geoflow™ Subsurface Irrigation, an Agrifim division, for the production of underground watering systems. In addition, Agrifim sub-licensed the technology to Torro for use in termite control products. Reemay, Inc. signed an exclusive license to manufacture a geotextile fabric containing herbicide pellets. Mantaline Corporation obtained a license to manufacture sewer line gaskets with the technology.

f. For the radiation therapy quality assurance case, as a result of the NIST scientist’s recommendation to the AAPM a national system was established to ensure more accurate radiation therapy dosage measurements, including a task force and a permanent subcommittee. The subcommittee chose a system of three, and later five, regional calibration laboratories. These five laboratories have their calibration equipment calibrated directly by NIST and provide a secondary standards level calibration to other organizations.

User Groups

a. The penetrometer was unusual in that the user group was strictly state and local government officials. Had the penetrometer instrument become commercialized, there would have been other user groups.

b. The user groups for the thermoplastic material are companies from aerospace, electronics, and other sectors.

c. The users of the tracer technology include power companies, hospitals, trade associations, university and commercial testing laboratories, instrumentation companies, the petroleum industry, railroads, other federal agencies, and similar groups overseas.

d. The users of the alginate-based herbicide/pesticide include those involved in plant and crop diseases, weed control, or insect infestation (e.g., farmers, professional greenhouses, nurseries, landscape firms, even homeowners).

e. The users of the chemically imbedded herbicide/pesticide material overlap the users of the alginate-based herbicide/pesticide. They include farmers, municipalities, facilities maintenance companies and, again, homeowners.

f. Users of the NIST radiation therapy quality assurance system would be those institutions offering radiation therapy for diseases such as cancer. The end users of the equipment are the patients undergoing such treatments, about 600,000 in this country.
**Barriers to Commercialization**

a. At the time of the penetrometer development, Mr. Ingram implied\(^3\) that Navy researchers did not receive much in the way of incentives for transferring technologies so it was not worth pushing through the system. Mr. Ingram did note that in recent years, however, CRADAs have made it easier to transfer technologies.

b. Part of the barriers to commercializing NASA’s thermoplastic material have revolved around corporate changes and re-directions in the two original licensees. The third company with current rights to the technology is a small firm with a lack of corporate resources for commercialization and the wherewithal to compete against products manufactured by General Electric, DuPont, and other larger players in the materials markets.

c. The level of demand for tracer technology in the application areas noted above apparently is not large enough to support an entire business. A commercial service based upon the technology appears to succeed only as a sideline business for smaller companies. There are mixed reviews about the success of its being offered through associations or consortia of companies.

d. The major barrier to commercializing the alginate-based herbicide/pesticide involves the costs associated with scaling up from laboratory and market testing to full-scale manufacturing levels. The raw materials, including the alginate/clay mixture, are expensive and, at higher levels of production, the product is more labor-intensive to produce and requires more quality control.

e. In terms of the chemically imbedded herbicide/pesticide material, there are some inherent marketing problems being faced by the partnering companies. First, there seems to be a bias against products that work long-term. Commercial ventures prefer throw-away products that only last for a short period of time, so it is difficult to market a product that lasts for two years or longer. Second, traditional chemical pesticide treatments involve larger quantities because they must be re-applied often. On the other hand, slow-release or controlled-release technologies are sold in smaller quantities. This requires a shift in thinking for consumers and distributors alike. Third, when a new product is introduced that doesn’t replace an old product, it is difficult to create product visibility or to create a market. Also, the raw materials going into the end product are expensive, so that value must be sold to the ultimate consumer.

f. There were no commercialization barriers in the radiation standards case.

\(^3\)Interview with Mr. Ingram, September 4, 1996.
User Benefits/Economic Impact/Outcomes

a. The penetrometer prototype was used to perform the originally intended river survey work; in fact, this was how the prototype was field tested. Only six prototype clones were produced by Sippican Corporation so there was little overall impact on the economy with this technology.

b. Both of the original NASA licenses for the thermoplastic material are dead because of corporate re-structuring and new business strategies. In NASA’s current database of available technologies, the material is stated as accessible through the NASA/SBIR firm that is still doing development work. The product has not been popular, however.

c. The National Association of Home Builders’ tracer technology service did not succeed in the long run and was discontinued. It is now being offered (along with other related services) by a small environmental service company using BNL for the analysis portion of the work. Provision of on-line tracer services by the private ventilation service company did not succeed, and the company now offers it on an as-needed basis along with other services. It is not known what the monetary benefits to the Electric Power Research Institute have been for its provision of the underground leak detection service to its member electric power companies; however, the service is still being offered. The demonstrations show that this leak detection method is less costly than traditional methods. The other miscellaneous utility testing work was not as successful as anticipated and was not pursued. Tests on the underground storage tanks were very successful, but the user company decided not to adopt this line of business. The explosives detection instrumentation development has been held up by the necessity for a Nuclear Regulatory Commission license, although it is still being pursued. Another company’s joint procurement collaboration with BNL became inactive once the project was completed; although the company still markets certain tracer technology instruments and/or services along with its other lines of business. The petroleum reservoir analysis service is being provided by BNL, only.

d. For the alginate-based herbicide/pesticide, Grace-Sierra test marketed GlioGard™, the first bio-fungicide on the market, for about two years. During this phase, the company sold thousands of pounds and received favorable feedback; however, they ran into problems when scaling up, so they changed the formulation and the product’s name to SoilGard™. About that time the Grace Company sold several products (including SoilGard) to Thermo Trilogy Corporation. Thermo trilogy is re-negotiating ownership rights with USDA. Biosys, Inc. manufactured a product called BioSafe® that was marketed for about six years by Ortho. Ortho eventually sold its retail line to Monsanto, which subsequently cancelled most of its products (including BioSafe). Meanwhile, Biosys signed a related CRADA with a USDA laboratory in Texas that evolved into a new line of three products for the company: Vector®, Lesco™ Vector®, and BioVector®. The company’s market share increased from 27 to 84 percent based upon two of the products, and the third product is reportedly doing well in its first year of introduction. EcoScience Corporation temporarily had a product called Aqua-Fyte™, which it field tested.
through an EPA Experimental Use Permit. But the company has been undergoing financial
difficulties and doesn’t produce it any more. After a number of years of keeping up its license,
Mycogen Corporation terminated its license in 1993 without having commercialized any
products.

e. Regarding the PNNL chemically imbedded herbicide/pesticide material, Agrifim’s
division Geoflow installed its Rootguard\textsuperscript{R} products on at least fifty agricultural sites, 28
landscape sites, and fifteen turfgrass sites. In addition, Geoflow’s Wasteflow\textsuperscript{TM} systems have
been installed in at least five sites. Reemay, Inc. manufactures two products: Biobarrier\textsuperscript{R} for root
control, and Biobarrier\textsuperscript{R} II for weed control. Although the company assumed the main market for
its root control product would be DOE nuclear waste sites, it found that these DOE sites are very
independent. A license from one site does not imply an inside track with other sites. However,
now Reemay is actively selling its product to municipalities for public works applications and is
finding the market receptive. The company cites at least five examples of cities and counties that
have used the product. The Mantaline Corporation license is now dead for unexplained reasons.

f. The NIST radiation therapy quality assurance system does not involve commercialized
products; instead, an important medical technology was transferred. There was one early study
of the new system that determined it was working well. Anecdotal evidence indicates that the
system was sorely needed at the time it was established. The system helps to ensure the public
health and safety of about 600,000 patients in the United States undergoing radiation therapy for
cancer each year. It also helps to reduce the probability of lawsuits related to negligence and
improper calibrations and dosages, thereby holding down health costs.

International Activity

a. There was no international activity on the penetrometer.

b. Although there have been expressions of interest in the thermoplastic material, there is
no international activity on that technology either.

c. Dr. Dietz of BNL used the tracer technology to conduct successful experiments for the
Commission of European Communities. He simulated global and regional pollution from
sources such as nuclear and/or chemical disasters.

d. An international consortium is using the alginate-based technology in its research on
agriculture-related chemicals pesticides and herbicides. Also, Mr. Connick’s work has spread to
other overseas scientists, as well, who have similarly cited him in their research.

e. Both companies involved in producing the chemically imbedded herbicide/pesticide
material, Geoflow and Reemay, are selling, testing, or marketing worldwide.

f. In addition to linking its customers’ radiation therapy equipment to national standards,
NIST’s calibration standards ultimately link the measurements of precision equipment to international standards.

**Government Gains**

a. The Navy was able to realize some unknown (possibly classified) benefit from the six penetrometers produced by Sippican, however, additional penetrometers were not under contract after that.

b. Although the NASA thermoplastic material was originally invented as an aerospace application, it is not being used in the space program.

c. As it turns out, the BNL’s tracer technology can be applied to the space station and can be used by EPA to do environmental monitoring -- two originally unanticipated uses of the technology.

d. The alginate-based application related to bioremediation could be used to clean up military sites, government explosive sites, or chemical dumps. It could also be used to help with the Superfund’s cleanup activities.

e. Ironically, PNNL’s chemically imbedded herbicide/pesticide material was originally developed for DOE use. It has not caught on with the DOE nuclear waste sites, but it is currently being considered for applications at military bases for the long-term control of insects. It may also be incorporated into military uniforms that repel bugs.

f. There has been more than one spinoff of Dr. Loevinger’s radiation therapy quality assurance program. Another program establishes certified laboratories among the federal laboratories for other types of calibrations. And another such program was established for x-ray protection instruments used by radiation workers in both the public and private sectors.

**Economic Development, Technical Assistance**

The only company that received any outside economic development services was the minority-owned company, High Technology Services, with the NASA-funded thermoplastic material. The company has been helped by both NASA and state programs aimed at assisting small firms.

**Elapsed Time**

a. The river bottom technical assistance work began in 1982, and the first penetrometer patent was filed in 1983. The prototype was developed and tested and “written up” in 1984. Sippican Corporation’s holotypes were made in the mid- to late-1980s. So the technology development took roughly five years from conceptualization to pre-commercialization, but the
instrument is not moving.

b. The thermoplastic material was developed in the early 1980s, patented in 1983 and 1984, and first licensed in 1985 (ending in failure). The SBIR contract with the small firm was from 1990 to 1992. So, it was over fifteen years from invention to pre-commercialization stages. The material is still not being mass-produced.

c. The tracer technology has been under development at BNL for over two decades. The building ventilation work reached its peak in the late 1980s and early 1990s. The successful underground utility work is still going on through EPRI. The other services (underground storage tank leak detection, petroleum reserve analyses, etc.) continue to be offered by BNL. Some tracer instruments and services are sold by private sector firms, as well. What will result from efforts to commercialize the explosive detector and pre-fire system remains to be seen.

d. Mr. Connick first developed the alginate-based chemical pesticide almost two decades ago. He continued his work and teamed with other USDA sites during the 1980s, with patents and articles resulting during that time frame. The work with Grace-Sierra began in the mid-1980s before CRADAs were possible. The company’s first product hit the market in the early 1990s, having been under development for about seven years. Biosys also began working with USDA in the mid- to late-1980s, but did not begin its CRADA work in Texas until later. The three products developed under the CRADA proceeded from basic research to commercialization and market introduction in a record time of three to four years. The scale-up phase only took six months, and the introductory market promotion lasted eight months. EcoScience Corporation’s experiments took place in the 1992-1993 time frame.

e. The chemically imbedded herbicide/pesticide material was conceived about two decades ago, with the research gearing up in the late-1970s. DOE conducted field tests at the Colorado sites in the early 1980s. Patents and publications appeared beginning in 1982 and 1983. Battelle negotiated licenses from 1983 to 1986, at a time when DOE did not have all the technology transfer procedures in place for the agency. Reemay’s Biobarrier root control product was commercialized in eight years and has been on the market for four to five years.

f. In the radiation therapy quality assurance case, Dr. Loevinger began working with the AAPM subcommittee over twenty-five years ago, after joining NIST in the late 1960s. The first set of regional calibration laboratories took form in the early 1970s. After a NIST-funded (but independently-implemented) study of the system in 1976, two additional regional laboratories were added. Other than that change, the system continues successfully to the present day.

POST-LEGISLATION FINDINGS SUMMARY

This appendix summarizes the findings for the selected post-legislation cases in Chapter IV organized according to the questions addressed in the interviews. The topic, “Other Factors,” is incorporated into the concluding section of the dissertation. The cases appear in the following
order:

a. Laser Method to Light Samples
b. Voice Coder
c. Paper Quality Tester
d. Variable-Frequency Microwave Oven
e. Gravity Meter
f. Oatrim Fat Substitute
g. Chemiluminescent Light Stick
h. Artificial Heart Blood Flow Analysis.

Roles of Laboratory Researchers and Other Personnel

a. Dr. Yeung at Ames Laboratory developed both the laser-based method of lighting biological samples and an instrument for accomplishing the illumination method. To get independent evaluations of the technology, he reached out to a medical laboratory instrument company, a university medical chemistry department, a hospital, the research arms of two drug companies, and a private laboratory overseas. He provided a variety of services to these organizations. For example, for the instrument company, he assembled a prototype instrument using various parts and components already manufactured by the company in hopes that the company would choose to mass-produce the instrument necessary to perform his fluorescent method. He also made presentations and published widely in scientific journals, both in this country and others. Even after business arrangements with the outside organizations were in place, he continued his work testing and further developing the technology, making significant improvements.

b. The Rome Laboratory team sought Air Force support for the voice coding technology against all odds, since it was competing for funding with existing industry telecommunications standards. Also, there were no valid in-house Air Force requirements for the technology. However, early-on they recognized the advantages of this technology over existing ones and persisted in their fight to convince others of the technology’s superiority.

c. After developing a laboratory prototype, the inventor of the paper quality testing technology, Mr. Gunderson, worked with others in his research unit to develop a technology transfer plan and market assessment. They contacted a hundred potential users, and solicited competitive CRADA proposals from equipment manufacturers they had identified. They also worked with the eventual partner in the equipment design and development. In addition, they published a number of scientific papers in scholarly journals. Some of these papers were co-authored with others from partnering organizations.

d. For the variable-frequency microwave oven, the Oak Ridge team combined their areas of expertise in different areas to come up with a new technology. They shopped for an off-the-shelf commercially available component, the traveling wave tube, and eventually discovered a
small defense contractor in another state. The company donated the needed component to ORNL, and ORNL bought the power supply necessary for the ORNL researchers to develop a large prototype system, while the company developed a bench-top version. The researchers presented their findings at various conferences and in scientific papers. The ORNL researchers’ relationship with the company partner has flourished over the years with a variety of joint patents and papers being produced.

e. Dr. Faller, who chairs NIST/JILA, developed the mechanical, electronic, and optical technology incorporated into the original prototype gravity meter. He was the principal technical advisor for the agency’s contract to procure several gravity meters. Dr. Faller also headed the effort to test and evaluate the commercial gravity meters when they were later delivered to NIST.

f. Dr. Inglett invented the technology to manufacture the Oatrim fat substitute. He wrote scientific articles for journals and provided USDA information to interested companies. Eventually, he announced Oatrim’s development at a national meeting of a professional society and subsequently received thousands of inquiries from companies. Consequently, he arranged a technology transfer conference at the laboratory, which was attended by seventy industry representatives. Once the technology was licensed, Dr. Inglett assembled an information packet on the licensees and hosted corporate visits to the laboratory. He did much “hand-holding” with the partnering companies during their product development work, visiting their pilot plants and inviting them to his laboratory to view processing techniques. In addition, he initiated “human studies” of the fat substitute, which were very successful. After all this, Dr. Inglett continued his research to improve processing and address production problems involved in scaling up from pilot plant levels.

g. In the light stick case, Dr. Richter and his team of scientists at China Lake researched and experimented with chemiluminescent technologies for a long period of time. Over the years, they performed a series of tests on a variety of chemical compounds and then continued testing to determine the most sustained, temperature-resistant, and non-flammable combinations. They performed both laboratory tests in glass vials and field tests in a variety of environmental conditions. Dr. Richter worked closely with the China Lake technology transfer officers. He produced a sample kit containing potential commercial products and performed demonstrations for manufacturing companies and all levels of government agency users. The group wrote a number of scientific papers and presented at conferences. The early private sector contacts resulted from this exposure.

h. Mr. Shaffer at FETC invented and developed the artificial heart blood flow analysis system. Mr. Shaffer and another scientist in the laboratory’s Fundamental Combustion Group helped the partnering medical researchers to set up the FETC-like system at Baxter Healthcare and trained them to use it. Also, the FETC scientists, along with various combinations of these partnering researchers, co-wrote a number of scientific papers.
Technologies and Applications

a. The laser-based method to light up biological samples helped researchers monitor those processes in detail, even for small volumes of samples. Previous detectors to perform these functions were based upon conventional light sources. This is applicable to the field of medical research.

b. The voice coding technology involved a revolutionary approach for compressing voice patterns digitally so that they could be transmitted long distances and then reassembled at the receiving end. Traditional coding techniques involved “linear prediction” programming rather than this new “sinewave-based” programming. Speech/voice compression technology is used in land mobile radios and mobile satellite telephones (in place of cellular service where that is not available). This technology is also used in digitally based voice answering machines and in desktop computer video conferencing.

c. FPL developed a paper quality testing device that allows accurate measurements of paper product deterioration as it is stored over time (such as rolls of paper in warehouses) and exposed to humidity. Better quality control assessments allow paper manufacturers to reduce the use of expensive coatings and wood fiber, which help preserve paper quality in the long run. The quality testing technique has also been found to work well in testing the plastic-type materials used in computer circuit boards, which degrade over time due to exposure to heat and other conditions.

d. The variable-frequency microwave furnace had advantages over conventional fixed-frequency ovens in that it could vary frequency to heat dead spots in a sample for more even heating. It is usable for uniform computer circuit board etching, application of synthetic films to industrial equipment, ceramic heating, and resin curing.

e. NIST/JILA’s gravity meter was a highly accurate device based upon absolute rather than conventional relative measurements of gravity. It is used for oil prospecting, measuring volcanic seismographic activity, and other purposes.

f. The fat substitute was called Oatrim by USDA because it is derived from oats. Upon incorporation as an ingredient in prepared foods, such as dairy products, dressings and sauces, meats, cereals, etc., it tastes like fat yet it has less than one-ninth the calories of fat. Also, it lowers blood cholesterol levels because it decreases bad cholesterol and increases good cholesterol.

g. Chemiluminescent light sticks are now known by the general public as the novelty items that glow in the dark and that are fun for kids. They are sold at parades, festivals, carnivals, etc. They were created by mixing certain chemical compounds and dyes together. They were originally developed for military purposes such as marking targets and locating
downed pilots.

**h.** FETC’s blood flow analysis technology used a laser to make a fluid fluorescent. The fluid was viewed using multiple exposures of digital photography. The velocity and other properties were measured using software which accompanies the digital photography. When this technology was applied to artificial hearts, it was the first time blood flow was visualized and measured on the internal surface of an artificial heart. This information was used to counter the tendency in artificial hearts for blood to clot, an often fatal complication.

**The Laboratories**

**a.** The laser-based method to light up biological samples was developed at Ames Laboratory. DOE’s Ames Laboratory has research programs in biochemistry and environmental sciences, yet the laboratory is known for its accomplishments in fields like materials science, metallurgy, and superconductivity. Dr. Yeung’s work in this area, his international visibility, and contacts with outside organizations improved the laboratory’s industrial and scientific standing.

**b.** The laboratory involved with the voice coding technology was the Air Force’s Rome Laboratory which comprises seventy laboratories around the country involved primarily in communications technology and coordinated from headquarters in Rome, New York. Rome Laboratory’s Electromagnetics and Reliability branch is located at Hanscom Air Force Base in the Boston technology corridor. This part of the laboratory focuses on telecommunications equipment, antennas, microelectronics, and related areas.

**c.** The paper and plastic quality testing technology was developed at the USDA Forest Products Laboratory, one of the eight Forest Service laboratories that are part of the USDA. Of the 350 employees at the laboratory, only about a hundred are scientists and engineers because the laboratory has a contingent of economists who conduct market research for the laboratory’s products.

**d.** The variable-frequency microwave furnace was developed at DOE’s Oak Ridge National Laboratory, a DOE multi-program laboratory. However, some of the funding for the technology development was obtained from the DOE Y-12 Plant next door to ORNL, which is one of DOE’s defense-oriented laboratories.

**e.** The gravity meter was developed at the NIST’s Joint Institute of Laboratory Astrophysics (JILA) located on the University of Colorado campus at Boulder, Colorado. The NIST employees at JILA report to the NIST Physics Laboratory located at the Gaithersburg, Maryland headquarters. The NIST/JILA structure is an interesting one not replicated in too many other federal laboratory/university locations around the country.

**f.** The fat substitute was invented at the USDA’s National Center for Agricultural Utilization Research in Peoria, Illinois.
g. Chemiluminescent light sticks for marking military targets were developed at the China Lake, California, site of the Naval Warfare Center’s Weapons Division.

h. The artificial heart blood flow diagnostics were developed at the Pittsburgh Energy Technology Center, which applied the same techniques normally used to analyze the flow of fuel through pipes to artificial heart pumps. This case “represents technology transfer in its finest sense, because it embodies the application of technology from one discipline -- fundamental engineering in fossil fuels -- to a quite different one -- medical technology.”

**University Involvement**

a. In the laser-based biological samples case, Dr. Yeung served as a long-term consultant to Northeastern University’s research program in High-Performance Capillary Electrophoresis so that they could become familiar with his method.

b. The voice coding technology was developed at the Massachusetts Institute of Technology through Air Force (and other) funds. The MIT research team published a number of papers on the technology in the early years of its development.

c. Universities were part of the network established by FPL for evaluating its paper quality testing technology, and also part of the panel screening the competitive CRADA proposals.

d., e., f., g. There was no university involvement in the microwave oven, gravity meter, Oatrim, or light stick technologies.

h. The University of Pittsburgh’s Presbyterian-University Hospital is serving as one of the FDA test sites for the artificial heart pump; in fact, doctors at the university’s medical school initiated the flow diagnostics work with FETC because they felt they did not have the proper testing techniques they needed. The school’s director of biomedical engineering approached FETC to request assistance with measuring and analyzing blood flow.

**Funding, Financing**

a. Ames Laboratory and DOE headquarters’ programs funded Dr. Yeung’s work on the laser-based method. Dr. Yeung’s work with the outside organizations was covered by those organizations through either independent consulting or contracts with Ames Laboratory. Iowa State University’s Research Foundation funded the patent application process since the patent was issued to Iowa State, the laboratory’s managing organization.

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b. The voice coding technology was funded by university funds and grants and contracts from federal agencies including the Air Force and some intelligence community funding. The resulting spinoff company has not received any federal funding since its founding.

c. In the paper quality tester case, at the same time that FPL was receiving funds from Isthmus Engineering for the CRADA work, the commercial product was provided at cost to the laboratory in return for the laboratory’s technical assistance. For the same technology, the laboratory put into place ten cooperative research agreements totaling almost $1 million to public and private organizations so they could independently evaluate the testing technology.

d. In the variable-frequency microwave oven case, the Oak Ridge National Laboratory researchers obtained funding from three DOE sources to allow them to continue work on the microwave oven, including two DOE headquarters programs, the Office of Industrial Technologies and the Laboratory Technology Transfer Program. The third source was the Advanced Manufacturing Program at the defense-oriented Y-12 Plant next door.

e. Funding for the R&D on the gravity meter was provided by NIST and the Defense Mapping Agency. NOAA provided the funds for the initial procurement and provided partial funding for the NIST/JILA lead scientist’s time. Among the spinoff companies, at least two of the original Axis principals invested almost $1 million of their own money toward starting up the company and developing the gravity meter. Micro-g received NOAA SBIR funds for further development work. The other spinoff has relied on small “angel”-type investments.

f. The Agricultural Research Service funded Dr. Inglett’s time to research the Oatrim fat substitute. Both the ConAgra and the Rhone-Poulenc/Quaker partnerships invested “millions of dollars” into their Oatrim products. This involved both further development of the technology, as well as development of the production process. Their high expectations were dashed when they found they had licensed a laboratory process which was “worlds apart” from pilot plant product level and then to full-scale mass production.

g. Various Navy and Army offices sponsored the chemiluminescent light stick research. The Marine Corps Exploratory Development Program provided funds for the patent process.

h. The CRADA involving the artificial heart flow analysis technique was one of the Pittsburgh Energy Technology Center’s (PETC) first CRADAs. Therefore, the agency was not sure how to handle the receipt of private industry funds when Baxter Healthcare offered it. Therefore, this particular CRADA and even the more recent follow-on CRADA involved equipment from Presbyterian-University Hospital and Baxter valued at $500,000.

Intellectual Property

a. The original patent and later extensions on the laser-based method were issued to Iowa State University, DOE/Ames Laboratory’s contracting operator.
b. The spinoff company that developed the voice coding technology received at least four patents with several pending, both foreign and domestic.

c. Two patents were issued to USDA for different applications of the paper quality testing technology; certain aspects of the technology were not patentable.

d. Oak Ridge National Laboratory was issued two patents for the variable-frequency microwave furnace system with a variety of laboratory, company, and non-profit scientists listed as inventors. There were three additional patents pending related to the CRADA work.

e. The gravity meter was not patented; however, it was a proprietary instrument for Axis Instruments, which produced the first devices.

f. There were at least two USDA patents on the Oatrim fat substitute with Dr. Inglett registered as the inventor.

g. The chemiluminescent light stick technology resulted in a number of patents over the years. There are two Navy patents that are still current with three China Lake scientists listed as the inventors.

h. A patent was issued to DOE for the artificial heart blood flow analysis technique with Mr. Shaffer listed as the inventor. Also, Baxter Healthcare received a patent on its artificial heart pump device.

Technology Transfer Mechanisms

a. In the laser-illuminated biological samples case, Ames Laboratory granted a license to Lachat Instruments, a relatively young but stable high-tech company with established product markets, for further developing and eventually selling the required instrument for accomplishing the laser-based method. The technology was also transferred to at least three other research facilities through consulting contracts to Dr. Yeung.

b. The transfer strategy used by the Rome Laboratory team to push the voice coding technology involved establishing a strong presence at standards meetings and presenting supportive arguments for their technology before standards committees. Consequently, the technology was entered into a number of federal, state, local and commercial competitions and independent evaluations where it performed well and was highly rated on a technical basis. Eventually, this new technology was accepted as the new national standard in a number of telecommunications areas.

c. The paper quality testing technology was transferred through a one-year CRADA and an exclusive license on both patents to a small cooperatively organized testing equipment
manufacturing firm. The time frame for the license is equivalent to the life of the patents and its field of use is paper products. In addition to these arrangements, the laboratory issued a variety of cooperative research agreements for testing purposes.

d. For the microwave oven, Oak Ridge National Laboratory granted a non-exclusive license to Microwave Laboratories, Inc. and eventually signed a CRADA with the company.

e. NIST implemented a competitive public solicitation to transfer the gravity meter technology and signed a five-year procurement contract with Axis Instruments Company, a small high-tech start-up in Boulder. Axis was to manufacture at least two gravity meters built to specifications being designed and developed by NIST/JILA. The first two instruments were turned over to NOAA from NIST. Axis also obtained rights, in exchange for building a gravity meter, to a new type of iodine laser from the International Standards Bureau in Paris, and agreed to pay them royalties.

f. For the Oatrim fat substitute, USDA granted three non-exclusive licenses to: ConAgra Specialty Grain Products Company (a $25 billion company and the second largest food manufacturer in the United States); Rhone-Poulenc, Inc. (a $16 billion French company); and Quaker Oats (a $6 billion company). A CRADA was later signed on a related technology.

g. For the light sticks, the Navy signed non-exclusive licenses with American Cyanamid Corporation and Chemical Devices Corporation, now called Omniglow, Inc., extending to 1993. Before the licenses expired, Omniglow brought a lawsuit against American Cyanamid for filing a patent excluding the government (and Omniglow, as a licensee) from rights to this technology which the government actually owned. In spite of the government not joining in the case, Omniglow won the case and was granted American Cyanamid’s light stick technology and business by the court. Omniglow subsequently canceled both licenses, saying they weren’t necessary. The company now holds the lion’s share of the chemiluminescent patents worldwide.

h. The artificial heart flow technology involved a multi-partner CRADA to cooperatively perform the FDA-required testing of the heart pump. The partners are PETC and the University of Pittsburgh’s Presbyterian-University Hospital and its schools of both Medicine and Engineering.

User Groups

a. For the laser-illuminated method, any type of laboratory (clinical, pharmaceutical, industrial, university, etc.) could benefit from its use. For example, pharmaceutical laboratories can test drugs on a cell-by-cell basis, whether blood cells or cancer cells.

b. Telecommunications equipment manufacturers are starting to make use of the voice coder. They are finding it to be a superior technology over existing standard technologies in this area.
c. The users of paper quality testing machines are paper product manufacturers. The technology allows quality testing before the products have left the manufacturing facilities. As a result, manufacturers will be able to experiment with less expensive combinations of coatings, fibers, and recycled ingredients so that products are not over designed and over processed to compensate for deterioration. Also, there will be less discarded scrap paper.

d. As with other technologies, initial users of the variable-frequency microwave oven in the short term include laboratories in all sectors: university research laboratories, commercial testing laboratories, etc. Ultimately larger user groups will include semiconductor manufacturers and other types of industrial equipment manufacturers and companies that perform ceramic heating or resin curing, in addition to the military.

e. Government agencies use gravity meters to measure global climate change and warming or to make earthquake and volcano predictions based upon, for example, ocean water levels. They can also contribute to oil prospecting and exploration.

f. The immediate users of the Oatrim fat substitute are food companies. The ultimate end users are their adult customers who are concerned about weight and cholesterol problems as they age.

g. The primary users of the manufactured light sticks are U.S. military personnel and policemen, but also many other countries’ military, law enforcement, and public safety agencies are using this technology. Children, as well, are “users” of light stick products sold in stores and amusement parks, as are doctors and medical clinics (for the chemiluminescent biomedical applications). In addition, other manufacturing companies use the technology for industrial safety applications, and fishermen use light sticks as bait and lures.

h. The ultimate beneficiaries of the artificial heart flow diagnostic technology are critically ill patients with heart diseases. There are thirty to fifty thousand people waiting for heart transplants every year. The intermediate users are the health care organizations that make use of artificial hearts in their practice.

Barriers to Commercialization

a. In the laser-based case, Dr. Yeung’s major barriers were having to make a special effort to convince skeptics that his technically proficient method was also easy to operate. Also, the licensee did not want to expend any effort on their own towards commercialization. They wanted a market-ready product.

b. The voice coding technology is used in the telecommunications industry, which maintains elaborate standards in all areas of technology in order for equipment to be functionally compatible. The problem in promoting the new speech coding technology was that it was
fundamentally different from all of the existing standards for this type of equipment. This required novel approaches to transferring the technology, because it first needed to be accepted within the industry.

c. When the paper quality testing device was first created, there was no market demand for the technology because it was a first-of-its kind. This made promoting its use difficult. Consequently, the laboratory used cooperative research agreements, among other mechanisms, to help promote the technology. But this strategy ran into problems when each organization required different machine configurations and data analysis methodologies, which made comparisons and overall technology assessment difficult.

e. Regarding the NIST procurement contract to obtain the initial gravity meters, NIST was still in the process of design work and developing product specifications while they were also in the process of negotiating the contract, which made the contract implementation difficult. In addition, years later, the two spinoff companies have to deal with the prospect of market saturation, given that their products are highly technical and specialized. As a result of this level of sophistication, most of their customers or competitors are publicly funded agencies, difficult to compete against as a small firm.

f. The Oatrim fat substitute experienced challenges that were surmountable. First, it had to gain U.S. Food and Drug Administration approval but being a natural product, the process was not as lengthy as for some products. Secondly, like other new products, market impact was initially slow because consumers need to receive samples and become educated. Also, although the partnerships offered advantages to the companies entering into them, they also brought certain inherent management, cultural, and communication challenges.

g. When China Lake began to seriously transfer the light stick technology, neither the laboratory nor the industry partners had extensive licensing experience, so the licensing process took at least a year.

**User Benefits/Economic Impact/Outcomes**

a. For the laser-based method, Lachat Instruments intended to market a spinoff product for monitoring contamination in drinking water and wastewater. However, the company expected the prototype to be readier for the market and was not willing to put effort into developing it further, and the license is now dead. The other outside users are still using the technology for research purposes, not for commercial gain.

b. The outcome of the Air Force-funded voice coding technology at MIT was a spinoff company, Digital Voice Systems, Inc. (DVSI). DVSI sells an Improved Multi-Band Excitation or IMBE™ Speech Compression System. The available accompanying hardware is either an IMBE™ VC-20 or an IMBE™ VC-100 Voice Codec Module. The company has recently introduced a new Advanced Multi-Band Excitation AMBE® system implemented by an AMBE-
The 1000™ Coder. The AMBE coder hardware costs anywhere from $38 (or less) up to $99, depending upon the size of the order. (Orders for 100,000 or more units can be negotiated.) DVSI has averaged ten employees since its founding. Being a privately-held company, the principals are not willing to divulge sales revenues, but they add that the company has been doing well.

c. The commercial version of the FPL’s paper quality testing device was developed by Isthmus Engineering and Manufacturing Co-op, which averages $10 million in yearly sales and is known for the high-quality of its products and product servicing. Within eight months of the signing of the one-year CRADA, Isthmus delivered a commercial version of the testing device called a Vacuum Compression Apparatus. The company subsequently sold three additional machines, for a total of $415,000 in sales. The fourth machine is called a Thin Film Analyzer because it tests the effects of humidity and other conditions on the materials in computer circuits. As with most of Isthmus’ business, the latter machine sale was the result of its word-of-mouth referral rather than through marketing. In fact, it is this latter application that may open up new markets for the technology, because in the paper industry new technologies have supplanted the technology developed by the FPL that are less expensive, simpler, and easier to implement. The original technology is still being used by those doing specialty research and requiring more sophisticated approaches. At its inception as a leading-edge product, it created a market need for the testing technology.

d. Oak Ridge National Laboratory’s original partner on the microwave oven went out of business when its defense contracts were cut back. Subsequently, Lambda Technologies was spun out of a portion of the defunct business with only one product line and a smaller more focused group of employees. The new company acquired the mother company’s inventory, patents, and licenses, although the legal agreements needed to renegotiated with ORNL. The new company delivered a prototype to DOE under terms of its CRADA agreement and introduced its first product, the Vari-Wave, in 1996. The company is producing two to three units a month in response to orders, and it is anticipated this will possibly soon grow to thirty to fifty thousand orders. Initially, the product is appealing to university research laboratories, but is being marketed as a multi-functional oven that can also serve as an analytical or measurement tool. Three models are available with varying wattages, frequencies, and sizes, in addition to a single-function basic model with programmable options. The company is gearing up to respond to orders for specialized manufacturing equipment (such as for the gluing of athletic shoe soles). The company has almost twenty employees. By 2000, the company hopes to do $50 million a year or more in sales. The original carry-over CRADA has ended, and a new one has been signed.

e. Axis Instruments called its gravity meter an “FG5 Gravimeter.” In addition to its NIST contract to build the two NOAA gravity meters, Axis Instruments obtained contracts with another eight agencies overseas, building up to about $3 million in revenues and twenty employees. However, the company went out of business. Subsequently, the Axis chief scientist bought the rights to the gravity meter and the Axis inventory, agreeing to certain royalties, and
formed Micro-g Solutions. This new spinoff was conservative in its spending and managed to grow to seven or eight employees. Micro-g sold eight gravity meters by mid-1996 for approximately $2.4 million in sales. The company has a CRADA with NIST to continue development work and is in the process of developing a smaller instrument. Revenues for the new product are projected to be $10 million per year.

Between Axis and Micro-g, the government has recovered a total of about $1.8 in taxes from the two companies over five years. Another Axis principal, the company’s physicist, obtained rights to the Paris iodine laser and formed a separate spinoff company, Winters Electro-Optics, Inc., which now pays the BIPM royalty payments, and also has a two-year CRADA with NIST. Winters agreed to handle the former Axis laser warranties, and found it was easier to replace the old lasers with the new Parisien version which essentially amounted to the company’s start-up costs. Winters has sold roughly forty lasers representing $1.2 million in sales over three years, providing a little over $425,000 in gross revenues.

f. In the fat substitute case, ConAgra is a publicly traded company, but since the company is in a joint venture with another company to produce Oatrim, they need to get permission from their partner to release information specifically related to Oatrim production. However, some observations can be deduced. Since Oatrim is an ingredient in ConAgra companies’ Healthy Choice product line, a $1.2 billion brand overall for the parent company, it must be used extensively. Also, ConAgra’s annual report stated that its gross margin increased in 1996 due to margin improvements in, among others, specialty food ingredients which would include Oatrim. Specialty ingredients also contributed to the company’s pre-tax earnings increase. ConAgra’s Mountain Lake Partnership and ARS-Peoria formed a CRADA resulting in a new fat substitute called Z-Trim that combined oats, corn and soybeans. The patent application was filed in November 1995, and Dr. Inglett announced the new technology at a conference in August 1996. So, ConAgra as the CRADA partner, had first right of refusal to an exclusive license up until a year after patent filing, even though, ironically, the patent may not be issued within that year-long deadline. Without a patent or some indication from the Patent and Trademark Office that it is likely, it would not necessarily be in the company’s interests to risk negotiating a license without the intellectual property rights being firmly in hand.

The Rhone-Poulenc/Quaker™ partnership started mass-producing an improved food ingredient product called Beta-Trim in September 1996. Both of the contacts for this partnership indicated disappointment in their sales and business growth, noting that, although they are selling their product to fifty or sixty companies at this point, significant sales should translate into $10 to 100 million (which they have not reached) for companies of their sizes. However, say they have major technical changes in progress that they hope will soon result in some breakthroughs.

g. Largely as a result of acquiring the light stick technology from China Lake, and also as a result of acquiring American Cyanamid’s light stick business and license, Omniglow Corporation has grown from being a small start-up business with three employees and one product, to three hundred employees and over a hundred products. During recent regional
conflicts, Omniglow sold over fifteen million light stick units to DOD, amounting to at least $150 in annual product sales in this area. Although the military, law enforcement, and public safety agencies are still the company’s largest customer group, Omniglow also sells products made for a variety of other customers, including retail toy and novelty stores, a number of major amusement parks like Disneyland, both the commercial and recreational fishing industries, industrial safety users, and now the biomedical market. Overall, since the early 1990s, the company has produced over 250 million light sticks.

h. The FETC blood flow diagnostics case involved a CRADA established to help with FDA clinical testing of Baxter’s artificial heart, since earlier testing had indicated that blood clotting was a serious problem. It was quickly apparent that the application of FETC’s fuel flow analysis system to artificial hearts was successful. The FETC system for performing flow diagnostics ultimately contributed to redesign of the heart pump. It also helped with transplant operation techniques and patient management. After eighteen months of animal testing, the new design was approved for clinical trials in 1995 and reapproved for investigational testing again in 1996. Statistics on the number of patients implanted or supported over time by the artificial heart device have been steadily improving. In the meantime, Baxter Healthcare cannot realize revenues in the United States until the device has passed all the required regulatory hurdles and is available on the open market. The development stages for products that require FDA approval are costly. Profits are difficult to measure because of the tremendous development involved (costing “multiple millions of dollars”). Each heart pump costs about $80,000. The immediate success of the heart pump work caused the first CRADA to be amended early-on to include artificial lung applications. Testing for this application proceeded from animal testing to clinical trials in 1993, and the flow diagnostics have been successful.

International Activity

a. Other than some foreign exposure and contact with overseas laboratories, there are no international business arrangements on the laser-based method such as foreign patents.

b. In addition to federal, state, local and commercial standards competitions, the voice coding technology was entered into several international competitions for the inherently global satellite market. Again, the technology performed in a superior fashion to existing standards and resulted in its adoption as the new standard.

c. In the paper quality tester case, FPL had a cooperative research agreement with the Swedish Pulp and Paper Research Institute and, as a result of this relationship, jointly sponsored a technical conference with the institute that had previously not been an international conference.

d. For the variable-frequency microwave oven, at least two foreign patents have been filed in more than one application area.

e. Many of the gravity meters have been sold to overseas customers, some of it involving
a great deal of export-related government paperwork. However, the individuals involved pointed out that all of this has helped the United States’ balance of payments.

f. The USDA waived its right to file foreign patents on the Oatrim fat substitute so Dr. Inglett, himself, patented Oatrim outside of the United States. He subsequently granted ConAgra an exclusive worldwide license, and the Rhone-Poulenc/Quaker partnership negotiated a sub-license from ConAgra for fourteen countries. More recently, ConAgra dropped its license in eight countries so each company is now selling in six foreign countries.

g. Omniglow, which is selling the light stick technology, has overseas sales offices in Canada, England, and Japan. It sells military/law enforcement products in twenty-five other countries and novelty products in thirty other countries. The company also worked with the Japan Tuna Association to further develop, test, and market the technology for use in the fishing industry. Omniglow has joint venture manufacturing facilities under construction (or consideration) in China, Indonesia, and Eastern Europe.

h. The original user of FETC’s blood flow analysis technique, Baxter Healthcare, is now using its artificial heart device in Europe. Their widest use is in England, France, and Germany. In addition, most health care companies developing artificial organs now use FETC’s flow analysis technique, and each have set up facilities duplicating the original FETC facility at their laboratories in Europe, Australia, and Korea.

Government Gains

b. A manufacturing base and skill base is being established for the new voice coder which can provide DOD with commercially available equipment that is state of the art. Also, state and local government emergency management personnel are upgrading from analog to digital radios, which require a speech coder.

c. In the paper quality tester case, the U.S. Treasury Department’s Bureau of Engraving and Printing signed an interagency agreement with FPL to test its technology. Over time, the laboratory received over $600,000 from the Bureau. The Bureau also purchased one of the original machines from Isthmus Engineering.

d. In the microwave oven case, traveling microwave tubes, a technology developed for military use, was adapted for civilian use. The adapted variable-frequency microwave furnace is contributing to the larger economy.

e. In addition to the original two NOAA gravity meters, the U.S. military purchased two gravity meters. Furthermore, the absolute gravity meter makes it possible for a new mass standard for kilogram replacement to be adopted, so the NIST Gaithersburg office has already purchased a gravity meter in anticipation of this turn of events in the next few years. Development of a less expensive, less precise but still highly accurate absolute gravity measuring
device will allow broader audiences to appreciate a new level of accuracy in this area.

f. It was pointed out that the Oatrim fat substitute, being derived from a raw agricultural farm commodity and converted into a value-added product, has helped the United States’ balance of trade, which helps the government indirectly.

g. Although the chemiluminescent light sticks were originally developed for fairly specific military purposes (primarily marking bomb targets and secondarily identifying downed aircraft pilots), once they were put into use, they found additional applications. There was an entire spectrum of military uses for the light stick technology that became apparent serendipitously during combat situations. The additional uses mostly involved alternate lighting to flashlights and identification in enemy territories.

h. In the blood flow diagnostics case, the original FETC application is benefitting from the input of researchers in the medical field. Plus, the original application is being spread into other FETC research activities.

**Economic Development, Technical Assistance**

None of the companies highlighted in this grouping has made use of state, regional or local economic development or technical assistance services of any type.

**Elapsed Time**

a. Dr. Yeung began promoting his laser-based technology through outside contacts in late 1989. He worked with Northeastern University from 1990 to 1992. The patent was issued in 1991. At that time he began working with Lachat Instruments in hopes that this relationship would ultimately result in instrument production and sales.

b. The MIT work on the voice coding technology began in the early 1980s, with related scientific papers being published during the decade. Digital Voice Systems, Inc. was founded in 1988, although the technology was not really ready for full-scale production until the early 1990s. Certain important standards competitions announced their selection of this technology in 1992 and also in 1993 when the first patent was issued.

c. The FPL’s paper quality testing device was patented in 1982 and 1984. The laboratory solicited industry partners in 1988. CRADA and license agreements were signed in late 1990, and the CRADA was completed in early 1992. Cooperative research agreements were implemented from 1991 through 1993. The international conference was co-sponsored in 1994. Additional CRADA activity focused on different applications continued through 1995.

d. For the variable-frequency microwave oven, the patent application was filed in 1991. The initial CRADA and license with the original company were executed two months later in
early 1992. Jointly written scientific papers were published in 1992 and 1993. The original company closed its doors, and the spinoff company was started in 1994. Agreements between the laboratory and the new company were re-executed after that time.

e. In the gravity meter case, the NIST/JILA absolute gravity measurement research has been going on since the early 1960s. In the mid-1980s, the team began developing a portable device. In 1989, NOAA requested the two gravity meters which set in motion the procurement. NIST transferred the device in 1990. The first two instruments were delivered in 1992, then went through a six-month evaluation phase. So the technology development lasted a short eighteen months. Axis Instruments was in business from 1990 to 1993, at which time Micro-g and Winters Electro-Optics were spun off.

f. Dr. Inglett recognized the Oatrim fat substitute’s potential in 1988. The patent application was filed in 1990. He announced Oatrim at a conference in 1990 while the patent was still pending. He held the technology transfer conference at the laboratory later that year. The first license was signed even later the same year with ConAgra. Their first product reached the market a year later. Widespread product marketing began in 1991, while the pilot plant was being completed. So overall scale-up from bench-top to commercial production was accomplished in record time with the ConAgra venture. The time from bench-top to commercialization, eleven months, was exceptionally fast, a process that would normally take about two years. By the end of 1991, the technology was licensed to the two other companies. These last two licensees soon formed a partnership. Comments received on the Rhone-Poulenc/Quaker partnership time frame were not consistent, but this may be a matter of semantics regarding the phases of product development. The Quaker Oats representative said\(^5\) they were hoping for a one-year commercialization period. The Rhone-Poulenc representative said\(^6\) that their average time for a product going from “ground zero” to being a commercial success was five to seven years. In mid-1996, they had been “at it” for four years. They are still within their average six-year product time line, although somewhat behind.

g. The light stick technology was under development at China Lake for more than twenty-five years before it was transferred in 1989. More specifically, the first invention disclosure was filed in 1973 and patented shortly after that. A number of demonstrations of the technology began in the 1970s. The two patents currently in effect were issued in 1986 (about the time Omniglow was founded) and 1987, and efforts to formally transfer the technology began in 1988. The two licenses were signed in 1989. In 1990, Omniglow branched out to markets beyond the military market, both in the United States and abroad.

h. For the PETC blood flow analysis system, the early jointly authored scientific papers were published from 1989 to 1992. The original five-year CRADA was initiated in 1991. Since

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\(^5\)Interview with Mr. Babbitt, October 4, 1996.

\(^6\)Interview with Mr. Freeland, October 11, 1996.
this CRADA recently expired, it was followed up by a new CRADA to extend the analysis technique to identify cancer cells using fiber optics.
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