

NIST Report B

11/25/96

Accomplishments of the National Institute of Standards and Technology during the Clinton Administration's First Term

The Administration's decision to invest in the future through NIST has paid off handsomely. NIST has transformed itself from primarily a premier measurement laboratory to a full-fledged, technology support agency with four interwoven programs that work together to support the civilian technology innovation process from basic research to adoption of new processes by small manufacturers.

- Americans can look forward to exciting technological advances with large economic payoffs in the years ahead due to the Advanced Technology Program. The ATP has emerged from a pilot stage in 1993 to become a proven vehicle for private-public sector partnerships to develop high-risk technologies that promise broad-based economic growth in the years ahead. With just 60 projects underway at the beginning of the Clinton Administration's first term, NIST added another 220 cost-shared projects with companies of all sizes and consortia involving multiple firms, universities and others that rarely had cooperated previously. The \$2 billion combined industry and government investment since ATP's inception in 1990 has begun to produce promising technological advances.
 - a bioreactor that grows human bone marrow cells for cancer therapies,
 - new synthetic materials technologies that might revolutionize the auto industry,
 - a new method for microsoldering integrated circuits to improve productivity in the electronics industry and reduce the generation of hazardous industrial wastes,
 - more powerful healthcare information systems that cost less.

These are among the ATP success stories in the making. The power of the ATP to spark economic benefits is exemplified by an ATP project in automobile manufacturing, one of the first to reach completion. Eight small automobile technology suppliers joined together with Chrysler, General Motors, the University of Michigan, and Wayne State University to improve the fit and finish of auto bodies. The result is software and other computer tools to control and streamline the auto manufacturing process, new laser-based sensors to control the dimensions of auto body parts, and precision technologies to reduce tiny warps and bends on large sheet metal parts. Just as importantly, demonstrating how the workplace is changing, the industrial partners teamed with auto workers to develop training techniques to help them to quickly introduce the new tools and techniques into production lines -- which is where the technology now is. The ATP contributed less than \$5 million, matched by \$9 million from the joint venture. Auto plants that have put the technology into practice now have been able to meet the challenge of foreign competitors. When fully in place, the industry-government research project should lead to increased market share for U.S. automakers, large savings in production costs and in maintenance costs for consumers, increased economic output, and more jobs for Americans.

- Small- and medium-sized manufacturers around the country are gaining new insights, finding more efficient ways to produce their products, and retaining and adding new jobs because the Administration had the foresight to recognize the need for manufacturing extension services. Blossoming from just seven extension centers in 1993, the NIST-managed Manufacturing Extension Partnership is meeting its goal of establishing a truly nationwide network of technical and business assistance for smaller companies with extension centers now in all 50 states and Puerto Rico. More than 2800 manufacturing engineers and business experts -- none are federal employees -- are providing hands-on assistance from 300-plus locations from Alaska to Hawaii and Maine to Florida. Data from companies assisted by NIST extension centers clearly show improvements in productivity, quality control and competitiveness -- a trend that bodes well for the vitality of American entrepreneurship.

Locally operated extension services are helping to improve the performance of thousands of small and medium-sized U.S. manufacturers, from the California

company that is saving \$3 million annually and has hired 56 new employees, to the Chicago firm that saw a 30 percent increase in sales and a 20 percent growth in employment, to the Wisconsin company that was facing a 20 percent cut in its workforce that has turned around and now plans to expand by 10 percent over three years.

- Under the Clinton Administration, NIST's world-respected measurement laboratories have launched new initiatives in computers, communications, manufacturing, electronics, health care, construction and international standards. Realizing their first real increases in funding during the past 30 years, between 1993 and 1996 NIST has been able to begin addressing a growing backlog of measurement and standards needs and to clear a path for the technologies of tomorrow. Among its accomplishments:

establishing a new facility that makes it possible for the more than 10,000 U.S. mammography centers to trace the accuracy of their X-ray exposure measurements to national standards, reducing the risk that women undergoing breast exams will receive inappropriate levels of X-ray exposure.

launching a new collaboration with automakers, the U.S. Environmental Protection Agency, and the California Air Resources Board to develop advanced measurement technologies that will help U.S. automakers meet state and federal emissions standards.

enabling an increase of \$300-500 million in U.S. exports to Saudi Arabia due to NIST's work in resolving differences between U.S. and Saudi standards.

- Recognizing that quality management is the key to business excellence and top-notch performance, the Administration has been a firm supporter of the Malcolm Baldrige National Quality Award. Eleven new companies were selected to join the elite club of award winners during the Administration's first term -- serving as role models for American manufacturers and service firms ranging from "mom and pop" operations to Fortune 500 companies with huge global markets. The program -- which places a greater emphasis on educating and enabling companies to excel than it does on winning the award -- has inspired thousands of U.S. companies to improve their products and expand their markets through quality management. Since 1993, the NIST quality award program has strengthened its ties to a growing array of state and local quality operations that mirror Baldrige quality management guidelines -- growing from 24 programs in 1993 to 38 in 1996. In the process, NIST has established an emerging national quality network poised to better serve U.S. companies. NIST also has prepared the foundation for major quality improvements in healthcare and education by running pilot award programs in those sectors.

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ATP Impacts the Economy

1. Overview

The Advanced Technology Program (ATP) bridges the gap between the research lab and the marketplace, stimulating prosperity through innovation. Through partnerships with the private sector, ATP's early stage investment is accelerating the development of innovative technologies that promise significant commercial payoffs and widespread benefits for the nation. The ATP provides cost-share funding in the early stages of R&D when other funding sources think the research risks are too high. The ATP awards are made strictly on the basis of open, rigorous, peer-reviewed competitions. All industries and all fields of science and technology are eligible. Selection is based on the innovation, the technical risk, potential economic benefits to the nation and the strength of the commercialization plan of the project. Between its start in 1990 and FY 1999, the ATP funded 468 projects totaling about \$1.5B in Federal funding matched by about \$1.5B in private funds.

In sharing the relatively high development risks of technologies that potentially make feasible a broad range of new commercial opportunities, the ATP fosters projects with a high payoff for the nation as a whole – in addition to a direct return to the innovators. The clearly demonstrated benefits derived from the projects ATP has funded to date would not have been achieved in the same time period in the absence of the program. These benefits have contributed to the nation's resilient, sustainable, and competitive economy and could improve the health and quality of life of the nation's citizens. More specifically, projects funded by the ATP generate employment and tax revenue. ATP technologies also result in higher quality, longer-life products, which translate into real cost savings to consumers. In fact, the value of the projected benefits resulting from the ATP contribution in just three projects would greatly exceed total ATP costs to date.¹ Technologies developed under ATP projects have the potential to impact the lives of many Americans. For example, one project in digital mammography is likely to yield significant improvements in the procedure leading to earlier diagnosis of breast cancer. In addition, the ATP continues to shape the way companies do business. It catalyzed new industries, such as DNA diagnostics, and increased cooperation among industry, non-profits and universities at the early stages of R&D.

While there is no guarantee that the research funded by the ATP will lead to broad economic or even commercial success, it is still appropriate to ask, "What are some of the things the Nation has received for its \$1.5B in investment?" This document provides an answer to this question. This overview is followed by Section 2, which presents some of the contributions the ATP has made to the nation's sustained economic growth; Section 3, which describes some of the benefits that have the potential to impact the quality of health and life of our citizens; and, Section 4, which illustrates some of the ways the ATP has shaped the way companies do business.

2. Contributions to the Nation's Sustained Economic Growth

The ATP's projects have benefited the nation and have contributed to its sustained economic growth. They have also enhanced its international competitiveness and have improved the nation's productivity. The following examples illustrate these points:

2mm Project: Economy-wide impact due to improvements in automobile manufacturing

Quality improvement in automobiles resulting from this project has been projected to stimulate an estimated increase in total U.S. economic output of more than \$3 billion, as well as create thousands of new jobs. This project developed system and metrology tools to control the variation in automobile body components and has led to an estimated reduction in production costs by \$10-15 per car and maintenance costs by \$50-100 per car in production lines in which the technology is used and is expected to improve product quality, customer satisfaction, and U.S. market share. This project was

undertaken by a joint venture comprised of 11 partners and multiple subcontractors. In the absence of ATP, it is not likely that the joint venture performing this research would have been formed and these benefits would not have been possible. (Source: Advanced Technology Program Case Study: The Development of Advanced Technologies and Systems for Controlling Dimensional Variation in Automobile Body Manufacturing (Consad 1997))

Flow-Control Machining: Projected increases in GDP due to New Process Technologies

The Flow-Control Machining Project developed a finishing technique for automotive engines that allowed for higher efficiency engines that consume less fuel while emitting fewer pollutants. This technology is projected to increase GDP by \$142 million annually within five years after implementation, and to generate \$34 million of increased tax revenues--none of which would occur without the ATP project. Furthermore, in the absence of ATP funding, this project would not have occurred. (Source: Study of Flow-Control Machining Project (Ehlen 1999))

Digital Data Storage: Expected Return on Investment High

Total economic benefits of \$3.7 B are projected from pioneering advances in the use of optical tape for data storage for extremely high capacity systems and from advances in linear scanning recording technologies for lower-cost medium-high capacity systems. (Source: "Estimating Future Consumer Benefits from ATP-funded Innovation: The Case of Digital Data Storage," Austin and Macauley: Resources for the Future, 2000)

Engineering Animation: Developing Training Tools for Surgeons and Patients

Engineering Animation, Inc. (EAI), with ATP support, developed computer software that can create 3D images of the human body, its various parts, their motion, tissues, and organs in realistic fashion. The technology is already being applied in diverse applications ranging from training tools for surgeons and medical students, to "real time" data analysis that will support less invasive and less costly surgeries as well as quicker patient recovery. The technologies developed under the ATP project have also contributed to the firm's rapid growth from 20 employees at the start of the ATP project to 957 in 1999. (Source: Update of First 38 Status Reports)

Illinois Superconductor: Using High-Temperature Superconductivity to Improve Cellular Phone Transmission

Using the new HTS RF filter developed by Illinois Superconductor Corporation as part of an ATP award, it is possible to extend the range of base stations of the cellular network, reducing the number of stations needed and decreasing the costs of supplying cellular phone service. Of particular interest to network carriers is the system's ability to lower the noise floor resulting in less interference and a greater capacity to increase both the quantity and quality of the signals. Cellular phone users receive clearer signals and suffer fewer dropped calls as their signals move from one base station to the next site. This new filter can expand the range of existing base station sites by 25 percent and can lead to a 40 percent decrease in the number of sites required to cover a given area. ISC currently has over 350 systems deployed throughout the United States and is an active participant in the global development of 3G systems where their HTS front end systems will be an enabling factor. (Source: Update of First 38 Status Reports)

Sage: Electrochromic Materials for Smart Windows Leading to Significant Reductions in Heating and Cooling Costs

SAGE Electronics used an ATP award to produce a prototype smart window that enables a 20-30% reduction in heating and cooling costs compared with high-end commercial glass. This electrochromatic window can be electronically switched to control the flow of solar light and heat in response to outside conditions in accordance with user preferences for heat and sunlight. (Source: Forthcoming Status

Report)

3. Contributions leading to improvements in the Health of the Nation's Citizens

ATP projects will lead to improvements in health and quality of life. These improvements include making healthcare diagnostic and therapeutic tools more accurate and more affordable. They will also include making medicine more accessible to rural populations.

Tissue Engineering: Portfolio-wide Impacts Potentially Enormous

The potential benefits from this suite of 7 tissue engineering projects are enormous based on the results of a detailed economic study. Projected net present value of benefits attributed to ATP's investment range from \$47 M to \$17,750 M across the projects, with a median value of \$947 M. Projected rates of return on the ATP investment ranged from 21% to 148%, with a median value of 111%. The technologies investigated by this report cover a variety of tissue engineering projects ranging from a cell production system for stem cell therapy to a new synthetic biopolymer for use in biomedical implants to a unigraft organ from transgenic pigs for more effective, readily-available organ transplants. (Source: "A Framework for Estimating the National Economic Benefits of ATP Funding of Medical Technologies: Preliminary Applications to Tissue Engineering Projects Funded from 1990-1996 – Seven Case Studies" (Research Triangle Institute, 1999)).

Digital Mammography: Making healthcare more affordable and more accurate

Significantly reducing the manufacturing costs will help make the world's first all-digital mammography system affordable for routine use in mammograms and opening opportunities for other, more cost-sensitive medical imaging applications. This technology holds the promise of dramatically improving patient outcomes through early and better detection and diagnosis while delivering substantial operating efficiencies to physicians and hospitals. The new system, the GE Senographe 2000D, was recently approved for clinical use by the FDA and has been installed at 8 U.S. sites. Much wider adoption is expected in the future. The new x-ray detection technology represents a significant technological advance in breast cancer detection giving the radiologist a selection of digital image-enhancement tools. It also provides better digital breast images than conventional film-based mammography in less than half the time. (Project Sponsor: General Electric Medical Systems; Source: Project management team and General Electric)

Telemedicine: Making healthcare faster and more accessible

ATP funded technology has reduced the amount of time it takes to transmit and interpret a radiology report in one part of rural West Virginia from 10 hours to within 15 minutes of an exam. The Charleston Area Medical Center, a major healthcare provider in Southern West Virginia, has used the results of an ATP project to establish a teleradiology network that provides rural patients access to a board certified radiologist 24 hours a day, seven days a week. In turn, this technology allows sick and elderly patients to stay close to their homes during treatment and greatly reduces the number of transfers and repeat exams required. Based on this project's initial success, there is potential for widespread commercialization of this technology in other rural areas. (Project Sponsor: Advanced Technology Institute; Source: Project management team and Advanced Technology Institute)

ATP-funded technologies will result in greater accuracy in medical procedures and impact physician training.

With ATP-funded technology, it is possible for a doctor to train for operating room decisions under real-life conditions, and even to make mistakes, without putting the patient at risk. One ATP project developed a new, interactive "virtual reality" (VR) simulator of medical procedures on relatively low-cost computers. The software allows the user to feel as though he is actually performing those

procedures on a live patient. This technology is the first, real-time interactive simulation that incorporated a realistic "touch and feel" experience. It has the potential to impact physician training on a wider scale. In addition, with this technology, it is possible to incorporate patient-specific data and practice different scenarios within the computer model. (Project Sponsor: HT Medical; Source: Project management team and HT Medical)

Astrom Biosciences, Inc.: Large Potential Benefits from Developing a Patient-Friendly Approach to Human Cell Transplantation

Astrom Biosciences, Inc. has been a leader in the development of new stem cell expansion and therapy. It has successfully developed a first-of-its kind clinical system designed for the production of clinically useful quantities of cells for a broad range of cellular therapies. Patients are expected to gain a less invasive procedure that is cost effective, provides greater procedural flexibility and offers tumor purging benefits. Furthermore, if the Astrom technology substantially expands the flexibility of cell transplantation, others who could not have afforded or had access to the treatment will now be able to and will benefit. The benefit may well be life itself, since stem cell transplantation from bone marrow and blood for cancer patients is frequently a life-saving therapy (Source: Forthcoming Status Report Update)

Molecular Simulations: Providing Benefits to Companies and Consumers by Using Mathematics to Find New Drugs

Molecular Simulations, Inc (MSI) has developed software to help deliver products faster and cheaper for a broad customer base. Firms in the chemical, petrochemical, pharmaceutical, biotechnology industries as well as research universities and scientific institutions are using MSI's software. Furthermore, downstream benefits also accrue to those who have access to new therapeutic drugs sooner and at lower cost. (Source: Update of First 38 Status Reports)

Integra LifeSciences Corporation: A New Bioabsorbable Polymer Suited for Use in Medical Implants

Integra LifeSciences Corporation developed a bioabsorbable polymer derived from tyrosine, a naturally occurring amino acid, that releases acidic byproducts at significantly lower concentrations than existing, FDA-approved bioabsorbable polymers. In its ATP project, Integra designed and developed a scalable manufacturing process of producing the tyrosine-based polymer with a high purity level, filed a patent, and began testing to see how well the material interacted with living cells. The new polymer does not adversely affect tissue or bone or emit toxic substances when it degrades and it appears to have resorption rates similar to existing FDA-approved polymers. With its mechanical properties, it can be used in a number of orthopedic devices, including weight bearing devices such as large surgical screws. It could provide significant advantages over existing orthopedic care. For example, the orthopedic implants that may result from this project could obviate the need for a second surgical procedure to remove hardware, and they allow for a gradual transference of loading to the healing bone, thereby eliminating a major medical problem known as stress shielding. Use of this technology in other medical procedures is likely to prevent some types of degenerative arthritic diseases. (Source: Forthcoming Status Report)

4. Changing the way companies do business

ATP has catalyzed new industries

ATP invested in technologies in industries while they were still in their infancy and when venture capital money was scarce. As a result, the ATP has provided innovative solutions to some of the nation's pressing problems, provided a "halo" effect and has changed the way companies do business.

ATP played a pivotal role in business-to-business (B2B) commerce without

displacing private capital

Vitria Technologies, a 1996 and 1997 ATP awardee, is an international leader in business-to-business automation. As early as 1994, long-before the internet became commonplace, Vitria was looking past the Web as a publishing tool and saw the B2B possibilities. According to the company's founder and Chief Technology Officer, "When we said, 'we don't have the technology yet, but we think the market will be there and we can have a product,' it didn't fly with venture capitalists." On the other hand, ATP recognized the potential this technology could have on the economy and had the foresight to invest in it in 1996. Presently, Vitria generates more than \$100 million per year in revenue and in 1999, launched the 11th most successful initial public offering in terms of return on investment. In the absence of an ATP award, the results would not have been the same. According to its founder, the company would be different, or not exist at all, if it did not receive an ATP award.²

"ATP is a 'godfather' of the fledgling US biochip industry."³

Biochip devices are suitable for use in hospitals, clinics or doctors' offices, to provide rapid, accurate diagnosis of a wide variety of diseases. Innovations made by ATP awardees have shaped the industry.

- A hand-held integrated nucleic-acid sample preparation cartridge, which is now in testing, was produced by Affymetrix (Santa Clara, CA) and Molecular Dynamics (Sunnyvale, CA).
- A "DNA chip" system that can quickly, reliably, simply and cheaply screen a single biological sample for many hundreds of normal and/or abnormal genetic features was produced by Vysis (Downers Grove, IL). Much of the firm's current and future technology can be traced back to ATP funding.

ATP helped transform healthcare informatics

The Information Infrastructure for Healthcare (IIH) focused program was a timely effort on the part of the ATP to address a sector of the economy comprising approximately 14% of the GDP. The healthcare industry was slow to adopt the information technologies which many other sectors had already used to increase efficiencies as well as productivity. The healthcare sector was plagued with cost increases exceeding the rate of inflation for over a decade with no visible end in sight while at the same time coming under increased scrutiny for the quality of care delivered.

Improved information systems are widely recognized as an important solution to the problem of medical error and may decrease the number of deaths and injuries in the healthcare system. The ATP has funded integrated patient record information systems that can help prevent accidental death or injury from a patient's receiving incompatible drugs. In addition, it has also participated in the development of "expert systems" that incorporate best-practice clinical guidelines that can help physicians in deciding on courses of treatment. Deaths and injuries in the healthcare system due to human error, incompatible information, or employing sub-optimal practices may be reduced by ATP-funded technologies in healthcare informatics. Potential for widespread impact include:

Knowledge-based Structure: Reducing Omission Errors and Offering Cost Savings

- A new software module created under an ATP award is now being used in electronic patient charts and has reduced errors of omission from as much as 60 to 1 percent in some cases. This translates into reduction in the loss of life and tremendous cost savings; for example, the Veterans Administration alone could realize savings of several hundred million dollars for each medical region by avoiding transcription costs and the need to hire certified staff for billing coding. This new software module is already in use at some 300 U.S. sites by an estimated 5,000 doctors. The underlying technology also could have applications in fields such as law and business. (*Project Sponsor: Vital Works; Source: Project management team and Vital Works*)

Intelligent Systems: Improving Decisions and Reducing Costs

- Improved clinical decision making and reduction of administrative costs at Connecticut-area hospitals will result from an ATP project that enables healthcare practitioners and researchers to evaluate drug therapies based on past clinical experiences at hospitals and healthcare facilities. These systems will also be used to reduce the onset and degree of costly medical problems. *(Project Sponsor: CHIME-Inc; Source: Project management team and CHIME-Inc.)*

Real-time decision-support systems: Fewer Deviations from Clinical Guidelines and Protocols

- ATP-funded technology will reduce healthcare providers' deviations from prescribed clinical guidelines and protocols. By creating a computing infrastructure for real-time decision-support systems, these systems are expected to lead to an annual savings of hundreds of millions of dollars through improved compliance with guidelines, improved data collection, and increased provider knowledge. *(Project Sponsor: Vital Works; Source: Project management team and Vital Works)*

The ATP IIR focused program also acted as a catalyst in establishing collaborations among stakeholders and providing the opportunity to pursue cross-disciplinary projects, with participation from healthcare providers as well as computer scientists and information technology specialists. These efforts have led to a reduction in the likelihood of closed systems and have increased industry entry opportunities for small to medium-sized companies. For the end user, this program has accelerated the development of technologies that have improved medical care while lowering costs.

ATP has encouraged industry-wide partnerships cutting across technology areas

Since 1990, the ATP has created an environment where firms can solve industry-wide problems. These are the types of problems that an individual company would neither be willing nor able to tackle on its own; and in the absence of ATP, there would not be a solution. In addition, the environment created by the ATP provides an atmosphere where small, highly-mobile firms could thrive and provide innovative solutions to pressing problems.

- In 1991, the Council on Competitiveness characterized the Printed Wiring Board industry as "losing badly or lost," meaning that the U.S. was not likely to have a presence within five years. As a mature industry, it attracted little private venture funding and only a handful of the 700 firms in the industry had the capability to undertake advanced research. The Joint Venture that was catalyzed under the ATP would not have been otherwise formed. The estimated research cost savings from this project exceed \$35 million. Furthermore, the project has been credited with saving the U.S. printed wiring board industry and its 200,000 jobs. Due to the lack of private incentives for forming the joint venture, these benefits would not have occurred by the private sector acting alone.

Appendix 1: More Details from ATP Status Reports

Impact of ATP Funding on Conducting Projects: Results from the First Set of Completed Projects

In the absence of ATP funding, firms report that the project would either have been undertaken at a slower pace or not at all.

Would Have Proceeded Without ATP Funding	Number of Projects	Percentage
No	21	66%
Yes, But at a Slower Pace, with Delay of:	11	34%
18 months	4	
21 months	3	
24 months	3	
60 months	1	
Total	32	100%

More Details on the Cases

Aastrom Biosciences, Inc.: Large Potential Benefits from Developing a Patient-Friendly Approach to Human Cell Transplantation

Aastrom Biosciences, Inc., which was an ATP awardee from 7/1/92 until 6/30/94, has been a leader in the development of new stem cell expansion and therapy. It has successfully developed a first-of-its kind clinical system designed for the production of clinically useful quantities of cells for a broad range of cellular therapies. The AastromReplicell™ System — the focus of the ATP project — consists of a multiuse instrument platform to be sold to clinical care institutions, and a growing line of single-use therapy kits sold for each patient treatment. The company, which already holds 21 patents related to the AastromReplicell™ System, expects to continue rounding out its patent base. The AastromReplicell™ System is designed to place patient specific cell production capability directly into patient treatment centers and to enable physicians to access cells for therapy as they do with traditional pharmaceuticals.

Aastrom has now entered the production stage of manufacturing and has received CE Mark approval to begin sales in Europe. One of its applications in a pivotal trial is in stem cell transplantation for treatment of cancer patients undergoing high dose chemotherapy and radiation therapy. Another clinical study uses AastromReplicell™ System produced cord blood to restore normal blood and immune systems in leukemia patients. The company hopes to move into commercial production in one to three years, depending on FDA approval.

As new emerging cell therapies are developed by other researchers to treat cancer, infectious diseases, autoimmune diseases, and to restore solid tissues, the company expects to collaborate with them in developing further cell expansion therapies; the AastromReplicell™ System is designed to facilitate implementation of these procedures as new therapies. The AastromReplicell™ System instrumentation platform will leverage a growing family of products. This is a particularly exciting time for the company as the technology platform is ready for partnering with new disease areas. Aastrom plans to initiate feasibility studies for its osteoporosis therapy with the first patients enrolled in the fall of 2000. Furthermore, there has been a significant amount of attention paid to dendritic cell therapy in cancer and Aastrom is actively developing a dendritic cell therapy kit for the AastromReplicell™ System, that is designed to address key market needs in this exciting new medical treatment. Aastrom is positioning itself for what may prove to be one of the most important advances in cancer treatment by using the patient's own immune system to treat cancer. (Source: Update of Status Report)

Engineering Animation: Outstanding Commercial Performance by Developing Training Tools for Surgeons and Patients

EAI with ATP support, developed computer software that can create 3D images of the human body, its various parts, their motion, tissues, and organs in a realistic fashion. The company developed large databases with detailed digitized images of a generic human body and the associated technologies for storing and retrieving the information. EAI researchers organized and integrated the digitized images and developed the software that presents the images as animated visualizations of human anatomy.

Initial commercialization of the ATP supported technology resulted in the Virtual Human, software for use in medical training, as well as three related CD-ROMs, the Dissectable Human™, the Dynamic Human™, and the CardioViewer 3DTM. Engineering Animation, Inc. (EAI) has grown rapidly from 20 at the start of the ATP project to 957 in 1999. It had a successful IPO in 1996 raising \$30.5M. The company has received a number of awards for use in the field of medicine, including Computerworld's Smithsonian Award. The company reports, "the (ATP) award was a major event that launched us into this growth phase...the cost sharing enabled us to assemble technology." (Source: Status Report Update)

Illinois Superconductor: Using High-Temperature Superconductivity to Improve Cellular Phone Transmission

As an ATP participant, Illinois Superconductor Corporation developed and demonstrated high temperature, superconducting thick film materials for equipment used in reception/transmission stations of cellular phone and other communications systems. Their HTS radio frequency (RF) spectrum filters improve the quality of signal transmission, including improvements in range, receiver sensitivity, and frequency stability, compared with conventional filters. Of particular interest to network carriers, is the system's ability to lower the noise floor resulting in less interference and a greater capacity to increase both the quantity and quality of the signals. These improvements extend the range of base stations of the cellular network, reducing the number of stations needed and decreasing the costs of supplying cellular phone service. Cellular phone users receive clearer signals and suffer fewer dropped calls as their signals move from one base station to the next site. Using the new HTS RF filter can expand the range and capacity of existing base station sites by 25 percent and can lead to the a 40 percent decrease in the number of sites required to cover a given area.

ISC successfully incorporated the ATP supported technology in its preselector receive filter, the SpectrumMaster, which it started selling in 1996 to companies operating cellular phone systems. In 1997, ISC launched RangeMaster, which incorporates the SpectrumMaster and a cryogenically cooled low-noise amplifier. By September 1997, ISC had installed the SpectrumMaster or RangeMaster in 22 base stations in 12 cities and had successfully completed 16 field trials in 10 cities. ISC's Powermaster, Rangemaster, and SpectrumMaster product families support domestic and international frequencies. The ATP award enabled ISC to accelerate its R&D in the early stages, to survive as a company, and to increase its credibility with investors, thus helping the company to raise private capital during its initial public stock offering in 1993. ISC currently has over 350 systems deployed throughout the United States and is an active participant in the global development of 3G systems where their HTS front end systems will be an enabling factor. (Source: Status Report Update)

Integra LifeSciences: A New Bioabsorbable Polymer Suited for Use in Medical Implants

For two decades, scientists have attempted to reengineer bioabsorbable polymers used in orthopedic implants to solve inflammation and other problems caused by their release of harmful acids and other toxins. Integra approached ATP for funds to develop a bioabsorbable polymer derived from tyrosine, a naturally occurring amino acid that releases any acids or toxins at significantly lower rates than existing, FDA-approved bioabsorbable polymers.

Integra designed and developed a scaleable manufacturing process of producing the tyrosine-based polymer with a high purity level, filed a patent, and began testing to see how well the material interacted with living cells. The results confirmed that the new polymer does not adversely affect tissue or bone or emit toxic substances when it degrades and that it appears to have resorption rates similar to existing FDA-approved polymers. It also has mechanical properties indicating that it can be used in a number of orthopedic devices, including weight bearing devices such as large surgical screws.

Integra has formed alliances with two device manufacturers, one for surgical screws, plates, pins, and other musculoskeletal surgical applications, another for smaller screws, tacks, and other arthroscopic fixation devices for attaching soft tissue to bone in the knee and shoulder. The partners forecast their

first commercial products will be launched in 2001. (Source: Status Report Update)

Molecular Simulations: Providing Benefits to Companies and Consumers by Using Mathematics to Find New Drugs

Companies from a wide variety of industries are using the Molecular Simulations, Inc (MSI) software that incorporates the ATP-funded technology to deliver products to market faster and cheaper. These include firms in the chemical, petrochemical, pharmaceutical, and biotechnology industries as well as research universities and scientific institutions, among others. In addition, downstream benefits also accrue to people who use the therapeutic drugs and other products made by the companies using the technology. MSI continues to carry newer generations of the software tools incorporating the ATP supported technology in its product portfolio, serving its broad customer base, including most of the world's major chemical companies.

With ATP support, MSI developed software tools that simulate molecular structures and reactions more efficiently than the conventional molecule-design techniques of 1995. The ATP funded effort employed density functional theory, a quantum mechanics method, and combined applied mathematics and computer programming to simulate the behavior and properties of molecules.

MSI incorporated the ATP supported technology in several of its software tools, including Turbomole, software that generates a 3-D structure of the molecule, and DMol, a quantum chemistry program that enables users to make reliable, quantitative predictions about molecular systems. Because the MSI software is relatively low cost, enters the discovery and development cycle close to its start, and is used by research and development personnel in universities, large firms, and research institutions, the benefits to the users of the software tend to be large relative to what MSI earns in software license fees.

MSI's product portfolio now includes DMol³, considered by MSI to be part of its core quantum mechanics capability and widely accepted as a classic code by the scientific community, and the recently released (May 2000) Cerius² Version 4.2 which incorporates the DMol³ code in the latest version of MSI's major molecular modeling environment. In 1998, MSI was acquired by Pharmacopeia and now generates about 2/3 of Pharmacopeia's annual revenues. (Source: Status Report Update)

Sage: Electrochromic Materials for Smart Windows Leading to Significant Reductions in Heating and Cooling Costs.

SAGE Electronics used an ATP award to produce a prototype smart window that enables a 20-30% reduction in heating and cooling costs compared with high-end commercial glass. This electrochromatic window can be electronically switched to control the flow of solar light and heat in response to outside conditions in accordance with user preferences for heat and sunlight. In 1998, SAGE formed a partnership with VIRACON and a sister company, VIRATEC® Thin Films, Inc., wholly-owned subsidiaries of Apogee Enterprises, which is headquartered in Minneapolis-St. Paul, Minnesota. For SAGE, this partnership provided the opportunity to team up with VIRACON, a producer of high-performance architectural glass for commercial buildings with a world-wide reputation and marketing expertise, and to tap VIRATEC's technical expertise in the manufacturing processes that are critical to scaling up the production of SAGEGLASS®, greatly enhancing the chances for commercial success. The next step in the development of SAGE's business involves the scale-up of production and the marketing of the technology to architects and the commercial building and construction industry. SAGE expects to have its product available for beta testing and demonstration projects in 2001. (Source: Forthcoming Status Report)

NOTE 1: Performance of Completed Projects, Status Report Number 1, NIST Special Publication 950-1, March 1999, William F. Long, p18.

NOTE 2: Interactive Week, Volume 7, No. 33, August 21, 2000, p52.

NOTE 3: Nature Biotechnology, Volume 16, December 1998, p1306.

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U.S. DEPARTMENT OF COMMERCE
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Strengthening the Commerce Department's Advanced Technology Program: An Action Plan

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