United States General Accounting Office

GAO

Report to Congressional Requesters

April 2000

# ADVANCED TECHNOLOGY PROGRAM

# Inherent Factors in Selection Process Could Limit Identification of Similar Research



GAO/RCED-00-114

# Contents



**Abbreviations**

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| ATP | Advanced Technology Program |
| CIC | Communication Intelligence Corporation |
| GAO | General Accounting Office |
| MIT | Massachusetts Institute of Technology |
| NIST | National Institute of Standards and Technology |
| PTO | U.S. Patent and Trademark Office |
| SEB | Source Evaluation Board |
| TE | Tissue Engineering |
| WDM | wavelength division multiplexing |

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**United States General Accounting Office**
**Washington, D.C. 20548**

**Resources, Community, and**
**Economic Development Division**

B-283784

April 24, 2000

The Honorable F. James Sensenbrenner
Chairman
Committee on Science
The Honorable John R. Kasich
Chairman
Committee on the Budget
House of Representatives

The Advanced Technology Program (ATP), administered by the National Institute of Standards and Technology (NIST), was established to support research that accelerates the development of high-risk technologies, with the potential for broad-based economic benefits for the nation. The Omnibus Trade and Competitiveness Act of 1988 (P.L.100-418), which established ATP, states that ATP program administrators should ensure that they are not funding existing or planned research that would be conducted in the same time period in the absence of ATP financial assistance. ATP is a competitive cost-sharing program that since 1990 has funded 468 projects at a cost of about $1.5 billion in federal matching funds. As of December 1999, 236 projects had been completed.

Research can provide both private benefits, which accrue to the owners of the research results, and social benefits, which accrue to society as a whole. In some instances, the private sector does not fund research that would be beneficial to society because doing so might not provide an adequate return on firms' investments. In other words, the market is unable to fund certain types of research either at all or at the most desirable or optimal level, resulting in what is commonly referred to as "market failure." To address this situation, the federal government, through tax credits or direct public funding, supports research that has very broad social benefits, such as basic research and research focused on developing technologies in areas such as public health and nutrition, energy conservation, and environmental protection. However, there is a continuing debate over whether the private sector has sufficient incentives to undertake research on high-risk, high-payoff emerging and enabling technologies without government support, such as ATP.

Because of your concern that ATP may have funded research that was similar to research already being funded by the private sector, you asked us

to review the NIST ATP document entitled Performance of Completed Projects, Status Report Number 1, dated March 1999, which provided the status of the first 38 completed projects. As agreed with your offices, we determined (1) whether, in the past, ATP had funded projects with research goals that were similar to projects funded by the private sector and (2) if such cases were identified, whether ATP's current award selection process ensures that such research would not be funded in the future. To determine whether ATP has funded projects similar to private sector projects, we chose 3 of the 38 completed projects, each representing a different technology sector—biotechnology; electronics; and information, computers, and communications. These three technology sectors represent 26 of the 38 completed ATP projects, or 68 percent. We analyzed the ATP project files and held discussions with industry and academic experts, technical reviewers, and award recipients to assist in our examination of these projects. We also conducted patent searches on the technical areas associated with each of the three projects. Our objective was not to provide an evaluation of the quality of the research funded by ATP or the private sector nor the impact these projects may or may not have had on their respective industries. To address the second objective, we reviewed ATP's current award selection process. We did not review the overall management of the program. (See app. I for a detailed discussion of our scope and methodology.) We performed our work from October 1999 through April 2000 in accordance with generally accepted government auditing standards.

## Results in Brief

The three completed ATP-funded projects, which were approved for funding in 1990 and 1992, addressed similar research goals to those already funded by the private sector. The projects included an on-line handwriting recognition system, a system to increase the capacity of existing fiber optic cables for the telecommunications industry, and a process for turning collagen into fibers for human prostheses use. In the case of the handwriting recognition project, ATP provided $1.2 million to develop a system to recognize cursive handwriting for pen-based (i.e., without a keyboard) computer input. We identified several private firms that were conducting similar research on handwriting recognition at approximately the same time the ATP project was funded. In fact, this line of research began in the late 1950s. In addition, we identified multiple patents, as early as 5 years prior to the start of the ATP project, in the field of handwriting recognition. We found similar results in the other two projects.

Two inherent factors in ATP's current award selection process—the need to guard against conflicts of interest and the need to protect proprietary information—make it unlikely that ATP can avoid funding research already being pursued by the private sector in the same time period. These factors, which have not changed since 1990, make it difficult for ATP project reviewers to identify similar efforts in the private sector. For example, to guard against conflicts of interest, the program uses technical experts who are not directly involved with the proposed research. Their acquaintance with on-going research is further limited by the private sector's practice of not disclosing its research efforts or results so as to guard proprietary information. As a result, it may not be possible for the program to ensure that it is consistently not funding existing or planned research that would be conducted in the same time period in the absence of ATP financial assistance.

## Background

ATP, which began in fiscal year 1990, was initiated to fund high-risk research and development (R&D) projects with broad commercial and societal benefits that would not be undertaken by a single company or group of companies, either because the risk was too high or because the economic benefits of success would not accrue to the investors. ATP is viewed as a mechanism for fostering investment in areas in which social returns would exceed private returns. ATP has addressed other opportunities to achieve broader social goals such as small business participation, as well as the establishment of joint ventures—for high-risk technologies that would be difficult for any one company to justify, because, for example, the benefits spread across the industry as a whole. Thus, ATP is seen by some as a means of addressing market failure in research areas that would otherwise not be funded, thereby facilitating the economic growth that comes from the commercialization and use of new technologies in the private sector. Advocates of the program believe that the government should serve as a catalyst for companies to cooperate and undertake important new work that would not have been possible in the same time period without federal participation. Critics of the program view ATP as industrial policy, or the means by which government rather than the marketplace picks winners and losers.

ATP's cooperative agreements are made through announced annual competitions. The ATP provides multiyear funding to single companies and to industry-led joint ventures. The proposal review and selection process is a multistep process based on NIST regulations. In general, these steps include: a preliminary screening, technical and business reviews,

semifinalist identification, oral reviews, ranking, and final selection. At the beginning of each round of ATP competitions, NIST establishes Source Evaluation Boards (SEBs) to ensure that all proposals receive careful consideration. Each SEB is comprised of NIST technical experts as well as outside specialists with backgrounds in business and economics. ATP supplements the SEBs with outside technical reviewers, generally federal government experts in the specific industry of the proposal. Independent business experts are also hired on a consulting basis, including high-tech venture capitalists, people who teach strategic business planning, retired corporate executives from large and small high-tech businesses, as well as economists and business development specialists. All SEB members and outside reviewers must sign nondisclosure statements, agree to protect proprietary information, and certify that they have no conflicts of interest.

As part of the proposal evaluation process, ATP uses the external reviewers to assess the technical and business merit of the proposed research. Each proposal is sponsored by both technical and business SEB members, whose roles include identifying reviewers, summarizing evaluative comments, and making recommendations to the SEB. The SEB evaluates the proposals, selects the semifinalists, conducts oral interviews with semifinalists, and ranks the semifinalists. A source selecting official makes the final award decisions based on the ranked list of proposals from the SEB.

The three projects that we reviewed received funding through the ATP competitions announced in 1990 and 1992. In those years, the selection criteria included: scientific and technical merit, potential broad-based benefits, technology transfer benefits, the proposing organization's commitment level and organizational structure, and the qualifications and experience of the proposing organization's staff. Each of the five selection criteria was weighted at 20 percent. Today, these same selection criteria are used but are grouped into two categories, each weighted 50 percent. The "Scientific and Technical Merit," category addresses a variety of issues related to the technical plan and the relevant experience of the proposing organization. The second category, "Potential for Broad-Based Economic Benefits," addresses the means to achieving an economic benefit, commercialization plans, as well as issues related to the proposer's level of commitment, organizational structure, and management plan. Technical and business reviewers complete documentation called technical and business evaluation worksheets addressing various aspects of these criteria.

## Three ATP Projects Addressed Similar Research Goals to Projects in the Private Sector

The three completed projects that we reviewed addressed research goals that were similar to goals that the private sector was addressing at about the same time. The three projects were funded in the early 1990s, and our efforts to locate similar research involved identifying, retrospectively, research that we now know was going on at that time. Each of the three projects was from a different sector of technology—computers, electronics, and biotechnology. The projects include (1) an on-line handwriting recognition system for computer input, (2) a system to increase the capacity of existing fiber optic cables for the telecommunications industry, and (3) a process for turning collagen into fibers for human prostheses use. (Apps. II through IV describe each of the ATP projects and the private sector research projects whose goals were similar to the ATP-funded projects.)

### ATP Project on Handwriting Recognition

Both the ATP project and several private sector projects had a similar research goal of developing an on-line system to recognize natural or cursive handwritten data without the use of a keyboard. This technology would make computers more useful where keyboard use is limited by physical problems or in situations where using a keyboard is not practical. On-line handwriting recognition means that the system recognizes handwritten data while the user writes. The primary technical problem in handwriting recognition is that writing styles vary greatly from person to person depending upon whether the user is in a hurry, fatigued, or a variety of other factors. While the technology for obtaining recognition of constrained careful writing or block print writing was commercially available, systems for cursive writing recognition were not commercially available because of the greater handwriting variability that was encountered.

The ATP project we reviewed sought to develop an on-line natural handwriting recognition system that was user-independent and able to translate natural or cursive handwriting. Communication Intelligence Corporation (CIC) was the award recipient. CIC used its ATP funding of $1.2 million from 1991 to 1993 to build its own algorithms [1] and models for developing its handwriting recognition system. During the project, CIC created a database that includes thousands of cursive handwriting samples

[1]Algorithm here refers to the mathematical procedures involved in recognizing writing as it is being written on a computer device.

and developed new recognition algorithms. Some of this technology has been incorporated into a registered software product that has the ability to recognize cursive writing in limited circumstances.

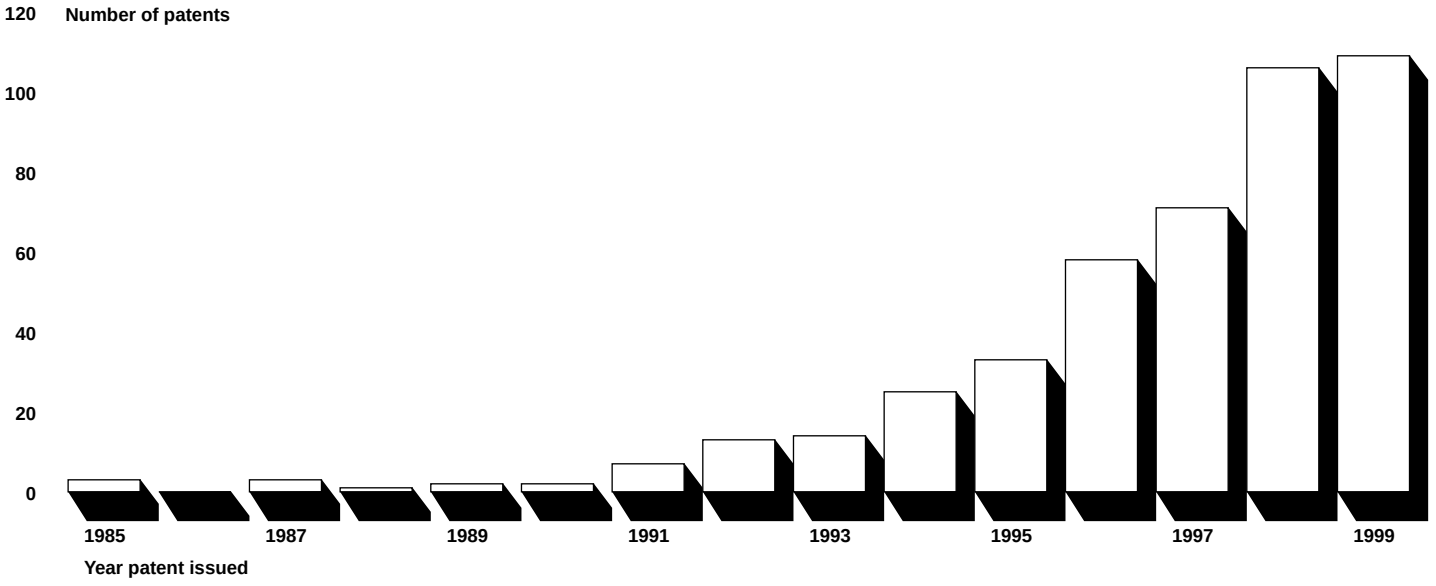
According to the experts we interviewed, as well as literature and patent searches, several companies were attempting to achieve a similar goal of handwriting recognition through their research around the same time that the ATP project received funding. Some of the key players in the private sector conducting research on cursive handwriting recognition included Paragraph International (in collaboration with Apple Computer) and Lexicus (which later became a division of Motorola). For example, Apple licensed a cursive handwriting recognition system from a Soviet company, Paragraph International, according to articles published in computer magazines in October 1991. According to these sources, this technology provided Apple with a foundation for recognizing printed, cursive, or block handwritten text.

Another indication of research of a similar goal appeared in the October 1990 edition of *PC Week*, which reported that "handwriting recognition is an emerging technology that promises increased productivity both for current microcomputer owners and for a new breed of users armed with hand-held 'pen-based' computers." Similarly a technical journal article indicated that there was renewed interest in the 1980s in this field of on-line handwriting recognition, from its advent in the 1960s, because of more accurate electronic tablets, more compact and powerful computers, and better recognition algorithms.[2]

[2]IEEE Transactions on Pattern Analysis and Machine Intelligence, "The State of the Art in On-Line Handwritting Recognition." (Aug. 1990), vol. 12, no. 8.

Moreover, as shown in figure 1, according to the U.S. Patent and Trademark Office's (PTO) database, over 450 patents[3] were issued on handwriting recognition software, concepts, and related products from 1985 through 1999, indicating that research of a similar goal was being conducted around the time of the ATP project. Given the fact that it can take many years between the time a research project takes place and the time that an outcome is realized, this time period for a patent search allowed us to determine whether there was research ongoing during the time of the ATP project. The dates of the patents actually occurred sometime after the research was conducted. And, as we reported in a prior report,[4] the time between the point when a patent application is filed until the date when a patent is issued, or the application is abandoned, ranged from 19.8 months to 21 months, adding additional time to when the research was done.

**Figure 1: The Number of Patents Issued from 1985 Through 1999 for a Handwriting Recognition System**




Source: Prepared by GAO using PTO's data.

[3]A patent is a grant given by a government to an inventor of the right to exclude others for a limited time (usually 20 years) from making, using, or selling his or her invention.

[4] Intellectual Property: Comparison of Patent Examination Statistics for Fiscal Years 1994-1995 (GAO/RCED-97-58, Mar. 13, 1997).

## ATP Project on Capacity Expansion of Fiber Optic Cables

Another ATP project we reviewed, which proposed to develop a system to increase the capacity of existing fiber optic cables for the telecommunications industry, also had a similar goal to that of research in the private sector. At the same time, firms in the private sector were attempting to increase the number of light signals that can be transmitted through a single strand of fiber optic cable using a technology called wavelength division multiplexing (WDM). [5] In the 1980s, telephone companies laid fiber optic cables across the United States and other countries to create an information system that could carry significantly more data than the copper wires they replaced. Tremendous increases in cable traffic, primarily from the Internet, have crowded these cables. WDM technology was aimed at providing a cost-effective alternative to the expensive option of installing additional fiber optic cables.

Accuwave Corporation (Accuwave) was the ATP award recipient. Accuwave used its ATP funding of approximately $2 million from March 1993 through March 1995 to develop a wavelength division multiplexing system that would substantially increase the number of signals that could be transmitted through a single optical fiber strand, using the concept of volume holography. Volume holography uses holograms to direct multiple light signals simultaneously through a single fiber strand. Accuwave was able to make improvements on these issues but not enough to fully develop and market a successful WDM system for the telecommunications market. In 1996, a competitor beat Accuwave to the market. After the completion of the ATP project, Accuwave filed for bankruptcy protection due to its inability to successfully commercialize a wavelength division multiplexing system.

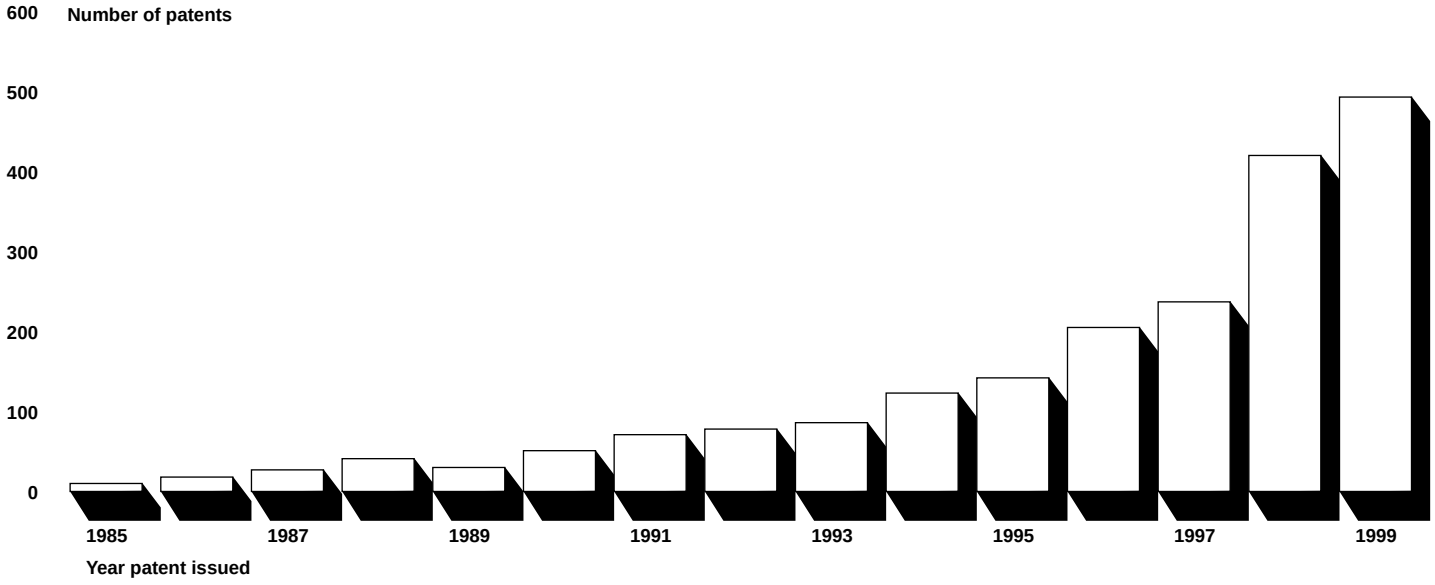
Other private firms were involved in research with a similar goal of increasing the capacity of fiber optic cable at about the same time as Accuwave was conducting its research. Conceptual research on such systems dates back to the early 1980s, but development and commercialization did not flourish until the mid- to late 1990s. Bell Labs (now Lucent Technologies), Nortel Networks, and Ciena Corporation, among others, were considered some of the major competitors in the industry. In the early 1990s, these firms were attempting to develop WDM technology using different methods and materials. For example, Ciena

[5]A fiber optic cable consists of many extremely thin strands of glass or plastic, each capable of transmitting light signals. Wavelength division multiplexing transmits separate light signals through a single optical fiber strand at different wavelengths.

Corporation developed a system that incorporated fiber-Bragg gratings, which are filters embedded directly onto fiber optic cable that help to separate multiple light signals through a single fiber strand.

We also found an indication of WDM-related research through a review of issued patents. According to PTO's database, over 2,000 patents were issued related to wavelength division multiplexing components, systems, and concepts from 1985 through 1999. As shown in figure 2, the patents issued ranged from 10 patents in 1985 to 493 in 1999.

**Figure 2: The Number of Patents Issued from 1985 Through 1999 for Wavelength Division Multiplexing Systems and Components**




Source: Prepared by GAO using PTO's data.

## ATP Project on Regenerating Tissues and Organs

Both the ATP project and private sector projects we identified in the tissue engineering field had similar broad research goals of developing biological equivalents for defective tissues and organs utilizing diverse technical approaches. ATP's project proposed procedures for extracting, storing, spinning, and weaving collagen (the main constituent of connective tissue and bones) into fibers suitable for human prostheses that could induce the body's cells to regenerate lost tissue. Tissue Engineering, Inc., received

ATP's award of about $2 million for use over the years 1993 through 1996. The company's long-term and yet unrealized goal is to transplant these prostheses into humans, after which the collagen framework, or scaffold, would induce the growth and function of normal body cells within it, eventually remodeling lost human tissue and replacing the scaffold.

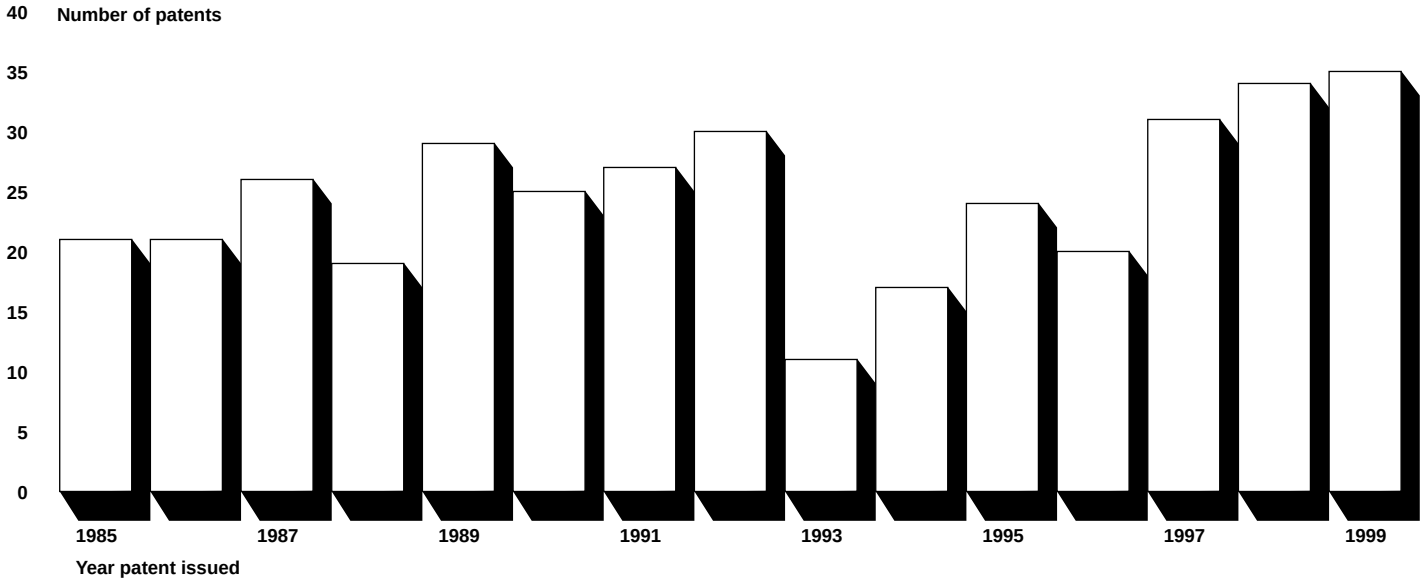
Within the very innovative field of tissue engineering, however, many competitors were attempting to achieve similar broad research goals. Organogenesis, the Collagen Corporation, Integra LifeSciences, Advanced Tissue Sciences, Genzyme Tissue, Osiris Therapeutics, Matrix Pharmaceuticals, and ReGen Biologics are key players in the market to develop structures that could replace or regenerate cells, tissues, and organs such as skin, teeth, orthopedic structures, cartilage, and valves. A number of these companies have subsequently received ATP awards. In addition, universities and medical schools have researchers investigating the many possibilities to engineer human tissues, and eventually complex organs, such as the liver, pancreas, and heart. According to one expert, there is a great deal of competition within the field of tissue engineering.

Although the Tissue Engineering, Inc., research focused on the use of collagen as the basis for these structures, other companies were pursuing a variety of technical approaches for addressing the goal of developing biological equivalents for defective tissues and organs. In addition to research in collagen, other companies and researchers have also been attempting to create human tissues and organs from other biological materials, synthetics, and hybrid products, which are both biologic and synthetic. For example, researchers from the Massachusetts Institute of Technology (MIT) developed an artificial skin product using collagen and a natural polymer. Several companies have since developed comparable products. In 1986, researchers from MIT and a hospital in Massachusetts began inserting cells into scaffolds created of biodegradable polymer. As the cells multiply, tissues form. The magazine *BusinessWeek* reported this concept as "an elegantly simple concept that underlies most engineered tissue."[6] Two competitors, Integra LifeSciences and Organogenesis, reported that they were also doing work on the use of collagen in various applications. Although their technical approaches were different than the ATP project, the broad research goals were similar.

[6]"Biotech Bodies," *BusinessWeek*, July 27, 1998.

In addition to our discussions with experts and literature searches, patent research shows that there was activity related to the field of tissue engineering prior to and during the ATP project. According to a search done on the PTO website, at least 370 patents were issued related to cell culturing, scaffolding or matrix development, and tissue engineering from 1985 through 1999. Experts have also indicated that there are several patents related to the field, with a considerable amount of overlap in the technologies described in those patents. Figure 3 depicts patents issued for research related to tissue engineering from 1985 through 1999.

**Figure 3: The Number of Patents Issued from 1985 Through 1999 Related to Tissue Engineering**




Source: Prepared by GAO using PTO's data.

## ATP's Current Award Selection Process Is Unlikely to Avoid Funding Similar Research

Two factors in ATP's current award selection process could result in ATP's funding research similar to research that the private sector would fund in the same time period. These two factors are inherent in the review process and limit the information the reviewers have on similar private sector research efforts. Due to conflict-of-interest concerns, technical reviewers are precluded from being directly involved with the proposed research, making them less likely to know about all the research in an area. Also, the information available about private sector research is limited because of the private sector practice of not disclosing research results. Until a patent is issued, a private sector firm generally publishes very few details about the research to protect proprietary information. Therefore, it is difficult for the reviewers to identify other cutting edge research.

### ATP's Conflict-of-Interest Provision Limits Its Ability to Identify Similar Research

ATP selection officials rely on outside technical reviewers to evaluate a proposal's scientific and technical merit. All reviewers must certify that they have no conflicts of interest. To minimize possible conflicts of interest, the technical reviewers are generally federal government employees who are experts in the specific technology of the research proposal but are not directly involved with the proposed research area. Although this approach helps to guard against conflict of interest, it has inherent limitations on the program's ability to identify similar research efforts. The technical reviewers rely on their own knowledge of research underway in the private sector. One of the technical reviewers we interviewed said that he did not personally know of other companies that were doing similar work. However, he believed that it was unlikely that there were not dozens of others working on the same issue.

### Proprietary Information Limits ATP's Ability to Identify Similar Research

ATP reviewers are significantly limited in their ability to identify similar research efforts by an inherent lack of information on private sector research. Although ATP officials use several sources such as colleagues, conferences and symposia, and current technical literature, to try to identify research efforts conducted by the private sector and the federal government, this information is often proprietary. Most of the private sector and university experts we consulted agreed that it can be very difficult to identify the specific research that private sector firms are conducting, especially considering the competitive nature of most industries. The early release of information on a company's research could be costly to the firm. If a competing firm could determine the nature and progress of another company's research, it could help the competitor to

develop and commercialize an identical or higher-quality product before the other firm. At the very least, the early release of research information by a firm can give competitors an idea as to the focus of the firm's strategic plan. Thus, many firms are very careful about releasing detailed information related to research and development activities they are conducting.

## Conclusions

Our retrospective look at the three ATP research projects showed that their goals were similar to research goals already being funded by the private sector. Looking at the process that ATP currently uses to select projects, we found two inherent factors—the need to guard against conflicts of interest and the need to protect proprietary information—that limit ATP's ability to identify similar research efforts in the private sector. These two factors have not changed since the beginning of the program. We recognize the valid need to guard against conflicts of interest and to protect proprietary information; thus, we are not recommending any changes to the award selection process. However, we believe that it may not be possible for the program to ensure that it is consistently not funding existing or planned research that would be conducted in the same time period in the absence of ATP financial assistance.

## Agency Comments

We provided a draft of this report to the Department of Commerce for its review and comment. The Department's National Institute of Standards and Technology (NIST), which administers the Advanced Technology Program, disagreed with both the methodology that we used and the conclusions that we reached in the draft report. NIST's disagreement focused on six areas, which are discussed in the following sections. NIST's comments and an enclosure describing the technical approaches of the three ATP projects that we reviewed are in appendix V.

First, NIST states that the report implies that the federal government should not fund research that shares the same overall goal as research funded outside of the government. We disagree. NIST believes that it is appropriate for the federal government to fund research projects that have similar research goals to research funded by the private sector as long as that research has an innovative technical approach and has the potential for broad-based economic benefits. However, the Omnibus Trade and Competitiveness Act, which established the ATP, states that ATP program administrators should ensure that they are not funding existing or planned

research that would be conducted in the same time period in the absence of ATP financial assistance.

Second, NIST believes that our report failed to understand and address a central aspect of the ATP: that it selects projects for innovative, high-risk technical approaches for break-through solutions to challenging problems and that these technical innovations offer broad potential national benefits. To the contrary, throughout the report we state that the goal of the program and the criteria for project selection support innovative research that accelerates the development of high-risk technologies with the potential for broad-based economic benefits for the nation. Furthermore, our report states that advocates of the program believe that the government should serve as a catalyst for companies to cooperate and undertake important new work that would not have been possible in the same time period without federal participation.

Third, NIST states that our report fails to define or address the distinction between funding projects with similar "research goals" versus funding projects with "unique project-specific objectives and technical approaches." We disagree. Throughout our report we distinguish between broad research goals and specific technical approaches. In determining whether, in the past, ATP had funded projects with research goals that were similar to projects funded by the private sector, our report identifies many competitors who were attempting to achieve similar broad research goals to those of the three ATP-funded research projects, albeit using different technical approaches. Our report includes descriptions of the unique technical approaches of the ATP-funded projects and states that the other firms were attempting to develop these technologies using different methods and materials. NIST included, as an enclosure to its comments, a description of the technical approaches of each of the projects, which we believe generally mirrors much of our descriptions of the projects, included in appendixes II through IV. While the ATP-funded projects had unique technical approaches, nevertheless, the broad research goals were similar to research goals of projects being funded by the private sector.

Fourth, NIST states that our report does not discuss the competitive value of having differences in the technical approaches of the research within the broad research fields being addressed. NIST further noted that the report does not mention the national benefits, which would result from accelerating the high-risk, yet critical technology resulting from specific projects. We agree that there could be value to funding a number of technical approaches or to accelerating critical technologies. However, if

ATP is to ensure that it is not funding existing or planned research that would be conducted in the same time period in the absence of ATP financial assistance, the fact remains that we found that the three ATP-funded projects that we reviewed addressed similar research goals to those already funded by the private sector. If the private sector is funding any of the technical approaches toward the broad research goal, the benefits resulting from these efforts may be realized without federal funding.

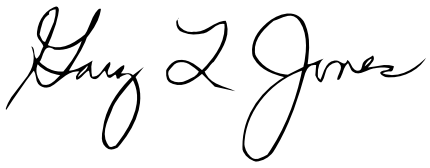
Fifth, NIST states that in conducting our review we "hand-picked" 3 of 38 completed projects, "presumably with the intent of making the strongest possible argument," and that we used these projects to draw conclusions that are unreasonably far reaching. This assertion is not correct. We selected these projects without prior knowledge of the industries or the technological approaches of the research projects. We chose three projects each representing a different technology sector. These three technology sectors represent 26 of the 38 completed ATP projects, or 68 percent. We have added additional information to explain the scope and methodology used in our case study approach. Our conclusion based on the review of the three projects is that the research goals of these three projects were similar to research goals already being funded by the private sector. To assist in our examination of these projects, we held discussions with outside experts, as well as with ATP technical reviewers and Source Evaluation Board members. These outside experts helped us to understand the industries within which each of the projects selected as case studies were operating and provided their professional assessment of whether similar research to that undertaken by the ATP award recipient was ongoing. We identified two inherent factors in ATP's current award selection process—the need to guard against conflicts of interest and the need to protect proprietary information—that led us to the conclusion that it may not be possible for the program to ensure that it is consistently not funding existing or planned research that would be conducted in the same time period in the absence of ATP financial assistance. This conclusion was based principally on our analysis of the current award selection process supplemented by our analysis of the three ATP-completed projects.

Sixth, NIST stated that if we "were to review all 199 ATP completed projects to date, the GAO might still have come to the same conclusions, i.e. that the research goals may have been similar to those funded by the private sector." However, NIST states that even a review of all of the completed projects "would utterly fail to capture the impact of the ATP." Our objective was not to provide an evaluation of the quality of the research funded by ATP or the private sector nor the impact these projects

may or may not have had on their respective industries. We have added this clarification to the report. Our review of completed projects was limited to identifying whether, in the past, ATP had funded projects with research goals that were similar to projects funded by the private sector.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issuance date. At that time, we will send copies of this report to the appropriate House and Senate committees; interested Members of Congress; the Honorable William M. Daley, Secretary of Commerce; Raymond G. Kammer, Director, National Institute of Standards and Technology; and Alan Balutis, Director, Advanced Technology Program.

If you have any questions regarding this report, please contact me at (202) 512-3841. Key contributors to this report are listed in appendix VI.



(Ms.) Gary L. Jones
Associate Director, Energy, Resources,
and Science Issues

# Scope and Methodology

To determine whether the Advanced Technology Program (ATP) had funded projects with research goals similar to projects being funded by the private sector, we examined 3 of 38 completed ATP projects from ATP's status report entitled Performance of Completed Projects, dated March 1999. These projects were chosen from the following technology sectors: information, computers, and communication; electronics; and biotechnology. These three technology sectors represent 26 of the 38 completed ATP projects, or 68 percent. We consulted with ATP officials at the beginning of our review regarding which technology sectors would provide a useful framework for our review. These officials supported our selection of the three industrial sectors and gave us information showing that they had each received increasing numbers of awards, since the start of the ATP program. ATP funded the selected projects as a result of two different competitions held in 1990 and 1992. We rank-ordered all of the projects within the three technology sectors by dollar value. All three selected projects had received a medium to high dollar award from ATP. As with all case studies, we did not attempt to generalize to the entire program.

It can be very difficult to identify the specific research that private sector firms are conducting. Firms are very careful about releasing detailed information related to research and development activities they are conducting given the competitive nature of most industries. Also, it can take many years between the time a research project takes place and the time that an outcome is realized. Thus, we chose projects that ATP awarded as a result of competitions held in the early 1990s to retrospectively identify similar research projects.

To fully understand the technologies under review, we studied the official ATP project files, located at the National Institute of Standards and Technology (NIST) headquarters in Gaithersburg, Maryland, for the three projects we selected. According to NIST officials, all documents maintained in these files are considered proprietary information. Within the project files, we reviewed the original project proposals, technical and business reviewer comment sheets, sponsor summaries and recommendations, and the project manager's quarterly status reports and final report. To ensure the confidentiality of the proprietary information, none of this information was shared with the experts that we consulted. These experts were provided project information drawn from ATP's March 1999 Status Report.

We interviewed ATP staff, outside experts, and award recipients to gain an understanding of each of the technology sectors and related research and to obtain their professional assessment of whether similar research to that undertaken by the ATP award recipient was being funded by the private sector during the same time period. To identify the ATP staff, we used NIST's list of the technical and business reviewers and members of the Source Evaluation Board (SEB), who had reviewed the project proposals. We asked these reviewers to identify additional knowledgeable contacts to interview and applicable reports and articles that would supplement our knowledge of the technologies under review. For the handwriting recognition project, we interviewed five NIST scientists who were either technical reviewers or members of the SEB related to the project and 11 experts from industry and academia. For the electronics project, we interviewed four NIST scientists who were either technical reviewers or members of the SEB related to the project and 13 experts from industry, academia, or other government agencies. For the biotechnology project, we interviewed two NIST scientists who were technical reviewers related to the project and 18 experts from industry, academia, or other government agencies. These outside experts represented Fortune 500 companies, such as Lucent, Microsoft, and IBM; major universities such as MIT and the University of Maryland; and government agencies, such as the National Aeronautics and Space Administration and the National Science Foundation.

We developed a structured interview to facilitate our conversations with the ATP staff, outside experts, and award recipients. The interview document provided questions that addressed issues such as the level of similar research at the time of the ATP funding, the identification of private sector firms that conducted similar research, and the innovativeness of the ATP proposals, among others.

To gather published and other information about each industry, we conducted a literature search, as well as an Internet search. The literature search used technical library sources to identify both academic journal and industry-specific publications with articles addressing the research goals relevant to each project. In addition, many of the technical experts identified articles for us that we reviewed. The Internet searches provided further information about the technologies under review and the private sector companies involved in similar research at the time that the ATP projects received funding. For example, we conducted a search on "wavelength division multiplexing" on the Internet, and we identified several articles related to this technology that provided background

information for our work. In addition, these articles provided contact names at some of the private firms conducting similar research and academic and/or consultant contacts who have expertise in the technologies under review. The project files at NIST provided contact information for the ATP award recipients.

To show the level of related research that firms were conducting during and around the time ATP funded the projects we reviewed, we also conducted patent searches on the technical areas associated with each project. To conduct our patent search, we accessed the U.S. Patent and Trademark Office's (PTO) website (www.uspto.gov ), which contains PTO's patent data base. For each of the three technologies we reviewed, we conducted a full-text keyword search of the PTO's patent data base, using key words that describe each technology as the criteria. For example, for our search for patents on related research to the ATP project on handwriting recognition software, we executed a search using "Handwriting Recognition" as the criterion. We repeated this search for individual years of patent issuance, beginning with 1985 and ending with December 1999. The patent information demonstrates that the private sector was working on research topics that related to the ATP projects we reviewed because the patents were issued after the research was conducted.

We also reviewed ATP's current award selection process to determine whether it could ensure that ATP would not fund research similar to that undertaken by the private sector. This process applies to all project proposals submitted to the ATP program. In conducting this review, we examined published reports on the ATP program, legislation that created and shaped the ATP program, and internal NIST documentation that describes the rules and processes of the ATP program. We also discussed ATP's award selection process with various NIST officials, including ATP management, project managers, and SEB members. We did not independently verify the data we obtained from NIST or the other entities we contacted. We conducted our review from October 1999 through April 2000 in accordance with generally accepted government auditing standards.

# Communication Intelligence Corporation Project Summary

This ATP project received funding from the 1990 competition, the first solicitation for the program. The project was completed in 1993. The ATP-funded software technology is widely licensed, and a new product fully incorporating the software is due on the market soon. The company also has several new products related to multilingual handwriting recognition systems and other software technologies that have been successful in the marketplace.

*Project Title*
Computer Recognition of Natural Handwriting (Communication Intelligence Corporation (CIC))

*Amount of Funding Granted*
$1,264,000 (58%), with CIC contributing $912,000 (42%) toward the project.

*Summary of Project Purpose*
To develop a natural handwriting data-entry system for computers for applications where pen-based entry works best and for use by people who do not or cannot use a keyboard.

*Market Data*
Dataquest, Inc., predicted the market for pen-based computers would increase, potentially to $13.1 billion by 1995.

*Description of Industry/Technology*
Handwriting recognition was an emerging technology promising increased productivity both for microcomputer owners and for users utilizing new hand-held “pen-based” computers. Starting in the late 1950s, character recognition developed into two areas—whether the characters to be recognized were machine-printed or handwritten. Thus, a separate body of technology research grew out of the areas of machine print and handwritten text. For handwritten text, further research efforts were focused on two additional areas—printed and cursive writing. To facilitate handwritten text recognition, a pen-based, or stylus-based computer, (essentially a tablet computer) that uses an electronic pen, or stylus, in conjunction with a digitizing screen for data input is employed. These systems were expected to supplement, rather than replace, traditional desktop systems. There was concern, however, that high introductory prices and lack of consistent handwriting recognition capabilities would impede the growth of pen-based systems.

Limitations in the technology's accuracy rate made it unsuitable for every user. While the technology had the potential for expanding the use of computers to people who find conventional keyboards unnatural or intimidating, for such tasks as text editing, dictation, or taking notes in a meeting, its accuracy rate and speed were inconsistent. In October 1990, handwriting recognition systems could only interpret unconnected block writing, and no system offered 100 percent accuracy. Complaints about hardware, software, and related components were common. For example, processing power was often inadequate, leading to inconsistencies in the machine's ability to capture data and analyze it. In addition, digitizers were often slow at recording the flow of the pen on the screen. This situation was expected to remain for the foreseeable future, until a new generation of hardware and software could be developed.

CIC proposed to conduct research and development in natural or cursive handwriting recognition to try to provide the means by which ordinary handwriting skill could be used to communicate with computers for a wide variety of applications.

*Private Sector Research Activities*

Handwriting recognition research has focused on print recognizers and cursive recognizers. Unlike printed character recognition, cursive recognizers must determine distinct characters in a continuous string of writing. In addition, the natural handwriting of most people consists of a mix of printed and cursive; therefore, the recognizer must be able to determine when a break means a new word and when it does not. Cursive recognizers can also exhibit some uncertainty in the identification of words. Since most cursive recognizers are dictionary-based, the system will attempt to approximate the word that a sequence of characters represents and then cross-reference a dictionary or glossary to see if such a character string exists. If the recognizer is uncertain, the system will select alternative word possibilities.

In October 1991, Paragraph International announced a licensing and development agreement with Apple Computer for Paragraph's cursive handwriting recognition technology. Paragraph's technology provided Apple with a foundation for recognizing printed, written, or block handwritten text.

In 1989, Paragraph JV, the Soviet half of the joint venture, started developing a cursive handwriting recognition technology, in affiliation with two Soviet agencies: the Council for Economics and Mathematics, and the

Academy of National Economics. Paragraph developed two main recognition technologies. The first, Calligrapher, is software that can decipher written text as it is written; in addition, it is the basis for the pen-based recognition system. The second technology, Parascript, is a static recognition system for use with an optical character reader. Lexicus, a division of Motorola, concentrated research on cursive recognition as well, as did Go Corporation, Palm Computing, and others.

*ATP Review Process*

For its technical evaluation, CIC was assessed on the quality and innovativeness of the proposal, coherency of the technical plan, overall scientific and technical merit, and staff quality, among others. The three technical reviewers were government scientists from NIST and DOD. For the technical categories, the evaluations consistently supported CIC.

Regarding its business evaluation, CIC was assessed on several issues, such as potential to improve U.S. economic growth, staffing and facilities, evidence of commitment to complete project beyond federal grant, and overall business merit, among others. For business and economic related criteria, CIC received scores that recommended funding.

*Results/Status of Project*

CIC researchers sought to perfect software that could effectively recognize cursive handwriting and now has products that provide handwriting recognition for printed English and some foreign languages. Currently, the company's core software technologies include multilingual handwriting recognition systems, dynamic signature verification, natural messaging, and operating system extensions that enable pen input. CIC describes its products as technologies designed to increase the ease of use, functionality, and security of wireless electronic devices ranging from handheld companions to cellular telephones. Key licensees of the company's technologies include companies such as Ericsson, Fujitsu, Hitachi, Microsoft, Mitsubishi, and National Semiconductor.

During the project, CIC researchers created a data base with thousands of cursive handwriting samples and developed new recognition algorithms. After analyzing the handwriting sample data base and developing the recognition methods, the researchers developed procedures that permit fast computation with modest computer memory requirements. The company has achieved other goals as well. For example, CIC has:

- incorporated some of the ATP-funded technology into a registered software product, Handwriter, which recognizes cursive writing in limited circumstances (previously it recognized only printing);
- licensed the Handwriter software to more than a dozen computer manufacturers worldwide, generating $360,000 in revenue from sales of 30,000 units in 1997;
- launched a new product in 1996 called Handwriter MX, a stylus and tablet data entry device using upgraded Handwriter software;
- sold 11,000 copies of handwriter MX in 1997, with sales totaling more than $2.2 million; and
- received the “Ease of Use Seal of Commendation” from the Commendation Program of the Arthritis Foundation for the company’s handwriter products—indicating their value to disabled people who have trouble with keyboard entry.

# Accuwave Corporation Project Summary

This ATP project was awarded funding from the 1992 competition. Although Accuwave eventually filed for bankruptcy protection and was unable to commercialize a wavelength division multiplexing system, it did complete the terms of its ATP cooperative agreement by the end of the project in 1995.

*Project Title*
Expanding the Number of Light Signals in an Optical Fiber (Accuwave Corporation).

*Amount of Funding Granted*
$1,987,000 (69%), with Accuwave Corporation contributing $898,000 (31%) toward the project.

*Summary of Project Purpose*
To develop holographic-optics technology[1] that will increase (by more than 10 times) the number of signals that can be transmitted through a single optical fiber strand. [2] This technology is based on the concept of wavelength division multiplexing (WDM), which transmits separate light signals through a single optical fiber strand at different wavelengths.

*Market Data*
According to consultants hired by Accuwave at the time of the ATP proposal, the total market for Accuwave's technology was expected to reach $40 million. Another consulting firm estimates that by 2003, sales of WDM systems will reach $40 billion worldwide.

[1]Holography is a technique that allows the recording and playback of true, three-dimensional images, called holograms.

[2]A fiber optic cable consists of many extremely thin strands of glass or plastic, each capable of transmitting light signals.

*Description of Industry/Technology*

Due to the increased use of telephones, fax machines, mobile telephones, and particularly, the Internet, U.S. telecommunication firms have experienced an increased demand for capacity of their transmission networks, which primarily consist of fiber optic cables. The installation of additional fiber optic cables to deal with the increase in demand for capacity can be very costly. WDM provides a cost-effective alternative to installing additional fiber optic cables. WDM allows for the simultaneous transmission of multiple light signals through the same fiber at different wavelengths. Conceptual research on WDM systems dates back to the early 1980s, but the development and commercialization of WDM systems did not begin to flourish until the mid-1990s. One of the primary reasons why WDM had not become practical until recently was the lack of suitable amplifiers for signals traveling long distances.[3] According to experts we interviewed, serious research in WDM began in the early 1990s as amplifier technology evolved.

This ATP project focused on using a holography-based approach to aid in the development of a WDM system to increase the capacity of existing fiber optic cables. Accuwave's approach employed volume holography, which uses a series of holograms as filters, stored in a volume of photorefractive (light-bending) material, to direct different light signals to separate wavelengths on a single fiber strand. The concept of volume holography dates back to the 1970s and was applied primarily to research on optical signal processing and memory storage. However, volume holography fell into disfavor during the 1980s, primarily because of two problems: efficiency (amount of signal loss) and reliability (deterioration of filters due to changes in temperature). According to the experts we consulted, no one else in the industry seriously considered volume holography as a method to direct multiple signals onto different wavelengths of an optical fiber strand for telecommunications.

[3]Light signals traveling through fibers fade to undetectable levels after a couple hundred kilometers, therefore requiring amplification to increase the strength of the signal.

*Private Sector Research Activities*

Several private firms were involved in research activities related to WDM in the late 1980s and early 1990s. One of the early participants in this industry was AT&T and its research arm, Bell Labs. Lucent Technologies, which used to be part of Bell Labs, developed an 8-wavelength WDM system in 1995. Ciena Corporation, a company formed in 1992, received a total of $40 million in venture capital funding and developed a 16-wavelength WDM system,[4] which was commercially unveiled in March 1996. Several other companies were researching and developing WDM systems in the 1990s, including Nortel, Pirelli, Alcatel, and others. The other companies competing in this industry used different methods and materials, other than holographic filters, to develop their WDM systems. For example, Ciena Corporation used fiber-Bragg gratings, which are filters that are written onto the fiber optic cable itself, to help separate multiple signals onto different wavelengths within a single optical fiber strand. Much of the research in this industry was kept proprietary and was not released to the public.

*ATP Review Process*

Technical reviewers from NIST, the U.S. Air Force, and the National Security Agency evaluated Accuwave's proposal on issues such as quality and innovativeness of the proposal, coherency of the technical plan, overall scientific and technical merit, as well as staff quality, and others. For these categories, three of the four technical evaluations were consistent, stating that Accuwave's proposal was innovative. The fourth technical evaluator, however, was more critical of the proposal, stating that Accuwave's method was "another in a long line of techniques under consideration for high density WDM systems."

Business reviewers assessed Accuwave's proposal on issues such as the potential to improve U.S. economic growth, staffing and facilities, evidence of commitment to continue project beyond federal grant, and overall business merit, among other items. For these categories, the business reviewers were critical of the proposal, citing poor commercialization planning, lack of manufacturing capability, etc. ATP officials, however, listened to the company's oral presentation. As a result of the presentation and despite both technical and business reviewer concerns, ATP decided to fund the project.

[4]WDM systems with more than 8 wavelengths are called dense wavelength division multiplexing (DWDM) systems.

*Results/Status of Project*

According to a former Accuwave official, problems of efficiency and reliability arose during Accuwave's research to develop a WDM system. Accuwave was able to make improvements on these issues but not enough to fully develop and market a successful WDM system for the telecommunications market. In addition, Ciena Corporation, a competitor, beat Accuwave to the market in 1996 with a 16-wavelength WDM system. Accuwave did not learn about Ciena until 1995, and Ciena's research was kept proprietary. Accuwave did commercialize a few WDM components; the most successful of which was called the wavelength locker, a device that controls the frequency of the laser. Accuwave's wavelength locker was a limited commercial success, according to a former Accuwave official. Sales of Accuwave's components reached about $3 million. According to a former Accuwave official, this was not enough to appease the Board members and the venture capitalists, and the decision was made to file for bankruptcy protection in October 1998.

# Tissue Engineering, Inc., Project Summary

This ATP project was awarded funding from the 1992 competition. Tissue Engineering (TE) was able to successfully complete their ATP project goals by the end of the project in 1996. However, the company has not yet developed a prostheses product that can be transplanted into humans and eventually be reabsorbed by the body.

*Project Title*
Prostheses Made of Biomaterials that Regenerate Body Parts [Tissue Engineering, Inc. (TE)]

*Amount of Funding Granted*
$1,999,000 (48%), with TE contributing $2,128,000 (52%) toward the project.

*Summary of Project Purpose*
To develop techniques for extracting and storing collagen and spinning and weaving collagen fibers into fabrics and other forms suitable for human prostheses that could induce the body's own cells to rebuild lost tissue while gradually replacing the prosthesis.

*Market Data*
According to *BusinessWeek* magazine, the president of the Pittsburgh Tissue Engineering Initiative research consortium has estimated that the potential overall market for engineered and regenerated tissues to be $80 billion.

*Description of Industry/Technology*
One industry expert said that the premise of the tissue engineering field is to create devices that are bio-regenerative, so that the body can eventually mimic and remodel what is damaged; potentially, experts believed that the result could be more natural than other transplants. In addition, engineered tissues could possibly replace donated organ transplants, which are very limited in supply. According to industry experts, by the early 1990s, the new multidisciplinary field of "tissue engineering" was drawing scientific interest.[1] For over a decade before,

[1]In 1987, the National Science Foundation sponsored a conference where the term "tissue engineering" was first defined.

however, related basic research was being conducted. Industry experts explained that research using synthetics as well as the protein collagen[2] led to discoveries; scientists were looking for a way to package cells in a three-dimensional format, like tissues and organs. According to industry experts, there are remaining challenges; particularly, the challenge to develop products that can be reliably transplanted into and interact with the body without creating a negative reaction by the host.

According to industry experts that we interviewed, tissue engineering research in the early 1990s focused upon synthetics and collagen technology for the development of products, as well as research attempting to understand extracellular matrix from a biological and cell biology perspective. [3] Some of these experts identified academic and private labs that were conducting research on collagen structures by 1993.

*Private Sector Research Activities*

Prior to 1992, a number of other private sector and university groups were also working on a variety of technical approaches to develop biological equivalents for defective tissues and organs for use in the human body. Among the groups involved in tissue engineering, the experts that we interviewed named the following: Organogenesis; Integra LifeSciences; Advanced Tissue Sciences; Collagen Corporation; Genzyme; Osiris Therapeutics; Matrix Pharmaceuticals; and, researchers at MIT and other universities, hospitals, and laboratories. A study published in the journal *Tissue Engineering* estimated that the government has provided less than 10 percent of tissue engineering funding.[4] According to one industry expert, this may have been an advantage as it forced researchers to start companies and move forward, rather than spend many years in academic settings. Projects by other companies included attempts to bioengineer bone, skin, teeth, cartilage, valves, or other cells, tissues and organs. For example, Integra LifeSciences, Organogenesis, and Advanced Tissue Sciences have all been involved in research leading to bioengineered skin. In addition, Genzyme Tissue, Integra LifeSciences, Advanced Tissue

[2]Collagen is a structural protein that occurs in vertebrates as the main constituent of connective tissue fibrils and in bones. It is the most widely distributed protein in the human body.

[3]Extracellular matrix is described as molecular networks that are crosslinked and are swollen in fluids surrounding the cells.

[4] "An Economic Survey of the Emerging Tissue Engineering Industry," Tissue Engineering, Fall 1998.

Sciences, ReGen Biologics, and Osiris Therapeutics are companies in competition to develop engineered cartilage products using different technical approaches.

According to some of the industry experts that we interviewed, some of what TE proposed and did during the ATP project did not advance the core of the technology of regeneration. However, in 1992, the industry had not defined an industry-wide critical or core technology goal. The TE project was intended to provide a unique structural support for defective tissue to be gradually replaced by healthy tissue. No other therapy was available at the time of the award. Nonetheless, one expert described TE's technology as a derivative technology, rather than a high-risk and innovative technology.

*ATP Review Process*

During the ATP selection process, technical reviewers assessed the TE project on scientific and technical merit, feasibility, coherency, and appropriateness of staff and equipment. The three reviewers, all federal employees, evaluated the project as innovative. Based on these reviews, evaluations by three business reviewers, and a Source Evaluation Board decision, ATP funded the project.

*Results/Status of Project*

According to TE, the company had a profitable and rewarding start with the ATP award. According to the company's founder, the ATP project was highly innovative because it would use naturally occurring collagen to re-grow tissue. The company developed a collagen spinning technique, which allows them to imitate the scaffolding of tissues in the body. A TE official claims this can be done on a commercial scale. In addition, the company has also been able to insert cells into the collagen to re-grow tissue in the laboratory. Some of the company's accomplishments include:

- Two patents were awarded to the company for its work under the ATP award: "Apparatus and Method for Spinning and Processing Collagen Fiber"[5] and "Bipolymer Foams Having Extracellular Matrix Particulates."[6]

[5]"Apparatus and Method for Spinning and Processing Collagen Fiber" U.S. Patent Number 5,562,946, granted on 10/8/1996.

[6]"Bipolymer Foams Having Extracellular Matrix Particulates" U.S. Patent Number 5,709,934, granted on 1/20/1998.

- TE indicated that it would soon begin animal trials for its orthopedic products and eventually progress into human trials. TE also mentioned that it has initiated collaborative efforts with larger biotechnology companies.

# Comments From the Department of Commerce

NIST

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899
OFFICE OF THE DIRECTOR

APR 14 2000

Ms. Gary Jones
Associate Director, Energy, Resources, and
Science Issues
United States General Accounting Office
Washington, D.C. 20548

Dear Ms. Jones:

Thank you for the opportunity to review and provide comments on the draft General Accounting Office (GAO) report entitled "Advanced Technology Program: Inherent Factors in Selection Process Could Limit Identification of Similar Research (GAO/RCED-00-114, code 141384)."

I disagree with both the methodology used and the conclusions reached in this report. The implied argument is that the Federal government should not fund research that shares the same overall goal as research funded outside of the government. By that doubtful criterion we would shut down Federal research on cures for cancer, AIDS, and a host of other diseases; wireless communications; computing technologies; manufacturing; etc.

The fundamental error in this report is its failure to understand and address a central aspect of the Advanced Technology Program (ATP): that it selects projects for innovative, high-risk technical approaches for break-through solutions to challenging problems, and that these technical innovations offer broad potential national benefits. This does not necessarily mean they are the only possible solutions. Numerous organizations, both government and private, fund research with similar goals. This does not mean they are funding the identical technical approach to attain the research goal. What makes each research project unique are the pathways or technical approaches to solving the problem. This report fails to define or address the distinction between funding projects with similar "research goals" versus funding projects with "unique project-specific objectives and technical approaches." This is a serious error. Lumping projects together under "research goals" is perhaps useful as a taxonomy to identify broad areas of interest, but it is not useful in judging the similarity of specific technical approaches.

Consistent with the ATP statute, ATP assists "United States businesses in creating and applying the generic technology and research results necessary to (1) commercialize significant new scientific discoveries and technologies **rapidly**." The ATP accelerates high risk technologies that are unlikely to be developed in time to compete in rapidly changing global markets, or to be developed at all without Federal support. ATP funded projects are technically challenging and innovative, with objectives that are often well beyond state-of-the-art in their research field. They are technically so challenging that the probability of failure is high and the technical objectives may be only partially met. The GAO report contains no reference to the high technical risks associated with the specific projects funded by ATP, nor the competitive value of having differences in the technical approaches of the research within the broad research fields being addressed. Neither does the GAO report mention the national benefits which would result from accelerating the high-risk, yet critical technology resulting from specific projects.

The GAO's review hand picked 3 of 38 completed projects, presumably with the intent of making the strongest possible argument, and draws conclusions which are unreasonably far reaching. Even in the case of these three projects, however, the report fails to adequately assess the unique technical approaches taken in these projects, factors which played an important role in their selection. I append a short outline of these unique technical approaches taken by each of these projects.

If it were to review all 199 ATP projects completed to date, the GAO might still have come to the same conclusion, i.e., that the research goals may have been similar to those funded by the private sector. However, it would utterly fail to capture the impact of the ATP. On April 4, GE Medical Systems recognized the ATP as a "Partner in Vision" for its support in the development of an innovative manufacturing technology to produce large-area, flat-panel amorphous silicon detectors for X rays. These panels are the heart of a unique new digital mammography system hailed as "the biggest breakthrough in mammography in more than 20 years," according to Senator Connie Mack. The ATP-funded research significantly reduced the number of processing steps required to manufacture these panels and increased the yield. In the sense that it was previously possible to make the panels, the ATP goal was not "unique", but the processing innovations can significantly reduce the cost of these panels, making the new mammography more affordable and more widely available to women. That is a clear benefit to rapidly bringing high-risk technologies to improve the quality of life for Americans.

In the 10 years that ATP has been in operation, if there was concern that ATP was funding research which duplicated that performed by other organizations, ATP would have received numerous complaints from those organizations. This is not the case. ATP's record speaks for itself in complying with the spirit of the law of funding high risk, high pay-off, emerging and

ENCLOSURE

## ATP PROJECTS REFLECT UNIQUE TECHNICAL APPROACHES

### I. Communication Intelligence Corporation (CIC) - Handwriting Recognition

The goal of the Communication Intelligence Corporation (CIC) project was to develop user-independent, cursive handwriting recognition software. This project was innovative in that the algorithms to be used would require the system to be "trained" to recognize a specific user's handwriting, and would recognize contiguous characters not separated by discrete spaces. The project was unique in its combination of specific algorithms and programming methodologies which, together, would lead to better speed and accuracy than theretofore attained. (The project had a target of 10 characters per second with 99% accuracy.) Also, differentiating this project from other ongoing efforts, the CIC software was intended to be unconstrained and adaptable to European languages.

### II. Accuwave Corporation - Capacity Expansion of Fiber Optic Cables

At the time the award was made, only a few WDM wavelengths had been multiplexed successfully in commercial systems. Accuwave's approach was both high-risk and unique. They proposed wavelength multiplexing using volume holography -- holograms "written" in the interior of thick crystals of photorefractive materials. In the demultiplexer crystal, for example, the multi-wavelength light enters one end of the crystal and encounters a series of holographic gratings, each tuned to reflect a separate and specific wavelength of light while passing all other wavelengths with minimal loss. When the award was made, Accuwave had already demonstrated the individual elements of a system that could multiplex wavelengths more than 10 times better than the current art at visible wavelengths. Under the ATP, Accuwave attempted to extend this technology to the infrared wavelengths used for long-distance telecommunications. If completely successful with this high-risk innovation, Accuwave's technology would have had the potential to increase the number of WDM wavelengths by almost three times the number commercialized by the companies mentioned in the report, which would have greatly accelerated the adoption of very high-capacity telecommunications systems.

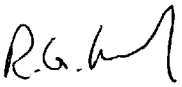
### III. Tissue Engineering, Inc. (TE) - Regenerating Tissues and Organs

Tissue Engineering was funded by ATP to investigate the combination of the technologies of traditional weaving via fabric weaving machinery and the use of animal-derived extracellular matrix (ADMAT). The resultant matrix is to be used for a scaffold for a variety of tissue engineering applications. The use of extracellular matrix from particular animals thought to be very close to that of human beings are less likely to be rejected when used in a scaffold created from tissue woven on traditional weaving machines. The scaffold can be seeded in a variety of ways to encourage cell growth. It will also resorb into the body as cellular growth takes place, thereby replacing the matrix with a body equivalent. The matrix would be a generic solution for many applications varying from relatively simple to complex including skin, ligaments, tendons, and vascular systems. At the time of the funding of this project, early 1993, this was a unique technical approach toward achieving the broad research goal of replacing human tissue in the body. Based on our information it is still a unique methodology that is not being pursued by others. This was a very high risk technology and offered a unique approach which, if successful, held the promise of widespread applicability. A variety of pilot studies have indicated that the basic hypotheses of this research have proven to be correct.

enabling technologies. To do this, ATP runs a competitive peer review process which has been applauded by the Department's Office of Inspector General as a program which "constitutes a best practice that should be used in other funding programs" (Audit Report No. DEN-10960-9-0001, ATP Award Process Promotes Merit-Based Decisions). It is a merit based program which uses technical and business experts to review proposals to ensure that ATP does not fund existing or planned research that would be conducted in the same time period.

Thank you for the opportunity to provide comments.

Sincerely,



Raymond Kammer
Director

Enclosure

# GAO Contact and Staff Acknowledgments

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## Acknowledgments

Phil Amon, Shannon Bondi, and Diane Raynes also made key contributions to this report.

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