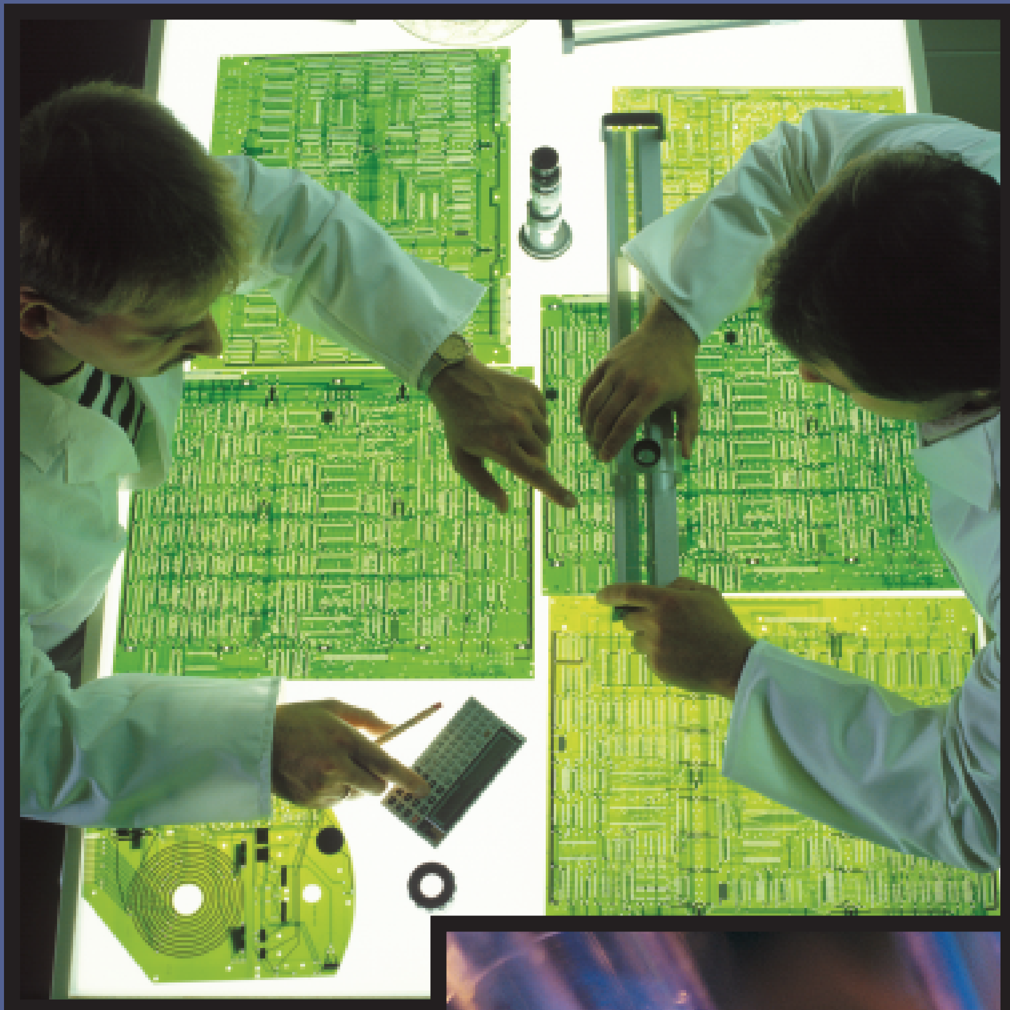
Measuring ATP Impact



ADVANCED TECHNOLOGY PROGRAM

Economic Assessment Office

2004 Report on Economic Progress

National Institute of Standards and Technology • Technology Administration • U.S. Department of Commerce

ATP Mission

To accelerate the development of innovative technologies for broad national benefit through partnerships with the private sector.

Mission Specifications

- Add to the nation's scientific and technical knowledge base
- Foster expanded/accelerated technology development and commercialization by U.S. firms
- Promote collaborative R&D
- Refine manufacturing processes
- Ensure appropriate small business participation
- Increase competitiveness of U.S. firms
- Generate broadly based benefits

Operational Mechanisms and Features

- Cooperative agreements with industry for industry-led, cost-shared research
- Focus on high-risk research to develop enabling technologies
- Competitive selection of projects using peer review and published criteria
- Sunset provisions for all funded projects
- Requirement that all projects have well-defined goals and identified pathways to technical and economic impacts
- Reporting requirements for project management
- Flexibility in the face of change as long as selection criteria still met
- Program evaluation

The Advanced Technology Program (ATP)

The Advanced Technology Program (ATP) of the National Institute of Standards and Technology (NIST) seeks to benefit the economy and the people of the United States by sharing the cost of research with industry to foster new, innovative technologies. ATP invests in risky, challenging technologies that create opportunities for world-class products, services, and industrial processes for the benefit not just of ATP participants, but of other companies and industries, and, ultimately, consumers and taxpayers. By reducing the early-stage research and development risks of individual companies, ATP enables industry to pursue promising technologies that would have been ignored otherwise or developed too slowly to compete in rapidly changing world markets.

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A Message About This Report

The mission of the Advanced Technology Program (ATP), a public-private partnership, is to encourage companies to develop innovative and high-risk technologies for broad national benefit. One of our best practices is a rigorous and comprehensive evaluation program that measures the economic impact of funding high-risk, enabling technologies. In addition, we seek to increase understanding of underlying relationships between technological change and economic phenomena. The National Academy of Sciences has praised ATP's evaluation program as "one of the most rigorous and intensive efforts of any U.S. technology programs."

We are pleased to announce the release of ATP's first Report on Economic Progress. The report draws upon our multifaceted evaluation portfolio to provide the technology, industry, evaluation, and policymaking communities, as well as the general public, with important facts, data, and analyses about ATP.

The Report on Economic Progress presents findings from our economic and policy studies and provides data about ATP-funded project outputs, outcomes, and impacts on the U.S. economy and society. For instance, entrepreneurs will be interested to learn that one-third of the applicants from the 2000 ATP competition had fewer than 10 employees. Innovators will find that, to date, almost 1,200 patents have resulted from just 736 ATP projects. Award statistics from all our competitions present an aggregate view of our program, and short case studies provide snapshots of a few completed projects.

We hope you find this report interesting and informative. We welcome your comments.

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Executive Summary

Technological ingenuity and innovation propelled the United States into a position of world economic leadership in the late nineteenth century. The capacity to unite innovation and opportunity has sustained U.S. economic growth into the twenty-first century and enabled our nation to rebound successfully from fiscal crises throughout our history.

During the great stagflation of the 1970s, businesses struggled to maximize profits in the short term, and many companies refrained from conducting long-term research and development (R&D). Other countries, including Japan, stepped up their investments in industrial R&D. These nations focused on bringing research results to the marketplace, which led to dramatic increases in the ability of Japanese firms to compete with the United States. In response, the U.S. Congress charged the Department of Commerce with creating and overseeing the Advanced Technology Program (ATP) to stimulate innovation in the United States.

Housed in the National Institute of Standards and Technology, the mission of ATP is to accelerate the development of innovative technologies for broad national benefit through partnerships with the private sector. ATP accomplishes this mission by providing cost-shared funding to industry for fledgling technologies that are high risk in nature, but which could lead to positive spillovers for other companies and industries, thereby boosting the U.S. economy and enhancing the quality of life of Americans.

Projects funded by ATP must meet the following selection criteria:

- Is the proposed technology highly innovative and high risk?
- Does the R&D plan feature feasible means of overcoming the high technical risk?
- Is it likely that sufficient equity or debt financing will not be available and/or that the scope, scale, or timing to meet a window of opportunity make federal government investment appropriate?
- Will the technology provide broad-based economic benefits for the United States?
- Is there a clear commercial pathway to economic benefits?

Another way to look at the issue of broad public benefits is to consider the *appropriability* of the benefits of a technology. ATP seeks to fund R&D where the resulting knowledge and technologies are not fully appropriable; that is, innovators cannot fully capture the financial returns to their investment. Instead, the benefits flow to other firms, industries, consumers, and the general public.

Through a competitive, merit-review process, ATP invests in projects that meet these criteria. Over 14 years, through 43 competitions and 6,054 submitted proposals to develop new technologies, ATP has made 736 awards which include 1,468 participants. Technology areas funded include manufacturing, information technology, biotechnology, electronics/photonics, and advanced materials and chemistry, covering a broad range of research topics. A total of $4.2 billion has been invested in ATP-funded projects, half of which represents industry contributions.

Since the inception of the program, ATP has performed rigorous and multifaceted evaluations to determine returns to the taxpayer. To assess whether the program is meeting its stated objectives, ATP's Economic Assessment Office (EAO) employs statistical analyses, case studies, surveys, benefit-cost analyses, and other methodological approaches to measure program effectiveness in terms of:

- Inputs (the funding and staff necessary to move the R&D effort forward)
- Outputs (project research results)
- Outcomes (products, processes, and services resulting from the innovation)
- Longer-term impacts (on industries, society, and the economy)

Key features of ATP's evaluation program include:

- The Business Reporting System, a unique online survey of participants, that gathers data on an annual basis on the business progress and indicators of future economic impact of funded projects.
- Status reports, which assess projects on a portfolio basis by rating completed projects three to five years out on a scale from zero to four stars, representing a range of performance from poor to outstanding. Rating criteria include solving challenging technical problems, producing patents or publications that could lead to further breakthroughs later on, making new technical knowledge available to others, accelerating the commercial use of new technologies, and assessing the future outlook for the project.
- Benefit-cost analyses, which identify, assess, and quantify the net private, public, and social benefits of ATP project outcomes.
- Economic and policy studies prepared by staff and external researchers that evaluate particular impacts of the program, including the effect of collaboration on the research productivity of participating organizations and the role of the program in the U.S. innovation system.

Returns for the American people, as measured from 41 of the 736 projects (just 6 percent of the portfolio), have exceeded $17 billion in economic benefits—more than eight times the amount invested by ATP. Resulting technologies have been delivered to the nation in new or improved industrial processes, products, and services, ranging from more efficient energy sources to improved medical tests.

EAO surveys have revealed the existence of a "halo effect" for participating firms—the ATP award establishes or enhances their expected value in the eyes of potential investors. Such validation is especially important for small companies with little or no market presence and limited financial resources—the type of firm ATP has most frequently funded. From 1990 through 2004, 66 percent of all ATP award recipients were small businesses; a large percentage had fewer than 50 employees.

ATP stresses the importance of partnerships and collaborations in its projects. A recent analysis of data showed that 86 percent of participants had collaborated with others in research on their ATP projects, with 69 percent of these companies stating that ATP brought about the collaboration "to a large extent." Company applicants are encouraged to propose projects that feature collaborations with other businesses, with federal laboratories, and with universities. Nearly 70 percent of joint ventures and more than 50 percent of single-company projects involve universities either as formal participants or subcontractors, which offers access to eminent researchers and open possibilities for further diffusion of knowledge created by the projects.

Several surveys confirm the fact that ATP involvement accelerates the development and commercialization of new technologies:

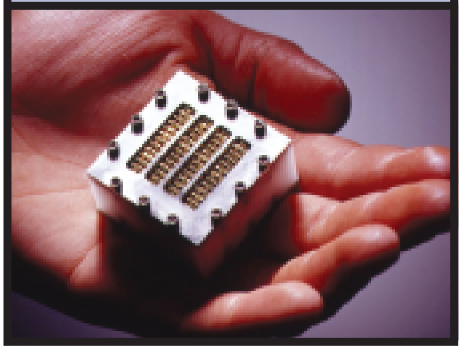
- Time to market was reduced by one year in 10 percent of projects; by two years in 22 percent of projects; and by three years in 26 percent of projects.
- Sixteen percent of funded projects would not have proceeded without ATP.
- In a control group of non-ATP winners, less than 40 percent had begun any aspect of their projects.

Success of ATP-supported R&D efforts can also be measured by:

- Increases in the number of patents granted—one study estimates an average increase of between 5 and 30 patents per firm per year of participation, attributable to ATP.
- The number of new products or processes—a study of the first 100 completed ATP projects shows that 122 new products or processes resulted from 64 of these projects.
- Changes in the size of participating companies—employment changes were profound for the small companies involved (59 companies at least doubled in size; 11 companies grew by more than 1,000 percent).

ATP's $2.2 billion investment has yielded substantial and measurable innovations for American businesses, industries, and the consumers of today—and tomorrow.

Technologies Fuel the Economy



ATP Invests in America's Future

Modern economies rely on the development of new technologies for economic growth and prosperity. The United States emerged as a world economic leader in the late nineteenth century due to ingenuity, breakthrough ideas, and the creative application of new knowledge. Since that time, emerging technologies have continued to support and promote America's economic growth. But while research, invention, and the creation of knowledge define an opportunity, it takes economic incentives to translate the opportunity into economic benefits. The success of a new technology depends on an economic environment conducive to its development and commercialization.

Since our nation's birth, the capacity to unite technological innovation and economic opportunity has enabled the nation to rebound from economic crises and achieve sustained growth. Today, America's ongoing commitment to foster technology development will depend on an environment that promotes exploration into new ways to address existing problems and challenges.

Investing in U.S. Technologies

After decades of strong growth in U.S. productivity, the oil embargo of 1973-74 led to a crisis in economic competitiveness. This crisis continued through the 1980s, with disabling energy shortages and a combination of high unemployment and double-digit inflation, or "stagflation." The dollar strengthened from a tight money policy and high interest rates, creating a ballooning trade deficit that affected not only traditional sectors like manufacturing, but also research-intensive industries—including electronics, machine tools, and semiconductors. The ability of U.S. firms to turn invention into innovations declined in the face of more formidable competition while investment capital dried up for research and development (R&D) into early-stage, high-risk technologies. This in turn heightened concerns about America's ability to compete economically with other world industrial powers.

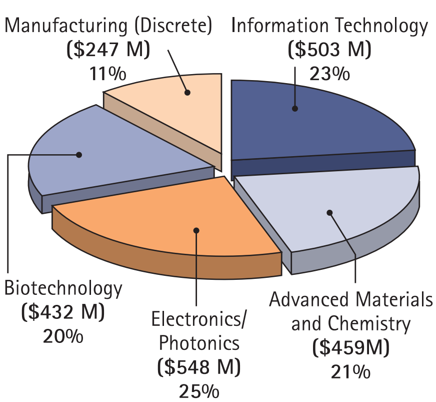
Congress passed several pieces of legislation to address declining U.S. competitiveness. Through the Omnibus Trade and Competitiveness Act of 1988, Congress charged the National Institute of Standards and Technology, an agency within the U.S. Department of Commerce, with creating and overseeing the Advanced Technology Program. With this step, Congress sought to provide cost-shared funding to industry to accelerate the development and broad dissemination of enabling, high-risk technologies with the potential to boost the U.S. economy and enhance the quality of life of Americans.

ATP at 14

In 14 years, through 43 competitions and 6,054 proposals for new technologies, ATP has made 736 awards to a total of 1,468 participants.[1] Projects with ATP involvement have totaled $4.1 billion, with $2.1 billion invested by ATP and another $2 billion by the commercial sector. Figure 1 shows the distribution of ATP funding by technology area. To date, more than 900 patents have resulted from ATP projects.

As shown in Figure 2, the projected returns for the American people from just a small portion of ATP projects far exceed the taxpayer dollars invested. These 41 projects—just 6 percent of the ATP portfolio—have returned estimated economic benefits exceeding $17 billion—far more than the total ATP cumulative investment of $2.1 billion for 736 projects.

Figure 1. 736 ATP Awards by Technology Area Forty-three Competitions (1990-May 2004)



The Need for a Federal Role

According to a 2002 study of the state of early-stage, high-risk funding for technology R&D in the United States, monies for such research remain limited—just as they were upon ATP's launch in 1990. Study coauthors Lewis M. Branscomb and Philip E. Auerswald report that the factors limiting the availability of R&D funding are several:

- Entrepreneurs see a lack of funding for projects "that no longer count as basic research but are not yet far enough along to form the basis for a business plan."
- "Markets, technologies, and their interrelation are becoming increasingly complex, further complicating the challenge of converting inventions into innovations."
- "...Even the large corporations with the largest R&D budgets have difficulty putting together all the elements required for in-house development and commercialization of science-based technologies."
- "Venture capitalists are not in the R&D business. Rather, they are in the financial business...to earn maximum returns for their investors."[2]

A further assessment of research data by Branscomb and Auerswald in 2004 examined corporate early-stage R&D investment decisions and the forces driving them. The new interview data from a sampling of 31 corporations reveal increasing pressure on these investments based on the sophistication of new technologies, the need to demonstrate financial value from the investment, and the maturity of the industry involved. In response, firms are exhibiting "a growing reliance on acquisitions, alliances, and outsourcing to obtain access to earlier stage technologies."[3]

These studies reflect a critical need for a federal role in funding. "National investment into the conversion of inventions into radically new goods and services," conclude the authors of *Between Invention and Innovation*, "...significantly affects long-term economic growth by converting the nation's portfolio of science and engineering knowledge into innovations generating new markets and industries."[4]

ATP as a Difference Maker—Addressing the Counterfactual

What difference did ATP make in the lives of fledgling technologies? In addition to accelerating technology development, ATP's involvement can provide a "stamp of approval" that attracts capital investment from other sources as well as opens the door to additional technical help. It can also broaden the scope of research and foster collaboration.

In measuring this counterfactual impact, all companies proposing new technologies to ATP were surveyed in 2000. Survey results indicate that without ATP support, many projects were not executed as originally proposed. As shown in Figure 3, survey data collected 18 months after the close of the 2000 competition reveal that 41 percent of nonawarded projects had no activity, and a similar number had less activity than proposed. Only 19 percent were pursuing research at or above the level of effort described in their proposals (which indicates ATP funding may not have been needed, and therefore was not awarded).[5]

Figure 2. Economic Benefits of 41 Selected ATP Projects in 10 Studies

Tissue Engineering	$10.90 B
Data Storage	3.00 B
Flow Control Machining	1.15 B
Advanced Composites	1.00 B
Component Based Software	0.80 B
Refrigeration	0.45 B
2mm Auto Body Consortium	0.20 B
Mammography	0.20 B
HDTV Technologies	0.13 B
Printed Wiring Board	0.04 B
Combined Net Economic Benefits—41 ATP projects	$17.87 Billion

Who Participates in the Program?

ATP provides competitively awarded funding to companies that wish to pursue innovative technologies. In response to an announced competition, companies propose R&D projects to the program. These proposals are then evaluated for technical and economic merit through a rigorous review process that includes strict criteria for companies that wish to participate. A variety of factors are considered before ATP makes its final choices for a given year, and invests in technologies that are high risk but also may be high payoff for many industries in many applications.

1 As of September 2003. Subcontracting organizations are excluded but are equal in number to formal participants.

2 Lewis M. Branscomb and Philip E. Auerswald, *Between Invention and Innovation: An Analysis of Funding for Early-Stage Technology Development*. NIST GCR 02-841, November 2002, pp. 3-11.

3 Lewis M. Branscomb and Philip E. Auerswald, *Understanding Private-Sector Decision Making for Early-Stage Technology Development: A 'Between Invention and Innovation' Project Report*, 2004.

4 Branscomb and Auerswald, *Between Invention and Innovation*, p. 11.

5 Advanced Technology Program, *Survey of Applicants 2000*, NIST GCR 03-847, June 2003, Fact Sheet 8: *What Happens to Nonfunded Projects?*

Figure 3. Current Status of Nonfunded Projects (Year 2000 ATP Competition)

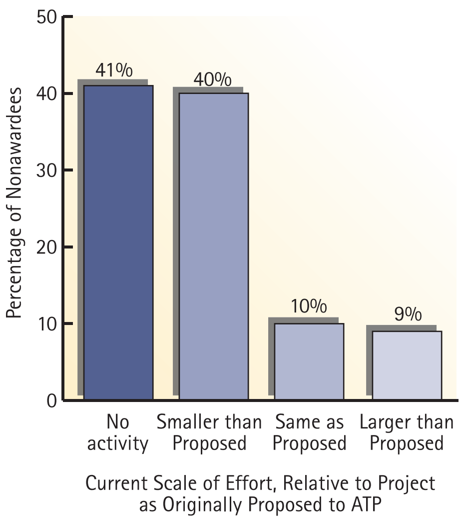
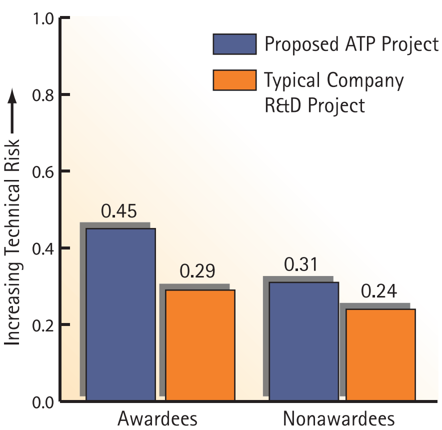


Figure 4. Technical Risk—Proposed ATP Projects and Typical Company R&D Projects



The survey also shows that ATP attracts and funds R&D projects with higher technical risk and longer time horizons than "typical" R&D efforts at applicant companies. "Technical risk" means extremely difficult technical challenges that make success uncertain.

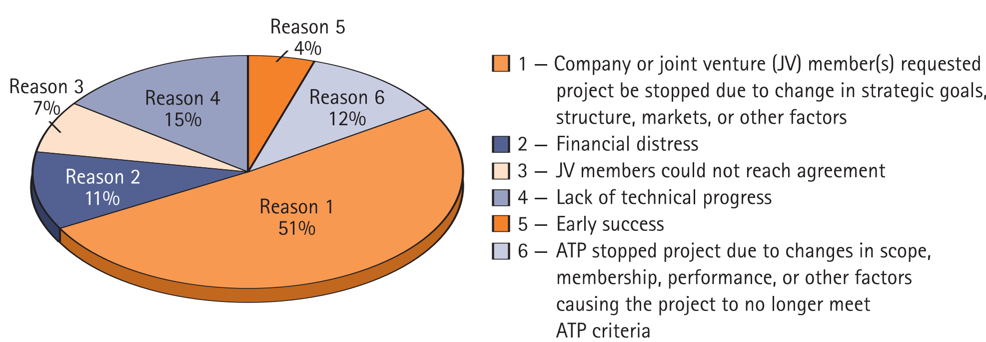
As shown in Figure 4, ATP awardees report a greater contrast between their proposed and typical R&D projects, as compared to nonawardees. Awardees estimate that the probability of *not* fully achieving technical goals in the ATP-proposed project is 0.45, while only 0.31 for nonawardees. Figure 4 also shows that both ATP awardees and nonawardees report a higher level of risk for projects proposed to ATP versus their typical R&D projects. Appropriately, awardees report significantly higher technical risk levels than nonawardees. In addition, the expected time it takes to see the impact of first revenue is longer for proposed ATP projects; more than half (54%) expect revenue in four years or more, while two thirds of nonawardees expect revenue before that time frame.

ATP funding has enabled companies in a variety of industries to pursue promising technologies that would otherwise have been ignored, developed more slowly, or pursued on a smaller scale.

Statistics from 2003 indicate that 86 percent of project participants believed they were significantly ahead in their R&D cycle as a result of ATP funding. Of these, 25 percent believed they would not have pursued the R&D at all without the ATP award; 53 percent believed they were one to three years ahead as a result of ATP funding; 7 percent believed they were more than three years ahead. The ideas and technologies developed from these research projects have sparked prosperity through innovation and improved the lives of Americans in a variety of ways.

In an economy where money invested in technology is measured in billions and even trillions of dollars, ATP's relatively modest allocations for research ($74.9 million to 35 companies, including 4 joint ventures in the May 2004 competition) make returns to date all the more significant. Just some of ATP's current portfolio of investments are expected to return $17.87 billion to the American people against the program's $2.1 billion investment. Each success strengthens participating companies while also delivering such economic benefits as quality-of-life improvements, consumer savings, productivity gains, and additions to Treasury receipts through taxes. Some innovations even spur whole new industries.

Figure 5. Distribution of Terminated Projects by Reason for Termination



Statistics based on 736 projects, including 74 terminated projects

Dealing with Failed Projects

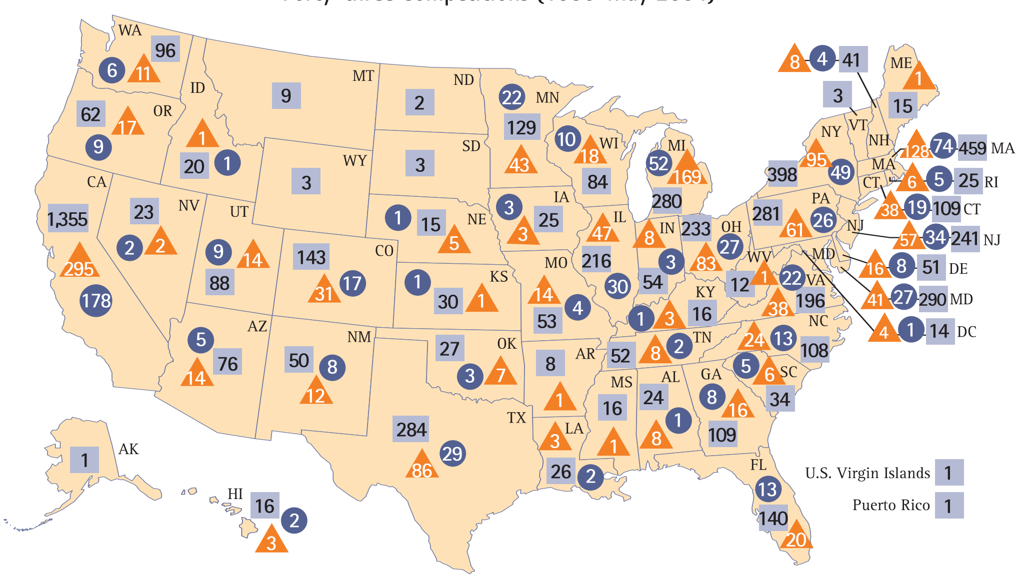
Not all ATP projects succeed; if ATP is meeting its mandate of funding high-risk research, failure must be expected from a percentage of funded projects. These "failures" include projects that never get off the ground, are terminated before completion, or show no or few outputs. In practice, however, most projects achieve something, whether it is patents, papers, collaborative relationships, or products—or knowledge about how to refine the program itself.

Only 5-6 percent of all ATP projects funded over the program's first decade were terminated after the award announcement and before completion.[6] Figure 5 reflects the 74 projects terminated by ATP, and the rationale for termination. Other poor performers are identified by ATP's rating system of 0 to PPPP (see page 26). Using these ratings, nearly a quarter of the first 50 completed ATP projects were considered to be poor performers. Such rigorous standards help to assure that projects are progressing and helping to meet program goals—even if a few never make it out of the gate, and others don't reach the finish line.

ATP Is a National Program

ATP does not take geographic location into consideration when making its project selections. Rather, ATP seeks to increase awareness across the nation of the program's opportunities for small, medium, and large businesses as well as other types of organizations. To date, ATP has received applications from organizations based in every state, and has provided funding to participating organizations located in 40 states and the District of Columbia—as shown below.

ATP Applications, Awards, and Participants by State
Forty-three Competitions (1990–May 2004)



Number of Applications (6,054 total)
Number of Awards (736 total)
Number of Participating Organizations (1,468 total)

Note: Total applications include six non-U.S. applicants.

[6] *Performance of 50 Completed ATP Projects, Status Report 2*, 2001, p. 260.

Positioning for Success

Through contractors and sponsored workshops, ATP provides both prospective applicants and awarded companies with a variety of resources designed to enhance the likelihood of a successful project. These resources include:

- The online *ATP PowerTips* interactive web site **(www.atppowertips.org)**, offering insights for entrepreneurs via audio clips in 10 categories plus the link, *Making Money With Your Technology: A Guide to Commercial Success.*
- *The Art of Telling Your Story: Tips & Insights for Putting Your Best Foot Forward with Investors and Corporate Partners* by Rick King **(http://www.atp. nist.gov/eao/gcr02-831/contents.htm)**, an easy-to-read, 41-page NIST guide to presentation tips and techniques for companies seeking investors.
- *The Alliance Network for R&D* on the web **(www.atp.nist.gov/alliance/ welcome.htm)**, which outlines the advantages and disadvantages of alliances for high-risk R&D, provides resources and best practices, and offers a bulletin board for R&D collaboration opportunities.
- *Commercialization and Business Planning Guide for the Post-Award Period*, a 265-page NIST text and workbook designed to increase the likelihood of commercialization success by companies that receive funding through the program.
- *ATP-sponsored workshops* on such topics as how firms should present themselves in order to maximize their opportunities for obtaining venture-capital funding.
- *Achieving Exports and Value-Added Partnerships with Japan: Considerations for U.S. High Tech Companies* by Gerald Hane, a study of U.S. emerging technology companies that have successfully entered markets in Japan, and their strategies for success.[7]

[7] Gerald Hane, *Achieving Exports and Value-Added Partnerships with Japan: Considerations for U.S. High Tech Companies*, 2004.

Does the Program Measure Up?

The Role of Evaluation at ATP

The nature of the Advanced Technology Program—combining federal tax dollars with private sector ingenuity and cost sharing to develop new technologies and refine manufacturing processes—demands that such a program be built on a foundation of evaluation. At any time, ATP must be prepared to show how the program benefits the U.S. economy. An effective measurement system for ATP must be sophisticated enough to answer a crucial question for Congress, the Office of Management and Budget, the General Accounting Office, and the American people: "*What does America gain by investing in high-risk technologies that industry would not fund on its own?*"

The ATP Economic Assessment Office (EAO) uses a battery of analytical tools to measure program effectiveness, including statistical analyses, case studies, surveys, stories, and more. These metrics address the design, conceptualization, implementation, and impacts of the program. They can look at selected features, or focus on measurement of certain outputs or outcomes expected based on the program's mission. They can be rigorous in the sense of searching for the most comprehensive and systematic set of causal linkages between and among variables, employing carefully constructed and sifted data. Or they can just be general and descriptive, offering a defensible answer to a particular question, given constraints on time, budget, and access to data.

ATP also attempts to measure the program's *counterfactual* impact—evaluating what would *not* have happened in the absence of ATP funding. What differences did the program funding make in scope of research, collaborations, attraction of additional capital, and acceleration of technology development. ATP benchmarks by scanning industries, patents, papers, and commercialization rates of companies that received ATP funding versus companies or industries that have not been funded through the program.

Figure 6 on page 10 depicts the progress of an idea from proposal through dispersal of knowledge and commercialization of a technology. It also shows the measures employed in the short, mid, and long term to compile a 3-D snapshot of the project and its impact. As shown, technologies that attract ATP investment tend to deliver a rather flat return for the developer(s), but a more significant return to the nation through absorption and use of the innovation by other firms and by society as a whole.

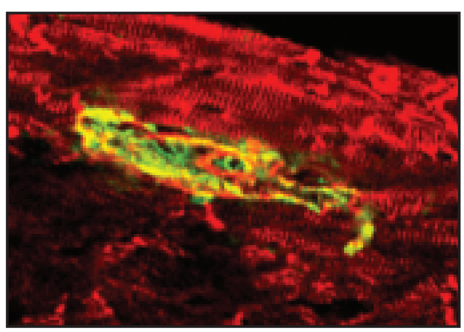
Short- and Long-term Measurement

How are benefits measured? The ATP evaluation program involves four categories of measurements, including:

- Program *inputs* derived from Congressional appropriations and industry cost-share to provide budgets for making awards, convening staff to carry out the research, and providing for equipment, facilities, and other direct costs.
- Principal *outputs*, including the funded projects, collaborative relationships formed as a result of the program, plus publications, patents, models and algorithms, and prototype products and processes.
- Principal *outcomes*, including sales of new and improved products, processes, and related services; productivity effects on firms; changes in firm size and industry size; changes in the inclination of firms and other organizations to collaborate; the spread of resulting knowledge through publications, presentations, patents, and other means; and the adoption of the funded innovations—and various adaptations—by the market.
- Longer-term *impacts* related to the broad societal goal that drove the program's creation, including increased GDP, employment gains, improved international competitiveness of U.S. industry, and quality-of-life improvements to the nation's health, safety, and environment. Impacts may also include an effect on the nation's capacity to innovate.

Evaluation objectives include tracking progress of funded projects; estimating benefits and costs of projects and of the program overall; identifying the more difficult-to-measure effects, such as adaptations of the knowledge by others; relating findings back to the program's mission; and applying tests of success. Additional objectives include disseminating evaluation results and feeding them back to program administrators (to improve the program) and to policy makers (to inform them and meet reporting requirements).

Not all projects progress at the same rate. Recent results from ATP's Business Reporting System (BRS) looked at the rate of development of innovative technologies by industrial sector. This study found that information technologies and electronics enter the market quickly, with commercialization soon after the ATP funding period. Manufacturing and materials/chemical projects tend to commercialize at a slower rate because they typically involve new process technologies in mature industries. Because of regulatory requirements for many health care applications, biotechnologies also enter the market at a slower rate, and major applications often can be implemented more than five years after ATP funding ends.[8]



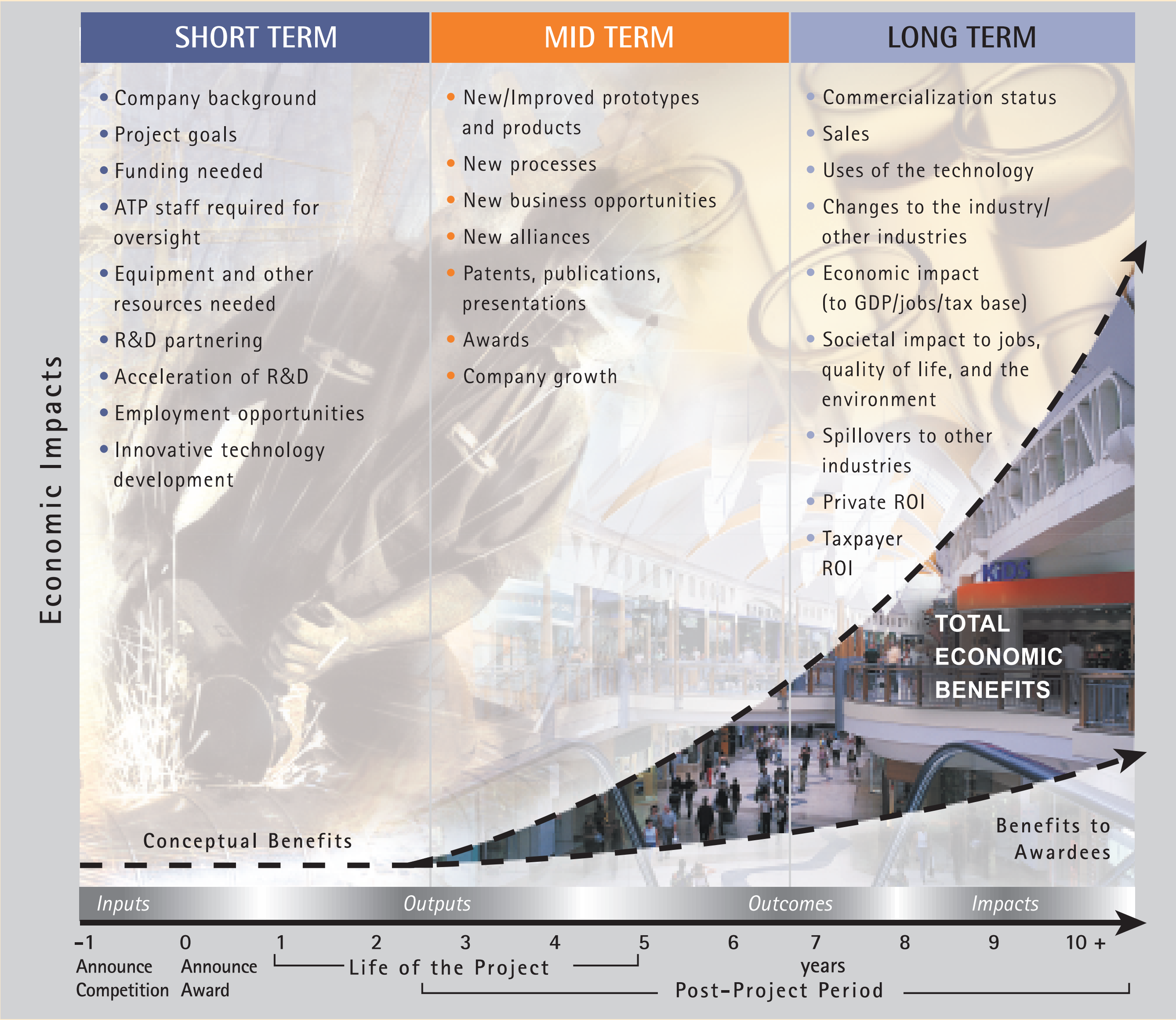
ATP funding helped Osiris Therapeutics, Inc., of Baltimore to research the regeneration of damaged heart tissue using adult stem cells derived from bone marrow. In this image from animal testing, human stem cells are seen in an adult mouse heart 60 days after implantation. Osiris worked with researchers at Johns Hopkins University, the University of Florida, and Emory University on the project. Fifty percent of ATP awards include a university researcher among the principals, which speeds the dissemination of new technologies.

[8] Jeanne M. Powell and Francisco Moris, *Different Timelines for Different Technologies: Evidence from the Advanced Technology Program*, NISTIR 6917, November 2002.

Figure 6. Timeline: What EAO Measures and When

In the EAO timeline, economic impacts are depicted on the vertical scale and time on the horizontal scale. A Conceptual Benefits curve starts above zero at the time of competition announcement, implying that there will be benefits from the technology project planning, and from the formation of collaborations stimulated by the announcement. The curve then splits at about mid-project. The lower curve, Benefits to Awardees, shows returns to the project innovators increasing over time as they commercialize or license their technology. This curve remains relatively flat, however, due to such factors as appropriability, or the degree that firms are able to protect the profitability of their inventions (see page 25 for more on appropriability). The upper curve, Total Economic Benefits, shows returns to the economy at-large increasing as the technology diffuses to wider use and generates spillovers. The Total Economic Benefits curve veers more steeply upward from the Benefits to Awardees curve as the project nears completion, signifying an expectation of increasing spillover effects over time.

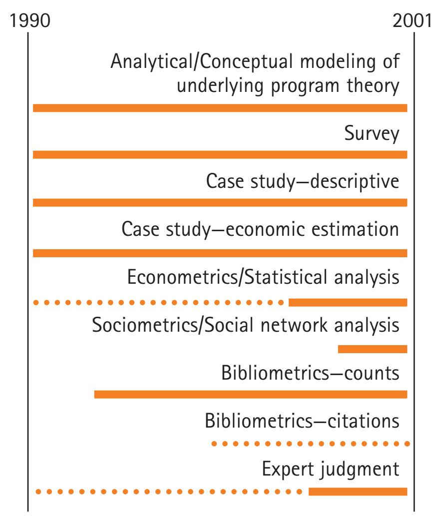
Sources: Ruegg, *Assessment of the ATP*, 1999, p. 19; Cohen and Walsh, *R&D Spillovers, Appropriability and R&D Intensity*, 2000.



How Does ATP Measure?

Programs such as ATP use a variety of evaluation methods to "measure against mission." These methods can range from early surveys used to generate immediate information to detailed case studies, statistical analyses, tracking of knowledge created and disseminated through patents and citation of patents, and informed judgments. Table 1 shows the full range of evaluation methods available to ATP. Figure 7 shows the actual use of these methods by ATP since its inception in 1990.

Figure 7. Intensity of ATP's Use of Evaluation Methods



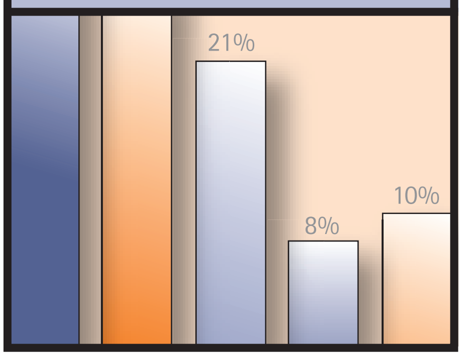
Since 1990, ATP has employed a growing number of evaluation methods to gauge the success of the program mission in accelerating U.S. technology development and increasing research partnerships.

Table 1. Overview of Evaluation Methods*

Method	Brief description	Example of use
Analytical/Conceptual modeling	Investigating underlying concepts and developing models to better understand a program, project, or phenomenon	To describe conceptually the paths through which spillover effects may occur
Survey	Asking multiple parties a uniform set of questions for statistical analysis	To find out how many companies have licensed their newly developed technology to others
Case study—descriptive	Investigating in-depth a program, project, technology, or facility	To recount how a particular joint venture was formed, how the collaboration worked, and reasons for success—or lack thereof
Case study—economic estimation	Adding quantification of economic effects to a descriptive case study, using, for example, benefit-cost analysis	To estimate whether, and by how much, benefits of a project exceed its cost
Econometric and statistical analysis	Using statistics, mathematical economics, and econometrics to analyze links between economic and social phenomena, and to forecase economic effects	To determine how public funding affects private funding of research
Sociometric and social network analysis	Identifying and studying the structure of relationships to increase the understanding of social/organizational behavior and related economic outcomes	To learn how projects can be structured so that the diffusion of resulting knowledge can be increased
Bibliometrics—counts	Tracking the quantity of research outputs	To find how many publications per research dollar a program generated
Bibliometrics—citations	Assessing the frequency with which others cite publications or patents and noting who is doing the citing	To learn the extent and pattern of dissemination of a project's publications and patents
Bibliometrics—content analysis	Pulling information from text using co-word analysis, database tomography, and textual data mining, as well as visualization techniques	To identify a project's contribution, and its timing relative to the evolution of a technology
Historical tracing	Tracing forward from research to a future outcome, or backward from an outcome to contributing developments	To identify linkages between a public research project and significant later occurrences
Expert judgment	Using informed judgments to make assessments	To hypothesize the most likely first use of a new technology

* Rosalie Ruegg and Irwin Feller, *A Toolkit for Evaluating Public R&D Investment Models, Methods, and Findings from ATP's First Decade*, NIST GCR 03-857, July 2003, pp. 30-31.

Continuous Monitoring and Improvement



ATP Project Management

The management process for projects funded by ATP is designed to assure that the R&D effort remains faithful to the original proposal (which satisfied the program's strict selection criteria), and to the cooperative agreement governing the award. Figure 8 defines the roles and responsibilities of the ATP project management team. Project management monitors the technological and business progress made in the projects through each project milestone. These include:

- Defining, qualitatively and quantitatively, what it means to overcome technical barriers.
- Integrating the efforts of various project tasks.
- Advancing the state of the technology.
- Describing a project's achievements.
- Providing a foundation for reporting project activities and accomplishments.

These milestones are used by the program in a number of ways. They help ATP to encapsulate the scope and merit of the project versus its original goals. They also help to define critical project decision points, and clarify alternative pathways that can optimize success.

Within the project oversight process, and because of the nature of innovative, high-risk research, ATP expects changes to occur. In fact, the program is accepting of changes that will strengthen the project and enhance the prospects for success—as long as those changes work in the context of the selection criteria, terms and conditions of the award, budget, commercialization plan, and other important factors.

Business Reporting

Since 1994 EAO has used its Business Reporting System (BRS) to gather data from companies, universities, and laboratories participating in ATP-funded projects. In 1999 EAO switched to the web and began collecting survey data via secure Internet connection. Figure 9 summarizes the system's five surveys that track ATP projects over time. The BRS helps to create an ever-more-concise picture of the company, the project, and the impacts of the technology under development.

The five BRS surveys are:

1. A *baseline report* completed before the project begins to identify a company and establish the goals of the project.
2. *Quarterly reports* to provide an update of developments in the project.
3. *Anniversary reports* to detail the status of the project in terms of collaboration, new applications of the technology, publications and presentations, and company financial data.
4. *Closeout reports* to identify remaining barriers to commercialization, set five-year business goals for the technology, and identify expected spillovers.
5. *Post-project reports* at two, four, and six years following the completion of the project to document actual progress in commercializing the technology and impacts of the innovation to the company and society.

Over time, BRS survey results form the basis for a database of companies, proposed technologies, business impacts, and spillover benefits for industries and the nation.

ATP Competitions

ATP concentrates on those technologies that offer significant, broad-based benefits to the nation's economy—technologies that likely would not be developed without program support because they are judged too risky. Often they are path-breaking approaches. The subjects of ATP research projects are proposed by industry, and competitions are open to proposals from any area of technology.

Of all the proposals received by ATP, about 12 percent result in awards because each potential research project must meet a list of strict criteria to qualify for funding. Each innovative technology must have the potential for broad benefits to the nation in jobs, economic growth, and better quality of life. Specifically, the program looks for proposals with strong technological and economic merits. As explained in the *ATP Proposal Preparation Kit:*

- The proposal must convince expert reviewers that the project involves a high level of **technical merit**.
- Successful proposals must effectively balance **high technical risk with evidence of scientific and/or engineering feasibility** for overcoming that risk.
- The **technical plan** must explain how the technical objectives will be reached, addressing all the anticipated problems and describing how these problems will be handled.
- Submitters must explain the business opportunity and identify future users of the technology, as well as describe its **national economic significance**, additional societal benefits, and how it improves upon existing technology.
- In establishing the **need for ATP funding**, efforts made to obtain funding from other sources must be described, along with the results of those efforts.
- To characterize the **pathway to economic benefits**, the experience and structure of the firm must be documented, as well as what products will result from the technology, how those products will be commercialized, and how the technology will be broadly diffused.[9]

Proposals are evaluated in peer-reviewed competitions against the above criteria. Reviewers are experts in such fields as biotechnology, photonics, chemistry, manufacturing, information technology, or materials, and sit on one of several technology-specific boards. All reviewers are screened by ATP for conflicts of interest and sign nondisclosure agreements.

Each proposal receives appropriate, technically competent reviews even if it involves a broad, multi-disciplinary mix of technologies. When proposals are deemed to meet all criteria, ATP uses cooperative agreements to enter into cost-sharing arrangements with recipients rather than awarding an outright grant. Awarded funds can only be applied to research costs approved by the board.

Figure 8. ATP Project Management (PM) Team Roles

Project Manager
- Provides general oversight and PM functions
- Ensures that the project is executed in accordance with the proposal and award
- Recommends appropriate actions to the NIST Grants Officer
- Reviews technical reports and progress against milestones
- Assists in research and evaluation of ATP projects

Business Specialist
- Reviews business and commercialization issues
- Follows the diffusion strategy of results beyond the commercialization path
- Assists in research and evaluation of ATP projects

NIST Grants/Cooperative Agreement Specialist
- Performs cooperative agreement administration
- Issues final prior approval for changes (Grants Officer)

Figure 9. Summary of ATP Business Reporting System

	Survey Type				
💻 = Web 📞 = Phone	Baseline	Quarterly	Annual	Closeout	Post project
Business Plans • Identification of planned applications • Strategies for commercialization, protection of intellectual property, and dissemination of non-proprietary information	💻				
Significant business developments					
Update of business plan and progress • Products, processes, and licensing activity			💻	💻	📞
Collaboration experiences			💻	💻	📞
Attraction of new funding			💻	💻	📞
New intellectual property			💻	💻	📞
Technology diffusion			💻	💻	📞
Company financial data			💻	💻	📞
Next 5 years—technical and business goals				💻	
Effects outside your organization				💻	📞

[9] Excerpted from the *ATP Proposal Preparation Kit*, February 2004.

Enhancing the Competitiveness of U.S. Companies

Program Impact on Private Firms

Private firms play a central role in ATP operations. The program seeks to attract these firms as partners, and relies on them for their:

- Specialized market knowledge.
- Profit orientation.
- Entrepreneurial ability.

At the same time, ATP seeks to create the conditions necessary to maximize the chances of project success. Recently, EAO compiled 13 studies that looked at the factors leading firms to seek funding from ATP for the development of new technologies—and how the program and its processes affected these firms. Table 2 lists these studies by author, with column headings indicating the six major sub-themes covered in the research.[10]

ATP Support Addresses the Financing Gap

Private firms face important barriers to innovation because of the great amount of time it takes to make progress in the research lab and commercialize in the marketplace. In 1999 ATP commissioned a study by Lewis M. Branscomb (principal investigator) and others to look at the decision-making process for the funding of early-stage, high-risk technology R&D projects inside firms and with outside investors. The goal was to better identify projects not undertaken or pursued less vigorously by industry that would meet ATP criteria of having broad-based technical benefits and commercial success. ATP bridges what the study refers to as this "…serious gap…the 'Valley of Death' in R&D."[11]

Table 2. Studies Showing the Impacts of ATP on Private Firms

Author	Year of publication	Financing gap and investment choices	Halo effect	Acceleration	Firm productivity	Small firm participation	Commericalization, company growth, and private returns
Darby et al.	2002				4		
Sakakibara and Branstetter	2002				4		
ATP Status Report 2	2001			4			4
Feldman and Kelly	2001	4	4				
Pelsoci	2001			4			4
Branscomb et al.	2000	4					
Powell and Lellock	2000	4	4	4			4
Ehlen	1999			4			4
Gompers and Lerner	1999	4					
Powell	1999					4	4
RTI	1998			4			4
Laidlaw	1997			4			
Solomon Associates	1993		4				

[10] Rosalie Ruegg and Irwin Feller, *A Toolkit for Evaluating Public R&D Investment Models, Methods, and Findings from ATP's First Decade*, NIST GCR 03-857, July 2003, pp. 295-365.

[11] Branscomb et al., *Managing Technical Risk: Understanding Private Sector Decision Making on Early Stage, Technology-based Projects,* NIST GCR 00-787, 2000, p.2.

In this desolate place between invention and innovation, the risk of failure may be too high to attract venture capital. In addition, the value to the individual company may not be high enough to warrant the investment, and the company may lack the infrastructure necessary to take it to fruition.

A 1999 study by the Harvard Business School looked at seven small start-up companies in the Boston area that turned to ATP for funding. The goal of the study was "to identify the role played by ATP in the R&D activities of these companies, to determine whether their needs were adequately addressed by private venture capital investors alone, and to examine the interactions between venture financing and public initiatives in assisting these firms."[12] This study found that, "The Advanced Technology Program has substantially expanded and enhanced the R&D activities of our seven-company sample."[13]

ATP helps to bridge the Valley of Death by providing participating companies with:

- Cost-shared funding.
- Partnership opportunities with other companies, federal laboratories, and universities.
- Peer-reviewed evaluations of technical and business plans.
- Control of intellectual property rights.
- ATP project monitoring activities and reporting regulations.
- The "halo effect" in attracting funding that results from the prestige of winning an ATP award.

Table 3 illustrates the impact of ATP involvement on the goals of three ATP projects. As can be seen, goals established with ATP funding were far more ambitious than those without ATP funding.

The Halo Effect

From the first survey of ATP effectiveness, firms participating in the program have recognized the validity of a "halo effect"—the fact that an ATP award enhances the respect paid to such a firm. In fact, ATP's second major survey, covering the first three competitions, replaced the term "halo effect" with "increased credibility." This survey concluded that 90 percent of participants benefited moderately or greatly from enhanced credibility because of the award.[14]

A study of BRS survey data in 2000 revealed that 93 percent of participating firms perceived that they had increased credibility due to the ATP award. This study stated that, "The 'halo effect' may be...of particular benefit to ATP-funded small businesses, which have little if any market presence and typically very limited financial resources at the time of the ATP award."[15]

Table 3. The Impact of ATP Funding on Company Goals for Three Different Technologies

Status at project start	Goal without ATP funding	Goal with ATP funding
1 gene per day sequenced	5 genes per day sequenced	100 genes per day sequenced
$500 cost per medical test	$500 cost per medical test	$50 cost per medical test
3.9 gigabytes data storage	4.7 gigabytes data storage	60 gigabytes data storage

Source: Powell and Lellock, *Development, Commercialization, and Diffusion of Enabling Technologies: Progress Report*, p. 11.

[12] Gompers and Lerner, *Capital Formation and Investment in Venture Markets: Implications for the Advanced Technology Program*, NIST GCR 99-784, 1999, p. iv.

[13] Gompers and Lerner, p. 20.

[14] Silber and Associates, *Survey of Advanced Technology Program 1990-1992 Awardees: Company Opinion About the ATP and its Early Effects*, 1996, pp. 41-43.

[15] Jeanne W. Powell and Karen Lellock, *Development, Commercialization, and Diffusion of Enabling Technologies: Progress Report*, ATP, 2000, p. 31.

Another study compared winners and non-winners, and found evidence that ATP encourages pursuit of new technical areas outside the scope of participating firms' past R&D activities. This study found that 28 percent of all proposals were in a technical area new to the proposing firm. For award winners, that number jumped to 47 percent. In effect, ATP cost sharing enabled firms "to initiate risky projects in new technical areas."[16]

Acceleration of Technology

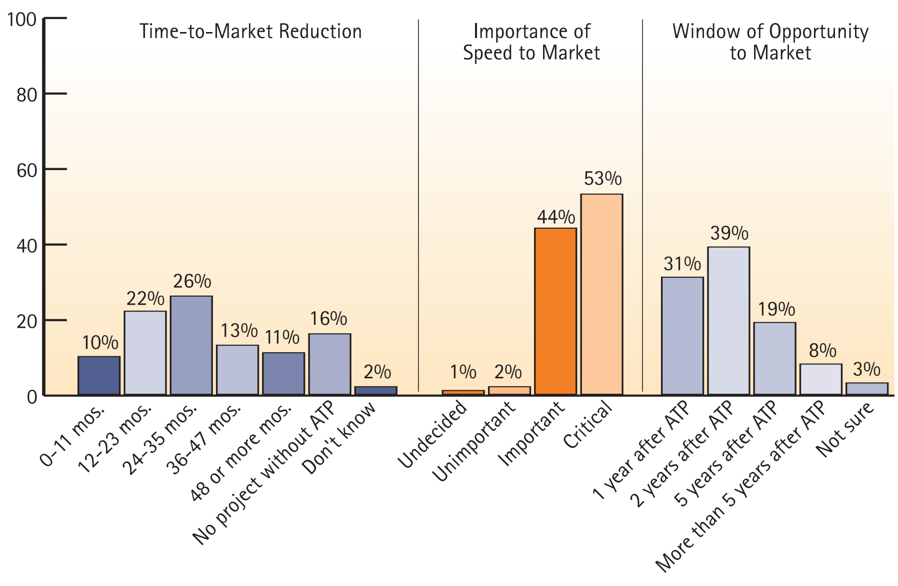
Since ATP was established to accelerate the development and commercialization of technology, success in the area of acceleration has been tracked by surveys throughout the life of the program. A 1996 survey by Silber & Associates found that the R&D cycle was shortened by at least two years for 95 percent of participants.[17]

Another study noted, "...nearly all companies expect some reduction in the time it will take to complete the R&D phase and bring their products to market/or implement new product processes as a result of ATP funding....A reduction of at least two years is anticipated for 65 percent of all applications." Based on BRS data, this study identified three aspects of timing: the estimated reduction in time to market, the importance of speed, and the perceived length of the window of opportunity. Figure 10 captures these aspects.[18]

ATP also affects acceleration in terms of likelihood to proceed with R&D, as less than 40 percent of one control group of non-ATP winners had begun any aspect of their projects after *not* being chosen by the program.[19]

An interview-based analysis of 28 companies funded in 1991 found that 96 percent of interviewees considered reduction of cycle time to keep pace with the competition to be "very important." When asked for an estimate of time savings due to ATP, the median response was by 50 percent or three years. The economic value of shortening the research cycle by just a year was estimated by many firms to be in the millions of dollars, as shown in Table 4. As for ways that ATP cut cycle time, firms participating in the study identified five principal factors. These are summarized in Table 5.[20]

Figure 10. Importance of Timing



Source: Business Progress Reports for 1,841 applications being pursued by 1,015 companies in 611 ATP projects funded 1993-2003.

Many firms stated that ATP's requirement of well-laid-out R&D and business plans meant even more to acceleration than ATP's funding. The same study found that 86 percent of those interviewed expected the time saved in the R&D stage to flow through to later project stages, including commercialization.[21]

Increasing Productivity Within Firms

Tracking changes in the number of patents secured by ATP participants helps to measure increases in productivity due to ATP. One study looking at changes in the number of patents secured by ATP firms estimated an increase in patenting that averaged between 5 and 30 patents per firm per year of participation, attributable to ATP.[22]

Another study also used patent data to measure productivity increases among ATP participants. The authors compared ATP participants with a control group and found that taking part in ATP joint ventures increased patenting in the targeted technology areas above those levels established prior to participating in the project. The rate of increase in productivity due to an ATP project, as measured by patents, was 8 percent per year. Productivity was found to be highest among consortia with members expert in the same area of technology.[23]

Table 4. Estimates of Economic Value of a One-Year Reduction in Applied Research Cycle Time, in Order of Decreasing Value ($5 Million to $6 Million Median Value)

Size of firm	Economic value to getting to market one year sooner	Nature of the economic value
Medium/Large	$100s of millions to billions	Sales revenue
Medium/Large	$1 billion	Sales revenue
Medium/Large	$100 to 200 million	Sales revenue
Small	$15 to 250 million to ultimately half-billion	Sales revenue
Small	$10 to 100 million	Sales revenue
Small	$10 to 30 million	Sales revenue
Medium/Large	$15 million	Sales revenue
Small	$5 to 6 million (median value)	Sales revenue
Medium/Large	$5.2 million	Capital cost savings
Small	$2 to 5 million	Sales revenue
Small	Millions of dollars	Sales revenue
Small	Millions of dollars	Sales revenue
Small	Millions of dollars	Sales revenue
Medium/Large	$2 million	Sales revenue
Small	$1 to 2.25 million	Sales revenue and cost savings

Source: Laidlaw

Table 5. ATP Effects that Helped Interviewees to Reduce Cycle Time

ATP effects that helped interviewees to reduce cycle time	Frequency of mention	Percent
ATP's required project planning and management	15	25.86
Achievement of critical mass of resources with ATP funding	12	20.69
Attraction of additional financial support through ATP "halo effect"	12	20.69
Greater project stability through focus on technical problem	12	20.69
ATP's emphasis on collaboration	7	12.07
Total	**58**	**100.00**

Source: Laidlaw

16 Maryann Feldman and Maryellen Kelley, *Winning an Award from the Advanced Technology Program: Pursuing R&D Strategies in the Public Interest and Benefiting from a Halo Effect*, NISTIR 6577, 2001, pp. 18-19.

17 Silber and Associates, *Survey of Advanced Technology Program 1990-1992 Awardees: Company Opinion About the ATP and its Early Effects*, ATP, 1996, pp. 37-40.

18 Powell and Lellock, pp. 11-12.

19 Feldman and Kelley, p. 29.

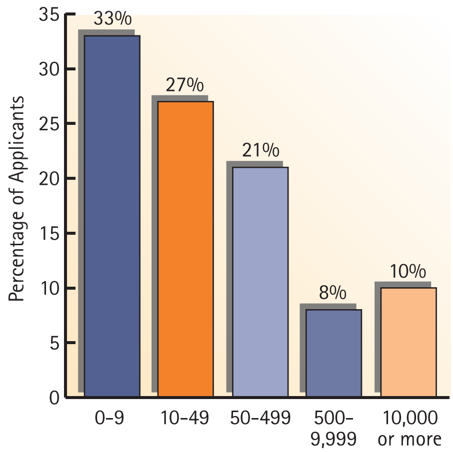
20 Frances Jean Laidlaw, *Acceleration of Technology Development by the Advanced Technology Program: The Experience of 28 Projects Funded in 1991*, NISTIR 6047, 1997.

21 Ibid, p. 25, pp. 34-35.

22 Michael R. Darby, Lynne G. Zucker, and Andrew Wang, *Program Design and Firm Success in the Advanced Technology Program: Project Structure and Innovation Outcomes*, NISTIR 6943, 2000, p. 10.

23 Mariko Sakakibara and Lee Branstetter, *Measuring the Impact of ATP-Funded Research Consortia on Research Productivity of Participating Firms: A Framework Using Both U.S. and Japanese Data,* NIST GCR 02-830, 2002, p. vi.

Figure 11. Number of Employees Among Year 2000 ATP Applicants



Participation of Small Firms

ATP's mission specifications include the line, "Ensure appropriate small-business participation." Since this is the case, ATP's self-evaluations address the following question: "Have small firms been able to compete successfully against larger firms for ATP awards?"

A study by the ATP Economic Assessment Office analyzed BRS data to help answer the question. These data show that the majority of ATP-participating companies, including subcontractors, are classified as "small," with fewer than 500 employees, and that 61 percent of awards have gone to projects led by small firms.[24]

ATP's year 2000 survey of firms applying for funding also addressed company size. Figure 11 shows the number of employees per firm applying to ATP in 2000.[25] The study looked for signs of commercial success and economic impact from the small companies that received awards from ATP. Results showed that small firms were making solid progress toward early stage commercialization.[26] Table 6 shows results from the study's comparison of small and larger firms in terms of earning revenue, adopting process improvements, and filing for patents.

Impact on Private Companies

As they make progress toward commerciali-zation, innovating firms that participate in a project cost shared by ATP may experience growth, higher sales, and increases in capitalized value, revenue, and return on investment. Figure 12 shows the employment change at 64 small companies receiving a single-company award from ATP.[27] Collaborators and licensees close to such firms are also positioned to make early commercial progress.

The activities of awardees and their collaborators and licensees constitute ATP's "direct path to impact." A study of the first 100 completed ATP projects shows that 64 of these projects yielded a total of 122 new products or processes. Employ-ment changes were profound for the small companies involved—59 companies at

Table 6. A Comparison of Small and Larger Firms in ATP

Measure of commercial progress	Small firms (percent)	Larger firms (percent)
Revenues earned	26	11
Filed for a patent	39	31
Adopted process improvements	45	38

Source: Powell, *Business Planning and Progress of Small Firms Engaged in Technology Development through the Advanced Technology Program*, 1999, p. 45.

[24] Jeanne W. Powell, *Business Planning and Progress of Small Firms Engaged in Technology Development through the Advanced Technology Program*, NISTIR 6375, 1999, with the percentage participation figure updated by Powell in 2002.

[25] ATP, *Survey of Applicants 2000*, fact sheet 11.

[26] Ibid., p. 45.

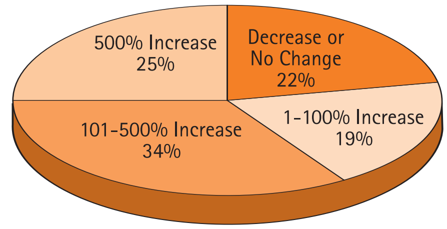
[27] *Performance of 50 Completed ATP Projects*, Status Report-Number 2, NIST SP 950-2, 2001.

least doubled in size; 11 companies grew by more than 1000 percent. Table 7 looks at the progress of the first 50 projects in reaching the commercialization of new technologies.[28] Table 8 provides examples of products and processes realized from the first 50 completed ATP projects.[29]

A recent study looked at the impact of new closed-cycle air refrigeration (CCAR) technology developed with cost-shared ATP funding by Air Products and Chemicals, Inc. of Allentown, Pennsylvania, and Toromont Process Systems, Inc. of Houston, Texas. (See also page 27.) This technology uses dry air as the working fluid for ultra-cold refrigeration. Applications include food processing, uses in liquid natural gas, and recovery systems for volatile organic compounds. The base case net present value of CCAR as of 2001 was $459 million, or $220 in returns for each dollar invested by ATP in the technology ($2.1 million total). CCAR also provides benefits across several industries, as well as significant reductions in harmful emissions of carbon monoxide, nitrogen oxide, and particulates. At the same time, direct economic benefits for the two companies involved were more modest, with $64.8 million projected from CCAR installations.[30]

Such returns to companies—versus industries and the economy as a whole—are brought about because of the strict criteria used by ATP in choosing technologies with the potential for broad impact.

Figure 12. Employment Change at 64 Small Companies Receiving a Single-Company Award



Source: Advanced Technology Program, *Performance of 100 Completed ATP Projects, Status Report 3*, 2004.

Table 7. Progress of Participating Companies in Commercializing New Technologies

Nature of commercialization progress	Number of projects	Number of products/process
Product/Process on the market	64	122
First product/process expected soon	11	21
On the market with additional product/process expected soon	12	42
On the market or expected soon	75	157

Source: Advanced Technology Program, *Performance of 100 Completed ATP Projects, Status Report 3*, 2004.

Table 8. Examples of Products and Processes from the First 50 Completed ATP Projects

Award name	Technology developed	Product or process commercialized or near commercialization
Integra LifeSciences	Scaleable process for manufacturing a new bioabsorbable polymer	Tyrosorb Synthetic Polymers, a new material for making implantation devices for musculoskeletal surgical applications
Cree Research	Methods for increasing quality and size of silicon carbide single crystals	Less expensive blue light-emitting diodes and improved silicon carbide wafers
American Superconductor Corporation	Wire fabrication and winding techniques for high-temperature superconducting materials	CryoSaver™: electrical wires that carry current into and out of cryogenically cooled devices

Source: Advanced Technology Program, *Performance of 50 Completed ATP Projects, Status Report 2*, 2001, Appendix A, pp. 253-258.

28 Extracted from the *Performance of 100 Completed ATP Projects*, Status Report – Number 3.

29 Ibid.

30 Thomas Pelsoci, *Closed-Cycle Air Refrigeration Technology: For Cross-Cutting Applications in Food Processing, Volatile Organic Recovery, and Liquid Natural Gas Industries*, NIST GCR 01-819, December 2001.

Collaboration in ATP Projects

Bringing the Best Minds Together for R&D

ATP's statute includes a mandate to "aid industry-led United States joint research and development ventures." Various studies by the ATP Economic Assessment Office and others have looked at joint ventures in terms of their stability, the factors that help them succeed, their benefits and costs, and the role of universities. A 1995 study of early ATP projects found that the average joint venture had six members, and that 43 percent of joint venture members "forged subcontracting relationships with an average of five additional companies."[31]

More recently, an analysis of BRS data from 415 participants in 198 ATP projects provides further evidence that collaborative activities are extensive. Among single-company applicants and joint ventures, 86 percent of respondents had collaborated with others on projects, with 69 percent of these companies stating that ATP brought about the collaboration "to a great extent." The same study noted that many strategic alliances—with producers, suppliers, customers, distributors, and licensing partners—had been formed primarily to commercialize ATP-funded technologies.[32]

Another study of firms that won—or failed to win—ATP awards determined that the program successfully encouraged applicants to propose projects featuring collaboration, frequently with entirely new partners. While 79 percent of 1998 applicants included other organizations in their proposals to ATP, 59 percent of award winners sought first-time partnerships, while only 42 percent of non-winners sought first-time partnerships. These numbers support the idea that the selection process at ATP encouraged new partnerships by favoring the selection of proposals that included new partnership opportunities.[33]

Table 9 summarizes the incidence of collaboration as tracked in a number of surveys throughout the life of ATP. Similar findings resulted from the *Survey of Applicants 2000,* which studied companies submitting proposals to ATP in the 2000 competition.[34]

Table 9. Summary of Study Findings on Frequency of Collaboration

Percent collaborating	Sample	When surveyed	Source
46% of participants	26 participants in 1990 competition	1992-1993	Solomon Associates survey
52% of single-company awardees	125 participants in three competitions 1990-1992	1995	Silber & Associates survey
79% of applicants	395 applicants in 1998 competition	1999	Feldman and Kelley survey
86% of participants	414 participants in 198 projects, 1993-1997	1998	Powell and Lellock
86% of completed projects	100 first completed projects	1997/2003	ATP
85-90% of applicants	555 applicants in 2000 competition	2000	ATP/Westat

[31] Silber and Associates, *Survey of Advanced Technology Program 1990-1992 Awardees: Company Opinion About the ATP and its Early Effects*, ATP, 1996.

[32] Powell and Lellock, *Development, Commercialization, and Diffusion of Enabling Technologies: Progress Report*, 2000, p. 19.

[33] Feldman and Kelley, *Winning an Award from the Advanced Technology Program: Pursuing R&D Strategies in the Public Interest and Benefiting from a Halo Effect*, NISTIR 6577, 2000, pp. 19-20.

[34] *Survey of Applicants 2000*, NIST GCR 03-847.

University Involvement

In its first decade of operation, ATP came to recognize the importance of universities as collaborators in projects. Universities involved in R&D efforts provide major benefits to the participants and their research: Companies working with universities gain access to eminent researchers, while universities collaborating with private firms in an ATP project acquire needed additional funding and, often, insights into industry problems that hone their research efforts. Table 10 shows the prominent role played by universities in the first 50 completed ATP projects.

Nearly 70 percent of joint ventures and more than 50 percent of single-company projects involve universities; one study found that as of 1999, 57 percent of all ATP projects included universities as joint venture members or subcontractors.[35] As reflected in Figure 13, 78 percent of firms included in the *Survey of Applicants 2000* considered university involvement to be a factor in proposals to ATP. It was "somewhat" or "very critical" to 51 percent of those surveyed.

A 2002 study queried 47 ATP participants about universities as research partners (collaborators or subcontractors). Results from such a small sampling couldn't provide accurate measures, but showed important trends:

- Projects involving universities usually took on more ambitious research.
- Respondents working with a university participant were more likely to report difficulty in acquiring and assimilating knowledge needed for progress toward the project's goal.
- University participants were more likely to act as ombudsmen or referees in the process.
- Projects involving universities tended to end in success, but took longer to complete—perhaps because of the more ambitious nature of the research.[36]

The Branscomb study also found that universities played a vital role in ATP research projects. Said the study, "Universities represent a vital source of new technical ideas for firms of all sizes. The ferment of industrial relationships pervades even the most elite academic institutions."[37]

Figure 13. How Critical Was University Involvement to Proposed ATP Project?
From *Survey of Applicants* 2000

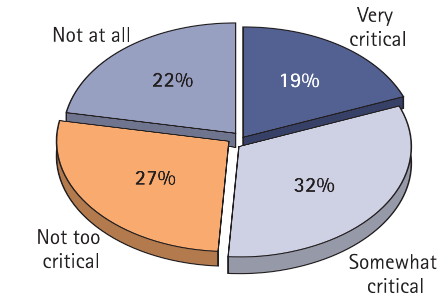


Table 10. Collaborative Activity of the First 50 Completed Projects

Type of collaboration	Percent
Collaborating on R&D with other companies or non-university organizations	56
Close R&D ties with universities	46
Collaborating on R&D with other companies or non-university organizations OR close R&D ties with universities	73
Collaborating on commercialization with other organizations	52
Collaborating in one or more of the above ways	86

Source: Advanced Technology Program, *Performance of 100 Completed ATP Projects, Status Report 3*, 2004, p. 4.

[35] From ATP Business Reporting System data.

[36] Bronwyn H. Hall, Albert N. Link, and John T. Scott, *Universities as Research Partners*, NIST GCR 02-829, 2002, pp. vi-vii.

[37] Branscomb et al. *Managing Technical Risk*, p. 6.

There Is No 'Lone Ranger'

It doesn't happen alone. Innovation—from initial idea through end use by industry and the American people—involves companies of all sizes working with universities, non-profits, federal labs, and other independent researchers. As shown below, ATP fosters collaborative efforts early in the process to enhance the likelihood of success. All participants bring unique capabilities; working together allows them to leverage strengths across organizations. When larger and smaller firms collaborate, they realize powerful synergies. Larger firms can gain access to promising new technologies, while their smaller partners can benefit from big-company expertise in product commercialization and marketing.

Almost one-third (29 percent) of ATP projects are formal joint ventures, and ATP has studied the factors that influence the success of R&D joint ventures in achieving technical and commercialization objectives.[38] On average, these joint ventures include 4.9 partners and 7.5 total organizations, including sub-contractors. Nearly 70 percent of joint ventures involve universities and 80 percent include a small company. Although 71 percent of ATP-funded projects are led by a single company, 4 out of 5 of these projects include other organizations. Single-company projects usually include two additional organizations at one time or another. More than 75 percent of all single-company projects involve a small company; more than half include a university as a subcontractor.

Changes in Collaborative Relationships

Because ATP projects typically unfold over a number of years, changes in the makeup of a joint venture can take place. One survey found that 59 percent of projects were carried out without changes in the group of collaborating organizations. The same survey found that for "23 percent of the projects, at least one participating company was changed to a different company, and [for] 18 percent, at least one participant, along with that company's piece of the project, was dropped altogether."[39]

Such changes in collaborative arrangements are important because they raise an issue for ATP project managers: At what point does a change in project makeup or goals no longer comply with the original criteria by which the project was selected for an ATP award?[40] By analyzing changes within projects, project managers can better understand this issue. It therefore represents a valid component of evaluation.

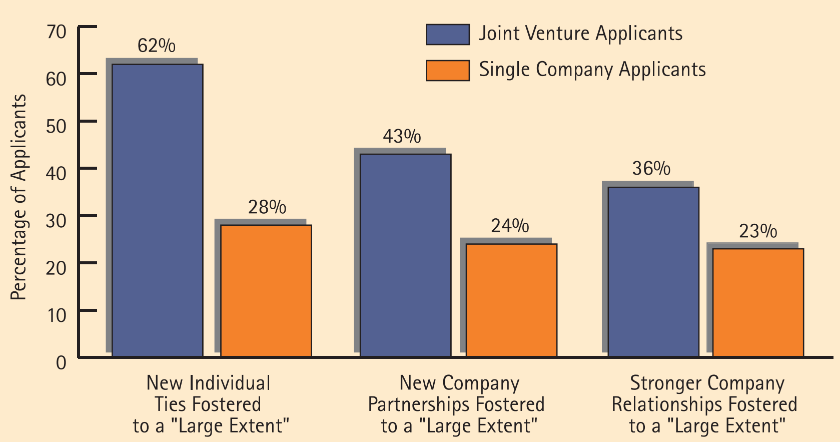
Determining Collaborative Success

In 2001 the ATP Economic Assessment Office published a study of ATP project managers and representatives of firms involved in 18 joint venture projects in the automobile industry begun between 1991 and 1997. EAO wanted to first determine how participants defined "success" for a joint venture, and then look at ways to determine if success was achieved in such projects. The findings would then form the basis for more in-depth studies later.

Indicators of joint venture success in the eyes of participants included: achieving technical objectives, reaching commercialization, obtaining patents, acquiring unanticipated technology, or forming unexpected networks of relationships.

The study identified factors affecting the chances of achieving this vision of success. They included the past experience of firms working together, competitors working together (it's difficult for them to do so successfully), the size of the joint venture, and maintaining the same people working on the project. The study also notes that, "...compared to collaborative R&D alliances without government involvement, ATP is accelerating and improving the successful outcome of collaborative endeavors."[41]

New Ties and Company Relationships: Single Company versus Joint Venture Applicants (From *Survey of Applicants 2000*)



[38] Jeffrey H. Dyer and Benjamin C. Powell, *Determinants of Success in ATP-Funded R&D Joint Ventures: A Preliminary Analysis Based on 18 Automobile Manufacturing Projects*, NIST GCR 00-803, December 2001.

Benefits and Costs of Collaboration

The 1996 survey of ATP participants by Silber and Associates revealed that 60 percent of respondents benefited "to a great extent" from collaboration, and another 35 percent "to a moderate extent."[42] Powell and Lellock, in their analysis of the BRS survey, continued to look at benefits of collaboration. Table 11 compares results of the two studies on the subject of benefits of collaboration. These benefits are listed in the left column in order of importance. The center column of BRS data lists the number of times the benefit was mentioned by respondents. The right column does the same in the Silber survey. Both studies reveal "stimulating creative thinking" to be the most important benefit of ATP R&D collaborations.

Collaborations also bring with them inherent problems, as revealed by the same studies. The Silber survey identified problems that included:

- Cultural differences between large and small companies, between companies and universities, and between individuals
- Differing agendas and needs among collaborating organizations
- No single source of direction ("no general, only 10 colonels")
- Lack of trust among collaborators
- The time-consuming nature of relationship building

Both Silber and the Powell analysis of BRS data indicate that costs associated with collaboration are present, but not serious, amounting more to "minor stumbling blocks" (according to Silber) than major barriers to success.[43] At the same time, 96 percent of joint venture respondents said they would pursue future joint ventures, providing evidence that the benefits outweigh the drawbacks for collaborative research efforts.[44]

Table 11. Specific Benefits of Collaborations

Benefits from collaboration	BRS data: Percent stating benefits "significantly" enabled by collaboration	Silber survey data: Percent stating benefits "to a great extent" enabled by collaboration
Stimulate creative thinking	72	72
Obtain R&D Expertise	55	60
Accelerate entry to marketplace	47	64
Encourage future collaborations	46	not included
To save time in general	43	57
Identify customer needs	42	60*
Save labor costs	30	42
Save equipment costs	26	48
Ensure reliable, quality source of supply	25	35
Plan for manufacturing during R&D phase	20	32**

*The Silber survey's closest matching category was called "increased customer acceptance."

**The Silber survey's closest matching category, for which the percentage applies, was called, "enabled you to develop technology while you engineered for volume manufacturing."

39 Silber and Associates, p. 33.

40 Responding to project changes requires balancing the need for flexibility to allow firms to make changes needed for project viability, with the need to adhere to ATP's legislated mandate to fund high-risk research to develop technologies with potential for generating broad-based benefits. To protect the public trust, ATP decides on a case-by-case basis, after reviewing changes in project makeup, whether to approve or disapprove the changes.

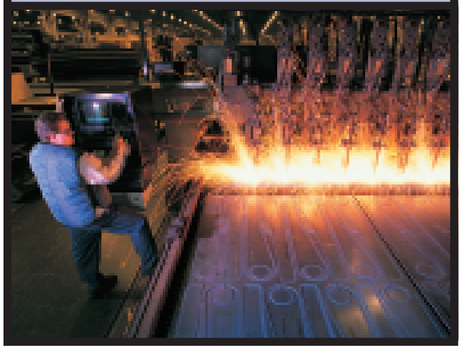
41 Jeffry H. Dyer and Benjamin C. Powell, *Determinants of Success in ATP-Funded R&D Joint Ventures: a Preliminary Analysis Based on 18 Automobile Manufacturing Projects*, GCR 00-803, 2001, p. vi.

42 Silber and Associates, p. 24.

43 Ibid, p. 31.

44 Ibid, p. 33.

Private and Social Returns of ATP Projects



Spillovers

ATP delivers technology impacts and achieves broad-based benefits to society via two pathways:

1. An *indirect route* by which knowledge, leading to private and social returns, is diffused through publications, presentations, patents, and other means of knowledge communication.
2. A *direct route* by which award recipients and their collaborators accelerate development and commercialization of technologies, resulting in private and social returns, and also in *spillovers*–products and processes that benefit other companies, other industries, and the American people.

Impact in the form of spillovers can take many forms.[45] For example, looking at products resulting from ATP projects:

- More than 8 out of 10 products reduce their customers' cost of production.
- On average, products have more than 250 customers.
- Half of companies with products have customers outside their own industry.
- Products resulting from ATP technologies are finding their way into a host of downstream products.

Because these spillovers get at the heart of ATP's mission, the ATP Economic Assessment Office has devoted considerable effort to measuring them. Proof of large spillovers supports the wisdom of a public investment in high-risk, high-impact technologies. A number of studies have looked at two important types of spillovers that benefit the nation: *knowledge spillovers* and *market spillovers*.

Estimating Knowledge Spillovers

Data revealed by both the ATP Business Reporting System and the *Status Report of Completed Projects* strongly indicate that as a portfolio, ATP-funded projects are generating outputs with the potential to lead to both knowledge and market spillovers.[46] These outputs include publications, patents, patent citations, collaborative linkages, and products and processes—all of which can lead to spillovers.

The 2000 study by Feldman and Kelley found that ATP is selecting projects likely to generate large knowledge spillover effects because of:

- Ties of proposing firms to other organizations.
- Positive attitudes of award winners toward information sharing and knowledge transfers to other firms.

The authors point out that, "The more embedded a firm is in a network of such inter-organization ties, the more quickly the knowledge generated by the firm is expected to be absorbed by other organizations in the system."[47] They confirmed the idea that award-winning firms exhibit "a tendency toward openness (30 percent), compared to non-winning applicants (19 percent)." This, in turn, "suggests that the public interest is being served by enabling R&D activities that are more likely to generate knowledge which benefits both the participating firm and other firms not directly involved in the project."[48]

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[45] ATP Fact Sheet: *Customers Across Many Industries Enjoy Significant Benefits*.

[46] Powell and Lellock, *Development, Commercialization, and Diffusion of Enabling Technologies: Progress Report, 2000;* and *Advanced Technology Program, Performance of 50 Completed ATP Projects,* Status Report 2, 2001.

[47] Feldman and Kelley, *Winning an Award from the Advanced Technology Program: Pursuing R&D Strategies in the Public Interest and Benefiting from a Halo Effect*, 2000, p. 11.

[48] Ibid, p. 17.

Another study from the same time frame, by Cohen and Walsh, focused directly on the measurement of knowledge spillovers. This study linked spillovers to *appropriability*—economic factors limiting a company's ability to capture profits from its own innovation—and the strategies they use to secure those profits. Results showed that information flowing inside an industry help the R&D efforts of individual firms. The finding is consistent with the core propositions that led to ATP's establishment and its key design features. In particular, by selecting generic technologies applicable to many firms both upstream and downstream, and by supporting specific joint ventures, ATP can foster the generation of knowledge spillovers, and thus increase the productivity of a firm's R&D.[49]

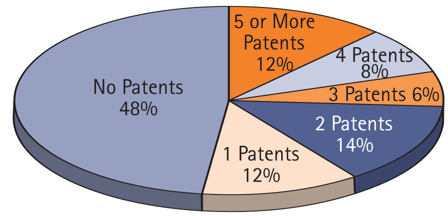
Other studies provide additional evidence of the potential of projects for large knowledge spillovers. Figure 14 displays the distribution of the first 50 completed projects by the number of patents filed—including those granted and not yet granted.

Estimating Market Spillovers

Several ATP-funded evaluations have sought to estimate the magnitude of market spillovers related to ATP projects. An early study by Research Triangle Institute (RTI) measured market spillovers for a portfolio of seven ATP-funded products in tissue engineering, focusing on the gap between estimated social and private returns. Table 12 shows the estimated social and private returns on investment for these projects. The market spillovers—the gap between social and private returns—are seen to be large due to estimates of the value of changes in quality-adjusted life years for patients from the new and improved medical treatments developed, in addition to treatment cost differences. RTI concludes that the private sector might under-invest in high-risk R&D due to the fact that "the social returns far outweigh the returns to the companies developing, commercializing, and producing these high-risk projects." This in turn indicates the importance of ATP in pursuit of such technologies to offset the lack of private investment.[50]

The Pelsoci study of CCAR technology also looked at market spillovers and found, based on sales of CCAR units, a large gap between the estimated social and private returns of the breakthrough. Another study of two digital data storage technologies funded in part by ATP produced an estimate for consumer welfare gains over five years of $1.5 billion and $2.2 billion for each of the two technologies.[51]

Figure 14. Distribution of Projects by Number of Patents Filed



Source: *Performance of 50 Completed ATP Projects* Status Report Number 2.

Table 12. Spillovers Imputed by Comparing Composite Social Returns, Public Returns, and Composite Private Returns on Seven Tissue Engineering Projects

Return on investment	Composite net project value (1996 $ millions)
Social return on investment	109,229
Social return on public investment	34,258
Private return on investment	1,564
Spillover gap attributable to project	107,665
Spillover gap attributable to ATP	32,694

Source: Martin et al., *A Framework for Estimating the National Economic Benefits of ATP Funding of Medical Technologies*, 1998.

49 Wesley N. Cohen and John P. Walsh, *R&D Spillovers, Appropriability and R&D Intensity: A Survey Based Approach*, ATP, 2000.

50 Sheila A. Martin et al., *A Framework for Estimating the National Economic Benefits of ATP Funding of Medical Technologies*, NIST GCR 97-737, 1998.

51 David Austin and Molly Macauley, *Estimating Future Consumer Benefits from ATP-Funded Innovation: The Case of Digital Data Storage*, NIST GCR 00-790, 2000.

High Risk Can Equal High Impact

Profiling ATP Investments

The Advanced Technology Program supports innovation by providing awards and resources to organizations that tackle long-term, high-risk research problems. For the program, the term "high-risk technology research" accepts a wide range of results, from outstanding success to outright failure. Some very high performers solve challenging and significant technical problems, make new technical knowledge available to others, and accelerate its commercial use. Many more participants reach levels of solid performance; they may be strong technically while achieving little or only some follow-on effort toward commercialization. Another group fails to show sustained direct progress toward commercialization, although their research may produce patents or publications and lead to other breakthroughs later on.

ATP rates projects on a scale from 0 to 4 stars, with 0 or P representing poor overall performance, PP signaling moderate performance, PPP strong performance, and PPPP outstanding performance. Figure 15 shows the overall performance of the first 100 completed ATP projects.

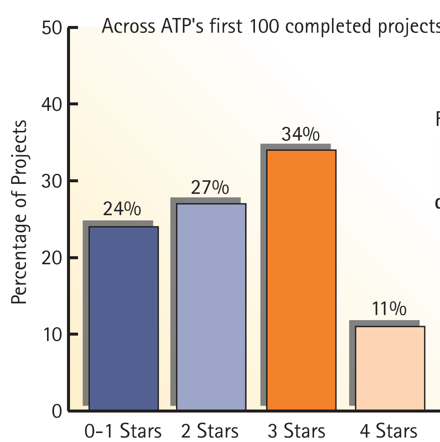
Returns on Investment

ATP has been funding long-term research for almost a decade and a half and provided $2.1 billion to innovators for 736 high-risk research projects from 1990 through May 2004. Industry matched this funding with $2.0 billion in cost sharing. In return, as previously noted, 41 projects from the program's portfolio yielded an estimated value of $17.87 billion in benefits to the nation. Participating companies, national laboratories, and academia have researched an array of breakthrough technologies to improve U.S. industrial processes, energy reliability, product durability, and products and services—as well as the quality of life of Americans.

In the field of health care alone, several ATP-sponsored technologies have resulted in significant breakthroughs in patient care, including:

- Stem cell replication technology (PPPP) developed by Aastrom Biosciences, Inc., of Ann Arbor, Michigan, estimated to produce $47 million in cost savings, attributable to ATP, by reducing the time and effort associated with collecting stem cells for use in bone marrow transplants.[52]

Figure 15. Star Performance Rating of Completed Projects



For each project:

Knowledge creation and dissemination + Commercialization progress and diffusion = Overall project performance

[52] William F. Long, *Performance of Completed Projects*, Status Report 2, NIST Special Publication 950-2, 2001, pp. 59-63.

- A new generation of digital mammography and digital radiology technology developed by GE Global Research of Schenectady, New York; this breakthrough provides more accurate detection methodologies at lower cost and has a net present value of $219-339 million (2002 dollars) in costs savings to health care facilities and patients, with a benefit-to-cost ratio of the ATP investment of 125:1 to 193:1.[53]
- High-energy imaging technology (PPPP) developed by X-Ray Optical Systems, Inc., of Albany, New York, that reflects X-rays and neutrons through thousands of tiny, curved glass tubes; 7 patents have resulted, along with use by NASA and the National Institutes of Health, a major 1996 photonics award, company growth from 1 to 22 employees, and recognition in *R&D* Magazine.[54]
- Surgical repair of cartilage and tendons using highly pure, manufactured "pseudo-polyamino acids" (PPPP) developed by Integra LifeSciences Corporation of Plainsboro, New Jersey; this polymer replaces screws, plates, pins, wedges, and nails in bone fracture repair at a savings of $98 million in the avoidance of second surgeries; the technology received a 1997 patent and has been recognized through a major award, numerous presentations, 15 publications, and licensing to commercial partners.[55]

A Technology Sample

As shown in this section, ATP's many assessment tools reveal the impact of each completed and ongoing project. Results from selected projects follow.

"Progress in freezing and cooling in the 20th Century often was measured by new, man-made refrigerants. Now industry is rediscovering natural solutions."

—Food Engineering Magazine November 1, 2003

Closed-Cycle Air Refrigeration (CCAR) 1995.[56] Air Products and Chemicals, Inc., and Toromont Process Systems, Inc.

Refrigeration systems blow compressed cold air into a cooling chamber. Continuous dehumidifying and compression is required to compensate for lost cold air. Emissions from such systems are harmful to the environment, depleting the ozone layer.

CCAR, a new form of industrial refrigeration technology, features an air-based system under higher pressure and in closed cycle to achieve ultra-cold temperatures using environmentally benign air as the working fluid.

Investment: $2.1 million by ATP;
$2.2 million by corporate partners

Economic impact:
- Technology valued at $459-$585 million (in year 2001 dollars)
- An internal rate of return of 83-90 percent
- A benefit-to-cost ratio of 220:1 to 280:1

Industry benefits:
- 50-percent reduction over standard cryogens in the cost of delivering ultra-cold refrigeration (-70ºF to -150ºF)
- Reduction in food evaporation and enhancement of taste
- Additional U.S. exports of $5-6 million per year
- Diesel emissions avoided for 12,000-14,000 truck shipments of cryogens per year
- Improved food safety due to rapid cooling of cooked foods to ultra-cold temperatures

Likely technology spillovers beyond the food processing industry:
- The chemical, metals, and automotive industries, for condensing and capturing harmful volatile organic compound vapor emissions
- The diesel fuel industry, for replacing high-polluting marine diesel fuels with clean-burning natural gas in the form of liquid natural gas
- The petrochemical and pharmaceutical industries, for low-temperature reactions and storage applications

Spillovers:
- 1999 Finalist for the Kirkpatrick Award in *Chemical Engineering* Magazine
- Expanded usage of innovative technologies associated with CCAR

53 Thomas M. Pelsoci, *Low-Cost Manufacturing Technology for Amorphous Silicon Detector Panels: Applications in Digital Mammography and Radiography*, NIST GCR 03-844, February 2003.

54 ATP "Gem": X-Ray Optical Systems, Inc.

55 ATP "Gem": Integra LifeSciences Corporation.

56 Thomas M. Pelsoci, *Closed-Cycle Air Refrigeration Technology: For Cross-Cutting Applications in Food Processing, Volatile Organic Compound Recovery, and Liquid Natural Gas Industries*, NIST GCR 01-819, December 2001.

What Is a Societal Benefit?

In creating ATP, Congress believed that for the federal government to support commercially relevant technology development, the resulting breakthroughs would need to benefit more than one company, and more than one industry, with the ultimate beneficiaries being the American economy and the American people. This pollination of technologies across sectors would inevitably yield rewards for society as a whole, as companies prosper, the economy strengthens, jobs are created, and new technologies reduce costs and enhance quality of life. From the technologies sampled on these pages to many others now in development, Americans are reaping the benefits of breakthroughs sponsored by ATP every day, in literally thousands of ways.

"It was at a stage where it was far too risky to get venture capital."

— David Wallace, Research Director, MicroFab Technologies, Inc.

ATP and Homeland Security

In its history, ATP has made 141 investments to technologies that touch on the area of U.S. homeland security. The total investment in these ATP projects has been $669 million—$364 million by ATP and another $305 million by industry. About $145.2 million or 40 percent was devoted to critical physical infrastructure projects, and $135.4 million, or 37 percent, in research related to chemical, biological, or radiological/nuclear exposure.

In the aftermath of the September 11, 2001 attacks on New York City and Washington, D.C., ATP is helping to enhance the nation's ability to respond to and even prevent terrorism. For example:

- GE Global Research of Schenectady, New York, has developed digital imaging technology of unprecedented detail and clarity using amorphous silicon panels to detect heart disease and breast cancer. The same technology could also be used to assure the structural integrity of aircraft and as a means of airport customs and cargo inspection.
- Genex Technologies, Inc. of Kensington, Maryland, is developing revolutionary facial recognition technology that integrates hardware and software and uses true 3D imaging for face enrollment, identification, and verification at airports, border crossings, and sensitive facilities.
- Quantum Signal, LLC, of Ann Arbor, Michigan, is developing 90-percent accurate biometric authentication through face or voice recognition for occupant sensing in vehicles, passenger screening at airports, and automated verification in telecommunications applications.

Materials

Composite Utility Poles (1995) PPP

Ebert Composites Corp., Chula Vista, California, and Strongwell Corp., Bristol, Virginia

Traditional upright utility poles and towers have disadvantages. Metal towers are difficult to transport, require teams of installers, and must be treated twice a year for corrosion. Wood poles require anti-decay treatments with chemicals that can leach into local water supplies.

Ebert Composites Corporation proposed to use composite materials to radically improve the design, manufacture, and cost of utility towers and poles. The company believed that composites would be price competitive with steel and wood, more durable, lower maintenance, and conducive to production in minutes rather than the hours necessary to manufacture a steel pole. Ebert did not, however, have access to the resources needed for the intensive research that would result in such a product. Today, four years after completion of the ATP project, industries from oil to defense are interested in the technology, as are state DOTs.

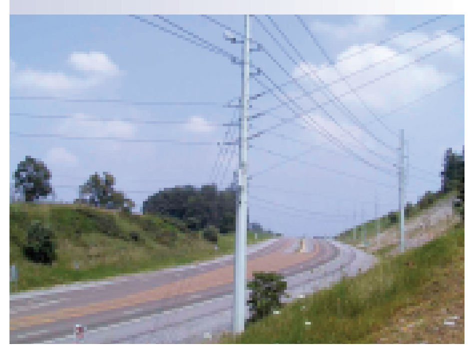
Investment: $1.03 million by ATP; $303,000 by the participants

Project achievements:

- All technical goals met
- A 97-percent reduction in manufacturing time for electric utility towers as well as cost savings and higher quality due to the development of innovative equipment
- Commercialization of composite structures for electric power poles and lattice towers
- Two patents for "high shear strength pultrusion"

Spillovers:

- The 1999 Charles Pankow Award from the Civil Engineering Research Foundation
- Publication in a Society of Manufacturing Engineers journal (1999)



IT and Electronics Breakthroughs

In the past decade, the areas of information technology (IT) and electronics have received increasing attention from ATP. The program strives for measurable productivity changes and accelerated technology development in electronics, electrical, photonics, memory storage, systems language and integration, displays for computers and televisions, and many other areas in IT and electronics. Important breakthroughs include:

- Collaborative Planning, Forecasting, and Replenishment (CPFR®) technology (PPP) developed by Benchmarking Partners of Cambridge, Massachusetts, that uses the Internet for supply chain coordination, reducing costs for consumers and making the industrial and retail sectors more competitive in global markets. One food manufacturer saw a 17-percent increase in sales and an 18-percent decrease in inventory; a women's clothing manufacturer experienced a 45-percent increase in sales and a 23-percent decrease in inventory.[57]
- New technology for health care legacy systems (PPP) that make it possible to integrate systems throughout the health care industry. With 15-percent funding from ATP and 85 percent from 3M, the technology became the foundation for the Department of Defense Military Health System and is used in 150 health care facilities in the U.S.[58]
- Speech recognition software (PPP) developed by Kurzweil Applied Intelligence, Inc., of Waltham, Massachusetts, that helps computer novices and the severely disabled to communicate by saying phrases in a natural language, touching a computer screen with a pen or mouse, or typing; 100,000 clients and 4 patents resulted, although the future of the technology was uncertain.[59]

Computer and Television Hardware

Dramatically Better Video Displays (1994) PPP Displaytech, Inc., Longmont, Colorado

With the explosion in multi-media technologies—from large-screen TVs to videophones and personal digital assistants (PDAs)—high-resolution displays have been highly sought after, but inhibited by the constraints of liquid crystal display (LCD) technology and the enormous costs of research.

In the quest for better displays, researchers turned to a new technology—the ferroelectric liquid crystal (FLC). Displaytech, a 20-employee small business, sought to mass produce FLC display chips using "dummy" silicon wafers.

Investment: $1.79 million from ATP; $1.5 million from Displaytech

Project achievements:

- Production capacity increased from one chip at a time in 1994 to a capacity of 100,000 chips a month by 2000
- 3 patents related to liquid-crystal displays
- Employment up from 20 employees to 150
- Technical barriers overcome to achieve a 600-percent increase in final image quality, a 100-percent increase in product lifetime, and a decrease in per-unit costs from $6,000 to $160

Spillovers:

- Joint ventures and partnerships formed with Hewlett Packard, Miyota, Motorola, Samsung, JVC, Concord, and Densitron Technology
- Network of worldwide licensees of Displaytech technology
- New FLC chip applied to flat-panel HDTVs, graphics arrays produced by Hewlett Packard, and displays produced by JVC, Samsung, and Minolta

High-Quality Color Displays for Televisions (1996) PPPP

ColorLink, Inc., Boulder, Colorado

For years, color televisions and computer monitors relied on color pixels composed of three monochrome pixels, each assigned a primary color (red, green, or blue). However, new types of electronics, from digital video cameras to PDAs, web phones, and flat-screen TVs, require higher resolutions than the pixel can accommodate.

ColorLink's new model for high-resolution display and imaging relies on a high-efficiency, tunable filter to encode color images in a rapidly changing sequence instead of traditional pixilated, slow-moving color switches. However, the development curve was too long to attract venture capital. An ATP award allowed ColorLink to partner with Polaroid Corporation, Kent State University of Ohio, and others to develop color management solutions for liquid crystal on silicon (LCOS) technology in High Definition televisions, display monitors, and other electronic devices. LCOS technology is now being used with color separation and recombination modules from ColorLink (pictured below) found in a new generation of JVC High Definition large-screen televisions.

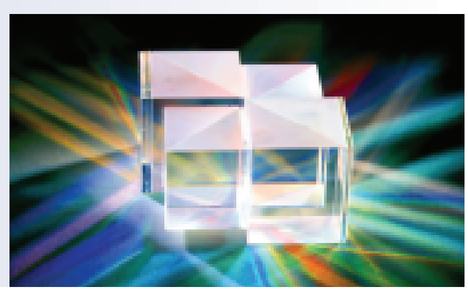
Investment: $1.79 million by ATP; $340,000 by ColorLink

Project achievements:

- 8 patents associated with imaging and display
- Cost and size of projection displays decreased
- Display resolution and brightness improved

Spillovers:

- Entered into partnerships with Thomson RCA, Arisawa Manufacturing, and original equipment manufacturers



[57] ATP Status Report 94-04-0046, December 2001.

[58] ATP Status Report 94-04-0027, December 2001.

[59] ATP Status Report 93-01-0101, June 2002.

Components for Easily Assembled Software Systems[60] ATP Component-Based Software Development (CBSD) Focused Program (1994-2000)

Historically, about 85 percent of all large software systems used in business have been customized applications with code written for a specific firm. Very little code is reused. These systems are critical to the operation of large firms, expensive to develop and maintain, and sometimes unreliable.

The use of components—independent pieces of software that interact with other components in a well-defined manner to accomplish a specific task—could facilitate the development of "off the shelf" large applications that are lower cost, and easier to maintain and upgrade.

Investment: $42.06 million for 24 projects; $55 million by private firms

Economic impact:

- Technology valued at $840 million (in year 2000 dollars) based on 8 of the most successful projects
- An internal rate of return of 80 percent
- A benefit-to-cost ratio of 10.5:1
- Total producer surplus of $538 million (in year 2000 dollars)
- Total consumer surplus of $1.13 billion (in year 2000 dollars)

Industry benefits:

- Reduced costs of developing and maintaining software systems
- Increased reliability of software
- Greater synergies across portions of software code and applications
- Two-thirds of the projects achieved their technical objectives
- Three of the projects generated enough returns to cover the entire cost of the focused program

Spillovers:

- Validation of the CBSD concept in the eyes of investors
- Premium pricing of products due to higher quality resulting from ATP involvement
- Internal credibility for participating firms, leading to more available R&D funds and expanded scope of the project

Information Systems

Technology to Control Hybrid Computer Systems (1995)[61] PPP Hynomics (formerly Sagent Corporation), Kirkland, Washington

Businesses and industries increasingly rely on complex, distributed networks of computers and information systems to manage operations. These "hybrid" systems are difficult to synchronize and control, and rely on extensive manual intervention to be functional.

Intelligent "middleware" developed by Sagent Corporation (now named Hynomics) provides a common interface between different applications or operating systems in a network, assuring that events occur in the proper order and that data managed by these different nodes remains consistent.

Investment: $1.93 million by ATP; $168,000 by Sagent Corporation

Project achievements:

- New technologies in hybrid systems, automata, and control theory that are now being commercialized
- 2 patents related to multiple-agent hybrid control architecture

Spillovers:

- 15 published articles in professional journals
- 10 conferences and presentations
- A partnership with SAP and a second with one of the world's largest software companies

Information Storage

Magnetic Recording Technology with Global Impact (1991)[62] PPP Information Storage Industry Consortium [formerly National Storage Industry Consortium (NSIC)]

In 1991, magnetoresistive (MR) head information technology moved disk storage forward—but it still couldn't keep pace with rapidly increasing storage needs caused by the memory-hogging nature of graphics and video images as software evolved.

NSIC proposed to vastly improve the potential for MR head technology, with the five-year goal of achieving 10 gigabytes of memory per square inch. It was a level of R&D that no company could afford to explore alone. The consortium received ATP funding on the condition that the magnetic recording industry as a whole be permitted to use the resulting series of innovations in product development.

Investment: $5.46 million by ATP; $5.98 million by NSIC

Project achievements:

- Giant magnetoresistive (GMR) heads developed during the project can record nearly 100 times more information per square inch of recording medium than other heads commercially available
- Read-and-write heads created so precisely that errors occurred once in every 10^{14} bits
- Hundreds of researchers coordinated across the U.S. in 8 companies and 7 universities

Spillovers:

- By 2000, after only 3 years, 100 percent of PCs made in the U.S. used GMR-head technology
- U.S. share of the global market increased from 62 percent to 70 percent in this time period

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60 William J. White and Michael P. Gallagher, *Benefits and Costs of ATP Investments in Component-Based Software*, NIST GCR 02-834, November 2002.

61 ATP Status Report 95-09-0052, March 2002.

62 ATP Status Report 91-01-0016, December 2001.

Investments to Keep America Energized

More than ever before, Americans rely on a steady supply of energy to power our lives. Consider the cost to the nation of the August 14, 2003 blackout, when overloaded power systems in the Northeastern U.S. failed. In all, eight U.S. states were affected, with an estimated cost to the economy of $30 billion.

ATP is supporting the nation's energy security through investments in breakthrough technologies for fuel cells, solar cells, and batteries. ATP was one of the first large government programs to fund distributed generation technologies, such as fuel cells, that can power residences and businesses and provide improved backup power for telecommunications.

The innovative technologies fostered by ATP will make sources of distributed, off-grid power ever more compact, secure, reliable, and affordable. Key energy projects currently under way include:

- Plug Power LLC of Latham, New York, which experienced a workforce increase by 2003 from 50 to 300 with its breakthrough in a proton-exchange membrane fuel cell; this cell has improved carbon monoxide tolerance by 100-fold, enabling clean, low-cost fuel cell performance for homes and businesses.
- Materials and Systems Research, Inc., of Salt Lake City, Utah, developer of high-performing, solid-oxide fuel cell technology—using natural gas or other combustible vapors—for emergency and remote power generation.
- Evergreen Solar, Inc., of Waltham, Massachusetts, creators of wide, ultra-thin, silicon ribbons that yield more than twice as many solar cells per pound of silicon as conventional methods, lowering the cost of solar power.
- PowerStor Corporation of Dublin, California, developers of a new supercapacitor that can deliver pulses of energy to portable or fixed electronic devises using carbon aerogels for high performance.
- MTI Microfuel Cells, Inc., of Albany, New York, which is developing a micro fuel cell that may provide power 5 to 10 times longer than the lithium ion batteries now used in cell phones, laptops, and PDAs.
- Ovonic Battery Co., of Troy, Michigan, which is developing magnesium-hydride alloys capable of storing 7-percent hydrogen in fuel-cell-powered electric vehicles, a level that far exceeds the capability of metal hydride technologies now in use.

These and other technologies will help future generations of Americans to enjoy uninterrupted power for a higher quality of life, enhanced security, and a more stable U.S. economy.

The DNA Story

In the past 10 years, more than 45 ATP awards have supported the development of diagnostic tools used to isolate and evaluate genetic information. Indeed, ATP has been called the "Godfather" of DNA diagnostic tool technology. Developments include production of a nucleic acid microarray, a microfluidic system, an informatics package, and an integrated platform that offers faster and cheaper methods of producing genetic data on a routine basis.

Third Wave Technologies, Inc., of Madison, Wisconsin (a company of three researchers), which proposed the first-ever direct method for analyzing genetic mismatches that make each human being unique—and cause some diseases. Previous identification of genetic mismatches were time consuming and expensive. Third Wave and its project were considered too risky by investors, but the two-year project (PPPP) begun in 1994 with ATP cost-shared funding resulted in 10 patents, more than 20 papers, 30 poster presentations, 12 conference appearances, and numerous articles. In 2001 Third Wave earned more than $34 million in revenues and conducted a successful initial public offering.[63]

Hyseq, Inc., of Sunnyvale, California, a start-up company, sought in 1995 to develop techniques critical for the quick and inexpensive sequencing of entire genes—research stifled by high-cost, slow, inaccurate processes. The Hyseq approach (PPP) developed with ATP cost-shared funds separated DNA into segments then placed on a test chip—the HyChip—covered with probes. The HyChip went on to sequence the HIV virus correctly on one million probes without error, achieved 100-percent accuracy on mitochondrial DNA tests, and sequenced 500-percent more bases than was possible with a traditional DNA diagnostic chip. Eight patents resulted as well as conference presentations. The potential of the HyChip is being pursued by Callida Genomics, a company spun off from Hyseq.[64]

PharmaSeq, Inc., of Monmouth Junction, New Jersey, wanted to address the high expense of detecting DNA sequences implicated in disease. In 1998, as part of the DNA Focused Program, ATP provided funding to PharmaSeq to develop a low-cost, high-throughput DNA analysis system that could identify gene sequences and store their information. The resulting technology received a patent, attracted multi-million dollar investment and a strategic partnership with an industry leader, and led to licensing and R&D relationships with multiple corporate partners.[65]

63 ATP Status Report 94-05-0012, January, 2003.

64 ATP Status Report 94-05-0018, December 2001.

65 ATP "Gem," PharmaSeq, Inc.

ATP in Manufacturing

Since its start in 1990, ATP has emphasized innovation in industrial processes. Two of ATP's central themes have been advances in manufacturing technology and leaps in process-related capabilities.

Approximately 11 percent of ATP's support through matching funds has been awarded to projects intended to catalyze the development of leap-frog technologies for material forming and removal, welding and assembly, manufacturing system integration and measurement, and other processes and products relevant to discrete-parts manufacturing. Including projects in the categories of "advanced materials and chemistry" and "electronics and photonics"—areas with a heavy manufacturing emphasis or relevance—ATP's investment in manufacturing accounts for nearly 60 percent of the $2 billion awarded by the program between 1990 and July 2003.

"Unlike every other revolutionary product, this one won't change the world.

— Cargill Dow's tagline for environmentally friendly PLA

Below are a few examples of manufacturing technologies either proven to be successful or with the potential to greatly improve aspects of U.S. industry:

- Polylactide (PLA), a corn-derived dextrose polymer developed by Cargill Dow for biodegradable packaging and clothing fibers resulted in the opening of a Blair, Nebraska, plant in 2002, 100 new jobs, greenhouse gas emissions in manufacturing reduced by 15-60 percent, and the production of 140 million metric tons of PLA per year.[66]
- Precision measurement for the automotive and bearing industries (PPP) created by Corning Tropel (formerly Tropel Corporation) of Fairport, New York, that uses diffractive optics and laser technology to measure even complex shapes, dramatically increasing accuracy while removing production bottlenecks and lowering consumer costs; five patents resulted as well as numerous papers and presentations.[67]
- A real-time vibration control technology being developed by BalaDyne Corp., for high-speed machining tools such as those used in automobile manufacturing; the results for U.S. industry could be hundreds of millions of dollars in savings from reduced downtime and safety-related incidents. Throughput of parts would be higher, with better surface finish quality.[68]

[66] Samuel Fromartz, *Newbiz: In "Green" Container, Corn Replaces Petroleum*, Forbes.com from Reuters News Service, November 6, 2003.

[67] ATP Status Report 95-01-0022, September 2001.

[68] ATP Project Brief, *Real-Time Active Balancing for High-Speed Machining*, October 1997.

[69] ATP Status Report 91-01-0178, December 2001.

Manufacturing

Lightweight, Recyclable Car Parts (1991)[69] PPP Ford Motor Company Scientific Research Laboratory and General Electric R&D

The movement to conserve energy and recycle in the late 1980s created a need for new composites to achieve weight reductions in automobile manufacturing–composites that could then be recycled at the end of a car's useful life. However, the thermoset polymers then used in car parts could not be heated or recycled.

A consortium of seven organizations approached ATP to pursue promising technology involving cyclic thermoplastics, which offered many attractive properties in manufacturing, including the fact that they could be recycled simply by reheating the material. However, this was unproven technology and a dramatic shift away from accepted thermoset polymers.

Investment: 5.29 million by ATP; $5.74 million by the consortium

Project achievements:

- 16 patents related to cyclic thermoplastics
- Substantial data collected regarding mold flow and filling
- Successful research partnership between Ford, GE, PPG, American Lisitritz, Rensselaer Polytechnic Institute, the University of Tulsa, and the Environmental Research Institute of Michigan
- Met the manufacturing cost target of approximately $1 per pound for automotive components and other parts (but did not achieve the goal of translating key properties from laboratory beaker reactions to materials made under simulated production conditions)

Spillovers:

- Composite molding process now used by Ford Motor Company
- Portfolio of patents sold to Cyclics® Corporation of Rensselaer, New York, in 1999
- Cyclics Corp., undertaking development projects for direct customers in structural composites and related technology areas

Manufacturing

Nanotechnology Works Cross-Industry (1991)[70] PPPP Nanophase Technologies Corporation (NTC), Romeoville, Illinois

The advent of nanotechnology—the ability to manipulate matter at the atomic or molecular level—offered the opportunity to rewrite the future by helping to fight disease and pollution and aid in manufacturing. However, the production of nanosized materials a billionth of a meter in length was cumbersome and expensive.

NTC proposed new technology to synthesize and process nanocrystalline ceramics that would be less prone to molecular breakdowns, then apply this nanotechnology to other materials and uses. With ATP funding, NTC created a gas-phase condensation (GPC) process as a foundation for research and development.

Investment: $944,000 by ATP; $3 million by NTC

Project achievements:
- 25,000-fold increase achieved in capacity to produce nanoscale materials along with a 20,000-fold reduction in costs
- Growth in NTC from 2 to 61 employees
- 3 patents received related to nanomaterials production, with 28 more patents licensed or pending in the U.S., Europe, and Japan

Spillovers:
- NTC customer base now 20 companies worldwide
- Technology now being applied in a variety of industrial applications, including automobile coatings, carpet fibers, cosmetics, sunscreen, and high-opacity inks

Soldering with Ink-Jet Technology (1993) PPP MicroFab Technologies, Inc., Plano, Texas

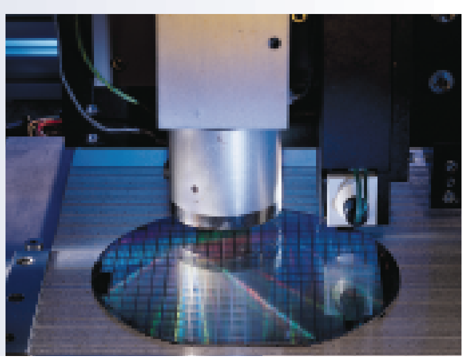
Continuing advances in electronics have led to new levels of miniaturization and corresponding needs for new ways to solder leads to circuit board contacts. Existing methods had been complex, expensive, and time consuming.

MicroFab proposed to use existing ink-jet printing technology to affix semiconductor chips to circuit boards at high temperatures via molten metal solder drops. Skepticism about the technology was high inside the industry, making venture capital unavailable.

Investment: $1.63 million by ATP; $695,000 by MicroFab

Project achievements:
- Successful prototype that dispenses 40-micron to 120-micron spheres of molten solders onto high-density electronic components at up to 220ºC, on demand, at rates up to 2,000 per second
- 5 patents received for solder-related microdroplet technologies
- Partners included Motorola, Delco, Texas Instruments, Kodak, and AMP
- Company grew from 18 to 30 employees

Spillovers:
- Several papers published and presentations given
- Funding received from the Defense Advanced Research Projects Agency to test the technology at up to 325ºC (with partial success)
- Technologies licensed to MPM, a division of the Cookson Group, PLC, for use in solder balls



Photonics

Light Distribution Technology (1993) PPP Physical Optics Corporation (POC), Torrance, California

Products in many industries—laptop computers, televisions, flashlights, cockpit and car dashboards, and ATM displays—rely on light diffusers composed of frosted glass or plastic to disperse light as needed. However, these have been notoriously inefficient because they can only scatter light rather than direct it.

Physical Optics Corp., used ATP funding to pursue holographic technology that would increase the brightness of any traditional light source and enhance the contrast of optical images. The result would be screens and filters that "sculpt" beams of light by distributing the light in a desired direction, avoiding "hot spots" for any light source.

Investment: $850,000 by ATP; $870,000 by Physical Optics Corporation

Project achievements:
- New holographic systems technology for recording diffusers with desired scattering distributions
- Coating and processing techniques for deep-surface structures substantially improved
- Fabrication techniques for high-resolution diffusion masters refined
- High-resolution screens developed in a variety of sizes, shapes, and properties for a range of applications
- Projection screens with intense and directed light beams; transmission screens greatly enhance a previously dull image
- 3 patents related to illuminated displays

Spillovers:
- Several publications and seminars
- Alliances with original equipment manufacturers
- Licensing agreements with specific application providers
- Interest from Ford Motor and other large automotive companies

[70] ATP Status Report 91-01-0041, December 2001.

Our Most Vital Resource

In 2003 the National Science and Technology Council, a cabinet-level body advising the president, labeled the U.S. capacity for innovation as "the nation's most vital resource for national security, economic development, and continuous improvements in living standards for all Americans."[71] But having great ideas is only half the battle. Innovators need to be able to take the next step. "...Truth be told," said *Boston Globe* columnist Robert Weisman in January 2004, "ideas are plentiful. For businesses, the hard part is choosing the right ones, turning them into products or services, and bringing them to the marketplace before their competitors do."[72] That's the job of the Advanced Technology Program, to help these innovators pursue their ideas and turn them into *possibilities*.

ATP has compiled a measurable record of success in helping private firms across the nation turn breakthrough ideas into high payoff innovations and build future capacity to innovate by:

- Pursuing the development of high-risk, enabling technologies.
- Requiring well-thought-out technical and business plans up front.
- Involving the right combination of companies, universities, and non-profit independent research organizations as partners in R&D projects.
- Monitoring their progress throughout the life of the project and measuring their outputs, outcomes, and impacts.

What are the next big ideas that will become breakthrough technologies? Right now, ATP participants are working on applications of nanotechnology to medicine and manufacturing, applications of information technology to virtual reality learning environments, the use of practical, affordable fuel cells for the home and automobile, a high-speed metal sorter to revolutionize recycling, exciting medical research into antibodies and drug delivery systems, and dozens of other R&D efforts that could make the United States more competitive, spur the economy, and help future generations of Americans lead longer, healthier, and higher-quality lives.

[71] Committee on Technology, *Advanced Foundations for American Innovation: Networking and Information Technology Research and Development, Supplement to the President's Budget, FY2004*, A Report by the Interagency Working Group in Information Technology Research and Development, National Science and Technology Council, September 2003, page iii.

[72] Robert Weisman, *Finding New Ideas is Easy, Choosing Right Ones Isn't*, Boston *Globe*, January 18, 2004.

Appendix A
ATP Statistics

The ATP Economic Assessment Office measures the success of the Advanced Technology Program through a variety of evaluation studies aided by leading experts. All the recent studies described in this appendix can be found at www.atp.nist.gov/eao/eao_pubs.htm.

1. Historical Statistics

	1990–May 2004
Number of Proposals Received	**6,054**
Number of Participants in Submitted Proposals	9,205
Total ATP Funding Request	$12,969M
Total Industry Cost Share	$11,152M
Number of Awards	**736**
Single Applicants	525
Joint Ventures	211
Number of Participants in Awarded Projects	1,468
Total ATP Funds Committed	$2,189M
Total Industry Cost Sharing	$2,045M
Award Size for Projects (range)	$434K–$31M
Award Size for Single Applicant Projects (range)	$434K–$2M
Award Size for Joint Venture Projects (range)	$600K–$31M
Percent of Projects that Collaborate	85
Percent of Acceleration	86
Percent of Projects Commercializing	46
Total Number of Publications	1,245
Total Number of Patents Filed	1,171

2. ATP Awards Funding (by project type and lead size)

Funding ($Millions)	TOTALS	2004†	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
Total Funding	**2,189**	**75**	**154**	**156**	**164**	**144**	**110**	**235**	**162**	**19**	**414**	**309**	**60**	**48**	**93**	**46**
Small*	1,154	63	107	116	121	96	70	112	101	10	99	143	35	19	39	23
Medium	312	4	18	18	15	12	9	44	10	3	118	45	9	5	2	0
Large**	426	8	18	22	4	36	20	68	37	6	93	69	13	15	13	4
Other***	297	0	11	0	24	0	11	11	14	0	104	52	3	9	39	19
Single Applicant	**953**	**45**	**105**	**97**	**85**	**74**	**49**	**92**	**87**	**10**	**110**	**93**	**41**	**29**	**28**	**8**
Small	752	39	101	89	81	66	42	78	71	10	62	46	24	19	20	4
Medium	102	4	2	0	3	2	4	11	8	0	28	26	7	5	2	0
Large	96	2	2	8	1	6	3	3	8	0	20	21	10	5	3	4
Other	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Joint Venture Lead	**1,236**	**30**	**49**	**59**	**79**	**70**	**61**	**143**	**75**	**9**	**304**	**216**	**19**	**19**	**65**	**38**
Small	402	24	6	27	40	30	28	34	30	0	37	97	11	0	19	19
Medium	210	0	16	18	12	10	5	33	2	3	90	19	2	0	0	0
Large	330	6	16	14	3	30	17	65	29	6	73	48	3	10	10	0
Other	294	0	11	0	24	0	11	11	14	0	104	52	3	9	36	19
Percent of Distribution††																
Total Funding	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Small	53	84	69	74	74	67	64	48	62	53	24	46	58	40	42	50
Medium	14	5	12	12	9	8	8	19	6	16	29	15	15	10	2	0
Large	19	11	12	14	2	25	18	29	23	32	22	22	22	31	14	9
Other	14	0	7	0	15	0	10	5	9	0	25	17	5	19	42	41
Single Applicant	**44**	**60**	**68**	**62**	**52**	**51**	**45**	**39**	**54**	**53**	**27**	**30**	**68**	**60**	**30**	**17**
Small	79	87	96	92	95	89	86	85	82	100	56	49	59	66	71	50
Medium	11	9	2	0	4	3	8	12	9	0	25	28	17	17	7	0
Large	10	4	2	8	1	8	6	3	9	0	18	23	24	17	11	50
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0
Joint Venture Lead	**56**	**40**	**32**	**38**	**48**	**49**	**55**	**61**	**46**	**47**	**73**	**70**	**32**	**40**	**70**	**83**
Small	33	80	12	46	51	43	46	24	40	0	12	45	58	0	29	50
Medium	17	0	33	31	15	14	8	23	3	33	30	9	11	0	0	0
Large	27	20	33	24	4	43	28	45	39	67	24	22	16	53	15	0
Other	24	0	22	0	30	0	18	8	19	0	34	24	16	47	55	50

For this table and succeeding tables:
* Fewer than 500 employees.
** Included in Fortune 500 listing.
*** Became ineligible under the American Technology Preeminence Act of 1991.
****Participants: Includes Single Applicants (SA), Joint Venture Leads (JVL), and Joint Venture Participants (JVP); excludes subcontractors, informal collaborators with joint ventures, and collaborators and strategic partners of single applicants.
† 2004 figures are through May 2004.
†† Distribution percentages are shown within each group.

3. ATP Awards and Participants (by project type and lead size)

Number of Awards	TOTALS	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
Total # of Awards	**736**	**27**	**67**	**61**	**59**	**54**	**37**	**79**	**64**	**8**	**103**	**88**	**29**	**21**	**28**	**11**
Small	484	23	55	51	50	41	26	53	48	6	40	40	16	12	16	7
Medium	89	2	4	2	4	3	3	10	6	1	26	19	5	3	1	0
Large	125	2	5	8	2	10	7	14	8	1	26	23	7	5	5	2
Other	38	0	3	0	3	0	1	2	2	0	11	6	1	1	6	2
Single Applicant	**525**	**23**	**55**	**51**	**46**	**39**	**26**	**52**	**49**	**6**	**62**	**50**	**24**	**18**	**18**	**6**
Small	410	20	53	47	43	35	22	44	40	6	33	24	14	12	13	4
Medium	57	2	1	0	2	1	2	6	5	0	16	14	4	3	1	0
Large	56	1	1	4	1	3	2	2	4	0	13	12	6	3	2	2
Other	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Joint Venture Lead	**211**	**4**	**12**	**10**	**13**	**15**	**11**	**27**	**15**	**2**	**41**	**38**	**5**	**3**	**10**	**5**
Small	74	3	2	4	7	6	4	9	8	0	7	16	2	0	3	3
Medium	32	0	3	2	2	2	1	4	1	1	10	5	1	0	0	0
Large	69	1	4	4	1	7	5	12	4	1	13	11	1	2	3	0
Other	36	0	3	0	3	0	1	2	2	0	11	6	1	1	4	2
Number of Participants																
Total # of Participants	**1,468**	**35**	**104**	**79**	**88**	**95**	**57**	**168**	**101**	**12**	**318**	**211**	**50**	**32**	**83**	**35**
Small	711	26	67	61	63	56	29	74	67	9	101	73	24	17	31	13
Medium	292	5	13	4	7	11	8	39	18	2	97	60	11	6	8	3
Large	323	3	15	12	9	22	17	40	12	1	81	54	14	6	24	13
Other	142	1	9	2	9	6	3	15	4	0	39	24	1	3	20	6
Single Applicant	**525**	**23**	**55**	**51**	**46**	**39**	**26**	**52**	**49**	**6**	**62**	**50**	**24**	**18**	**18**	**6**
Total JV (JVL+JVP)	**943**	**12**	**49**	**28**	**42**	**56**	**31**	**116**	**52**	**6**	**256**	**161**	**26**	**14**	**65**	**29**
Joint Venture Lead	**211**	**4**	**12**	**10**	**13**	**15**	**11**	**27**	**15**	**2**	**41**	**38**	**5**	**3**	**10**	**5**
Joint Venture Participants	**732**	**8**	**37**	**18**	**29**	**41**	**20**	**89**	**37**	**4**	**215**	**123**	**21**	**11**	**55**	**24**
Small	227	3	12	10	13	15	3	21	19	3	61	33	8	5	15	6
Medium	203	3	9	2	3	8	5	29	12	1	71	41	6	3	7	3
Large	198	1	10	4	7	12	10	26	4	0	55	31	7	1	19	11
Other	104	1	6	2	6	6	2	13	2	0	28	18	0	2	14	4
Percent of Distribution																
Total # of Awards	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Small	66	85	82	84	85	76	70	67	75	75	39	45	55	57	57	64
Medium	12	7	6	3	7	6	8	13	9	13	25	22	17	14	4	0
Large	17	7	7	13	3	19	19	18	13	13	25	26	24	24	18	18
Other	5	0	4	0	5	0	3	3	3	0	11	7	3	5	21	18
Single Applicant	**71**	**85**	**82**	**84**	**78**	**72**	**70**	**66**	**77**	**75**	**60**	**57**	**83**	**86**	**64**	**55**
Small	78	87	96	92	93	90	85	85	82	100	53	48	58	67	72	67
Medium	11	9	2	0	4	3	8	12	10	0	26	28	17	17	6	0
Large	11	4	2	8	2	8	8	4	8	0	21	24	25	17	11	33
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0
Joint Venture Lead	**29**	**15**	**18**	**16**	**22**	**28**	**30**	**34**	**23**	**25**	**40**	**43**	**17**	**14**	**36**	**45**
Small	35	75	17	40	54	40	36	33	53	0	17	42	40	0	30	60
Medium	15	0	25	20	15	13	9	15	7	50	24	13	20	0	0	0
Large	33	25	33	40	8	47	45	44	27	50	32	29	20	67	30	0
Other	17	0	25	0	23	0	9	7	13	0	27	16	20	33	40	40
Percent of Distribution																
Total # of Participants	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Small	48	74	64	77	72	59	51	44	66	75	32	35	48	53	37	37
Medium	20	14	13	5	8	12	14	23	18	17	31	28	22	19	10	9
Large	22	9	14	15	10	23	30	24	12	8	25	26	28	19	29	37
Other	10	3	9	3	10	6	5	9	4	0	12	11	2	9	24	17
Single Applicant	**36**	**66**	**53**	**65**	**52**	**41**	**46**	**31**	**49**	**50**	**19**	**24**	**48**	**56**	**22**	**17**
Total JV (JVL+JVP)	**64**	**34**	**47**	**35**	**48**	**59**	**54**	**69**	**51**	**50**	**81**	**76**	**52**	**44**	**78**	**83**
Joint Venture Lead	**22**	**33**	**24**	**36**	**31**	**27**	**35**	**23**	**29**	**33**	**16**	**24**	**19**	**21**	**15**	**17**
Joint Venture Participants	**78**	**67**	**76**	**64**	**69**	**73**	**65**	**77**	**71**	**67**	**84**	**76**	**81**	**79**	**85**	**83**
Small	31	38	32	56	45	37	15	24	51	75	28	27	38	45	27	25
Medium	28	38	24	11	10	20	25	33	32	25	33	33	29	27	13	13
Large	27	13	27	22	24	29	50	29	11	0	26	25	33	9	35	46
Other	14	13	16	11	21	15	10	15	5	0	13	15	0	18	25	17

4. ATP Awards (by technology area and project type)

Number of Awards	TOTALS	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
Total Awards	**736**	**27**	**67**	**61**	**59**	**54**	**37**	**79**	**64**	**8**	**103**	**88**	**29**	**21**	**28**	**11**
Single Applicant	525	23	55	51	46	39	26	52	49	6	62	50	24	18	18	6
Joint Venture Lead	211	4	12	10	13	15	11	27	15	2	41	38	5	3	10	5
Total Biotechnology Awards	**181**	**6**	**13**	**18**	**21**	**14**	**14**	**18**	**20**	**2**	**22**	**22**	**4**	**3**	**4**	**0**
Single Applicant	147	6	13	16	16	12	13	16	18	2	10	16	3	2	4	0
Joint Venture Lead	34	0	0	2	5	2	1	2	2	0	12	6	1	1	0	0
Total Chemistry/Materials Awards	**162**	**4**	**11**	**13**	**15**	**10**	**6**	**28**	**5**	**4**	**19**	**28**	**8**	**4**	**7**	**0**
Single Applicant	117	3	10	13	13	8	1	20	3	3	17	12	7	3	4	0
Joint Venture Lead	45	1	1	0	2	2	5	8	2	1	2	16	1	1	3	0
Total Electronics/Photonics Awards	**158**	**7**	**19**	**16**	**9**	**18**	**7**	**22**	**7**	**2**	**10**	**7**	**11**	**7**	**8**	**8**
Single Applicant	94	6	14	10	5	12	5	8	2	1	5	3	9	7	4	3
Joint Venture Lead	64	1	5	6	4	6	2	14	5	1	5	4	2	0	4	5
Total Information Technology Awards	**150**	**8**	**18**	**12**	**9**	**4**	**6**	**9**	**21**	**0**	**27**	**29**	**2**	**2**	**2**	**1**
Single Applicant	117	7	15	11	8	4	4	7	18	0	18	18	2	2	2	1
Joint Venture Lead	33	1	3	1	1	0	2	2	3	0	9	11	0	0	0	0
Total Manufacturing (Discrete) Awards	**85**	**2**	**6**	**2**	**5**	**8**	**4**	**2**	**11**	**0**	**25**	**2**	**4**	**5**	**7**	**2**
Single Applicant	50	1	3	1	4	3	3	1	8	0	12	1	3	4	4	2
Joint Venture Lead	35	1	3	1	1	5	1	1	3	0	13	1	1	1	3	0
Percent of Distribution																
Total Awards	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Single Applicant	71	85	82	84	78	72	70	66	77	75	60	57	83	86	64	55
Joint Venture Lead	29	15	18	16	22	28	30	34	23	25	40	43	17	14	36	45
Total Biotechnology Awards	**25**	**22**	**19**	**30**	**36**	**26**	**38**	**23**	**31**	**25**	**21**	**25**	**14**	**14**	**14**	**0**
Single Applicant	81	100	100	89	76	86	93	89	90	100	45	73	75	67	100	–
Joint Venture Lead	19	0	0	11	24	14	7	11	10	0	55	27	25	33	0	–
Total Chemistry/Materials Awards	**22**	**15**	**16**	**21**	**25**	**19**	**16**	**35**	**8**	**50**	**18**	**32**	**28**	**19**	**25**	**0**
Single Applicant	72	75	91	100	87	80	17	71	60	75	89	43	88	75	57	–
Joint Venture Lead	28	25	9	0	13	20	83	29	40	25	11	57	13	25	43	–
Total Electronics/Photonics Awards	**21**	**26**	**28**	**26**	**15**	**33**	**19**	**28**	**11**	**25**	**10**	**8**	**38**	**33**	**29**	**73**
Single Applicant	59	86	74	63	56	67	71	36	29	50	50	43	82	100	50	38
Joint Venture Lead	41	14	26	38	44	33	29	64	71	50	50	57	18	0	50	63
Total Information Technology Awards	**20**	**30**	**27**	**20**	**15**	**7**	**16**	**11**	**33**	**0**	**26**	**33**	**7**	**10**	**7**	**9**
Single Applicant	78	88	83	92	89	100	67	78	86	–	67	62	100	100	100	100
Joint Venture Lead	22	13	17	8	11	0	33	22	14	–	33	38	0	0	0	0
Total Manufacturing (Discrete) Awards	**12**	**7**	**9**	**3**	**8**	**15**	**11**	**3**	**17**	**0**	**24**	**2**	**14**	**24**	**25**	**18**
Single Applicant	59	50	50	50	80	38	75	50	73	–	48	50	75	80	57	100
Joint Venture Lead	41	50	50	50	20	63	25	50	27	–	52	50	25	20	43	0

5. ATP Awards Funding (by technology area and project type)

Funding ($Millions)	TOTALS	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
Total Funding	**2,189**	**75**	**154**	**156**	**164**	**144**	**110**	**235**	**162**	**19**	**414**	**309**	**60**	**48**	**93**	**46**
Single Applicant	953	45	105	97	85	74	49	92	87	10	110	93	41	29	28	8
Joint Venture Lead	1,236	30	49	59	79	70	61	143	75	9	304	216	19	19	65	38
Total Biotechnology Funding	**432**	**12**	**26**	**51**	**58**	**30**	**29**	**46**	**40**	**4**	**32**	**75**	**10**	**13**	**6**	**0**
Single Applicant	281	12	26	32	30	23	25	29	34	4	19	31	6	4	6	0
Joint Venture Lead	151	0	0	19	28	7	4	17	6	0	13	44	4	9	0	0
Total Chemistry/Materials Funding	**467**	**12**	**22**	**26**	**32**	**23**	**32**	**62**	**21**	**7**	**96**	**92**	**15**	**11**	**16**	**0**
Single Applicant	209	6	19	26	24	16	2	35	5	4	29	19	13	5	6	0
Joint Venture Lead	258	6	3	0	8	7	30	27	16	3	67	73	2	6	10	0
Total Electronics/Photonics Funding	**550**	**29**	**47**	**52**	**32**	**56**	**16**	**107**	**23**	**8**	**50**	**20**	**24**	**12**	**31**	**43**
Single Applicant	167	12	26	19	10	22	8	15	2	2	8	6	14	12	6	5
Joint Venture Lead	383	17	21	33	22	34	8	92	21	6	42	14	10	0	25	38
Total Information Technology Funding	**493**	**19**	**40**	**21**	**24**	**8**	**23**	**16**	**54**	**0**	**162**	**115**	**3**	**3**	**4**	**1**
Single Applicant	213	13	28	18	15	8	8	12	32	0	33	35	3	3	4	1
Joint Venture Lead	280	6	12	3	9	0	15	4	22	0	129	80	0	0	0	0
Total Manufacturing (Discrete) Funding	**247**	**3**	**19**	**6**	**18**	**27**	**10**	**4**	**24**	**0**	**74**	**7**	**8**	**9**	**36**	**2**
Single Applicant	83	2	6	2	6	5	6	1	14	0	21	2	5	5	6	2
Joint Venture Lead	164	1	13	4	12	22	4	3	10	0	53	5	3	4	30	0
Percent of Distribution																
Total Funding	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Single Applicant	44	60	68	62	52	51	45	39	54	53	27	30	68	60	30	17
Joint Venture Lead	56	40	32	38	48	49	55	61	46	47	73	70	32	40	70	83
Total Biotechnology Funding	**20**	**16**	**17**	**33**	**35**	**21**	**26**	**20**	**25**	**21**	**8**	**24**	**17**	**27**	**6**	**0**
Single Applicant	65	100	100	63	52	77	86	63	85	100	59	41	60	31	100	-
Joint Venture Lead	35	0	0	37	48	23	14	37	15	0	41	59	40	69	0	-
Total Chemistry/Materials Funding	**21**	**16**	**14**	**17**	**20**	**16**	**29**	**26**	**13**	**37**	**23**	**30**	**25**	**23**	**17**	**0**
Single Applicant	45	50	86	100	75	70	6	56	24	57	30	21	87	45	38	-
Joint Venture Lead	55	50	14	0	25	30	94	44	76	43	70	79	13	55	63	-
Total Electronics/Photonics Funding	**25**	**39**	**31**	**33**	**20**	**39**	**15**	**46**	**14**	**42**	**12**	**6**	**40**	**25**	**33**	**93**
Single Applicant	30	41	55	37	31	39	50	14	9	25	16	30	58	100	19	12
Joint Venture Lead	70	59	45	63	69	61	50	86	91	75	84	70	42	0	81	88
Total Information Technology Funding	**23**	**25**	**26**	**13**	**15**	**6**	**21**	**7**	**33**	**0**	**39**	**37**	**5**	**6**	**4**	**2**
Single Applicant	43	68	70	86	63	100	35	75	59	-	20	30	100	100	100	100
Joint Venture Lead	57	32	30	14	38	0	65	25	41	-	80	70	0	0	0	0
Total Manufacturing (Discrete) Funding	**11**	**4**	**12**	**4**	**11**	**19**	**9**	**2**	**15**	**0**	**18**	**2**	**13**	**19**	**39**	**4**
Single Applicant	34	67	32	33	33	19	60	25	58	-	28	29	63	56	17	100
Joint Venture Lead	66	33	68	67	67	81	40	75	42	-	72	71	38	44	83	0

6. Applications, Awards, and Participants by Geographic Regions—Cumulative 1990–May 2004

Region/State	Applications	Total Awards	Participants
New England	**652**	**102**	**181**
Connecticut	109	19	38
Maine	15	0	1
Massachusetts	459	74	128
New Hampshire	41	4	8
Rhode Island	25	5	6
Vermont	3	0	0
Middle Atlantic	**920**	**109**	**213**
New Jersey	241	34	57
New York	398	49	95
Pennsylvania	281	26	61
South Atlantic	**954**	**97**	**166**
Delaware	51	8	16
District of Columbia	14	1	4
Florida	140	13	20
Georgia	109	8	16
Maryland	290	27	41
North Carolina	108	13	24
South Carolina	34	5	6
Virginia	196	22	38
West Virginia	12	0	1
East South Central	**108**	**4**	**20**
Alabama	24	1	8
Kentucky	16	1	3
Mississippi	16	0	1
Tennessee	52	2	8

Region/State	Applications	Total Awards	Participants
East North Central	**867**	**122**	**325**
Illinois	216	30	47
Indiana	54	3	8
Michigan	280	52	169
Ohio	233	27	83
Wisconsin	84	10	18
West North Central	**257**	**31**	**66**
Iowa	25	3	3
Kansas	30	1	1
Minnesota	129	22	43
Missouri	53	4	14
Nebraska	15	1	5
North Dakota	2	0	0
South Dakota	3	0	0
West South Central	**345**	**34**	**97**
Arkansas	8	0	1
Louisiana	26	2	3
Oklahoma	27	3	7
Texas	284	29	86

Region/State	Applications	Total Awards	Participants
Mountain	**412**	**42**	**74**
Arizona	76	5	14
Colorado	143	17	31
Idaho	20	1	1
Montana	9	0	0
Nevada	23	2	2
New Mexico	50	8	12
Utah	88	9	14
Wyoming	3	0	0
Pacific	**1530**	**195**	**326**
Alaska	1	0	0
California	1355	178	295
Hawaii	16	2	3
Oregon	62	9	17
Washington	96	6	11
U.S. Territories	**2**	**0**	**0**
Puerto Rico	1	0	0
Virgin Islands	1	0	0
Foreign Country	**7**	**0**	**0**

7a. University Participation (by technology area, project type, and lead size) (number of universities/percent distribution)

Number of Universities	TOTALS	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
Total # of Projects	736	27	67	61	59	54	37	79	64	8	103	88	29	21	28	11
Total Universities	**639**	**16**	**45**	**43**	**50**	**33**	**28**	**60**	**60**	**3**	**121**	**97**	**26**	**21**	**31**	**5**
Technology Area																
Biotechnology	139/22%	4/25%	13/29%	12/28%	18/36%	5/15%	2/7%	14/23%	19/32%	1/33%	15/12%	27/28%	7/27%	1/5%	1/3%	0/0%
Chemistry/Materials	169/26%	6/38%	7/16%	7/16%	13/26%	7/21%	8/29%	17/28%	8/13%	1/33%	32/26%	41/42%	9/35%	7/33%	6/19%	0/0%
Electronics/Photonics	121/19%	2/13%	7/16%	19/44%	5/10%	9/27%	8/29%	25/42%	3/5%	1/33%	12/10%	1/1%	5/19%	5/24%	15/48%	4/80%
Information Technology	110/17%	2/13%	10/22%	4/9%	11/22%	2/6%	7/25%	3/5%	7/12%	0/0%	36/30%	25/26%	1/4%	1/5%	1/3%	0/0%
Manufacturing (Discrete)	100/16%	2/13%	8/18%	1/2%	3/6%	10/30%	3/11%	1/2%	23/38%	0/0%	26/21%	3/3%	4/15%	7/33%	8/26%	1/20%
Project Type																
Single Applicant	367/57%	13/81%	31/69%	29/67%	35/70%	20/61%	16/57%	30/50%	33/55%	3/100%	54/45%	48/49%	23/88%	16/76%	14/45%	2/40%
Joint Venture	272/43%	3/19%	14/31%	14/33%	15/30%	13/39%	12/43%	30/50%	27/45%	0/0%	67/55%	49/51%	3/12%	5/24%	17/55%	3/60%
Lead Size																
Small	334/52%	10/63%	33/73%	27/63%	40/80%	19/58%	14/50%	30/50%	33/55%	3/100%	45/37%	45/46%	17/65%	6/29%	10/32%	2/40%
Medium	72/11%	4/25%	2/4%	7/16%	5/10%	3/9%	1/4%	10/17%	5/8%	0/0%	19/16%	6/6%	3/12%	3/14%	4/13%	0/0%
Large	157/25%	2/13%	6/13%	9/21%	2/4%	9/27%	11/39%	17/28%	16/27%	0/0%	31/26%	34/35%	5/19%	11/52%	4/13%	0/0%
Other	76/12%	0/0%	4/9%	0/0%	3/6%	2/6%	2/7%	3/5%	6/10%	0/0%	26/21%	12/12%	1/4%	1/5%	13/42%	3/60%

Totals: 1990-May 2004		
Totals	**639**	**100%**
Single Applicant	**367**	**57%**
Small	274	75%
Medium	35	10%
Large	56	15%
Other	2	1%
Joint Venture	**272**	**43%**
Small	60	22%
Medium	37	14%
Large	101	37%
Other	74	27%

	Biotechnology		*Chemistry/Materials*		*Electronics/Photonics*		*Information Technology*		*Manufacturing (Discrete)*	
Totals	139	22%	169	26%	121	19%	110	17%	100	16%
Project Type										
Single Applicant	113	81%	94	56%	47	39%	68	62%	45	45%
Joint Venture	26	19%	75	44%	74	61%	42	38%	55	55%
Lead Size										
Small	123	88%	71	42%	50	41%	58	53%	32	32%
Medium	8	6%	16	9%	24	20%	10	9%	14	14%
Large	6	4%	79	47%	30	25%	16	15%	26	26%
Other	2	1%	3	2%	17	14%	26	24%	28	28%

7b. University Participation (by technology area, project type, and lead size) (number of projects with university participation)

Number of Projects	TOTALS	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
Total # of Projects	736	27	67	61	59	54	37	79	64	8	103	88	29	21	28	11
Total Projects w/Univ. Part.	368/50%	11/41%	28/42%	28/46%	31/53%	22/41%	19/51%	39/49%	28/44%	3/38%	60/58%	46/52%	17/59%	16/76%	17/61%	3/27%
Technology Area																
Biotechnology	77/21%	2/18%	7/25%	10/36%	11/35%	4/18%	2/11%	8/21%	8/29%	1/33%	6/10%	13/28%	3/18%	1/6%	1/6%	0/0%
Chemistry/Materials	94/26%	4/36%	4/14%	4/14%	9/29%	4/18%	4/21%	14/36%	3/11%	1/33%	16/27%	18/39%	4/24%	4/25%	5/29%	0/0%
Electronics/Photonics	70/19%	2/18%	5/18%	9/32%	3/10%	7/32%	5/26%	13/33%	2/7%	1/33%	4/7%	1/2%	5/29%	5/31%	6/35%	2/67%
Information Technology	67/18%	2/18%	7/25%	4/14%	7/23%	1/5%	5/26%	3/8%	5/18%	0/0%	18/30%	12/26%	1/6%	1/6%	1/6%	0/0%
Manufacturing (Discrete)	60/16%	1/9%	5/18%	1/4%	1/3%	6/27%	3/16%	1/3%	10/36%	0/0%	16/27%	2/4%	4/24%	5/31%	4/24%	1/33%
Project Type																
Single Applicant	243/66%	8/73%	19/68%	23/82%	23/74%	14/64%	12/63%	22/56%	19/68%	3/100%	36/60%	24/52%	15/88%	13/81%	10/59%	2/67%
Joint Venture	125/34%	3/27%	9/32%	5/18%	8/26%	8/36%	7/37%	17/44%	9/32%	0/0%	24/40%	22/48%	2/12%	3/19%	7/41%	1/33%
Lead Size																
Small	211/57%	7/64%	20/71%	21/75%	25/81%	14/64%	11/58%	22/56%	19/68%	3/100%	25/42%	18/39%	11/65%	6/38%	7/41%	2/67%
Medium	39/11%	2/18%	1/4%	1/4%	3/10%	2/9%	1/5%	5/13%	3/11%	0/0%	10/17%	5/11%	1/6%	3/19%	2/12%	0/0%
Large	85/23%	2/18%	4/14%	6/21%	1/3%	5/23%	6/32%	10/26%	4/14%	0/0%	16/27%	18/39%	4/24%	6/38%	3/18%	0/0%
Other	33/9%	0/0%	3/11%	0/0%	2/6%	1/5%	1/5%	2/5%	2/7%	0/0%	9/15%	5/11%	1/6%	1/6%	5/29%	1/33%

Totals: 1990-May 2004		
Totals	**368**	**100%**
Single Applicant	**243**	**66%**
Small	181	74%
Medium	24	10%
Large	36	15%
Other	2	1%
Joint Venture	**125**	**34%**
Small	30	24%
Medium	15	12%
Large	49	39%
Other	31	25%

	Biotechnology		*Chemistry/Materials*		*Electronics/Photonics*		*Information Technology*		*Manufacturing (Discrete)*	
Totals	77	12%	94	15%	70	11%	67	10%	60	9%
Project Type										
Single Applicant	64	83%	58	62%	36	51%	50	75%	35	58%
Joint Venture	13	17%	36	38%	34	49%	17	25%	25	42%
Lead Size										
Small	66	86%	41	44%	38	54%	41	61%	25	42%
Medium	4	5%	9	10%	10	14%	8	12%	8	13%
Large	5	6%	41	44%	16	23%	10	15%	13	22%
Other	2	3%	3	3%	6	9%	8	12%	14	23%

8. Number of Patents (by technology area, project type, and lead size)

	TOTALS	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
Total # of Projects:	736	27	67	61	59	54	37	79	64	8	103	88	29	21	28	11
Total Patents	**1171**	**0**	**0**	**1**	**22**	**47**	**62**	**80**	**93**	**31**	**300**	**308**	**88**	**46**	**56**	**37**
Technology Area																
Biotechnology	302/26%	0	0	1/100%	0	1/2%	1/2%	28/35%	23/25%	7/23%	33/11%	180/58%	19/22%	8/17%	1/2%	0
Chemistry/Materials	311/27%	0	0	0	2/9%	3/6%	60/97%	24/30%	27/29%	5/16%	74/25%	60/19%	24/27%	1/2%	31/55%	0
Electronics/Photonics	289/25%	0	0	0	16/73%	17/36%	1/2%	14/18%	28/30%	19/61%	34/11%	43/14%	38/43%	23/50%	19/34%	37/100%
Information Technology	170/15%	0	0	0	0	25/53%	0	13/16%	11/12%	0	93/31%	24/8%	4/5%	0	0	0
Manufacturing (Discrete)	99/8%	0	0	0	4/18%	1/2%	0	1/1%	4/4%	0	66/22%	1/0%	3/3%	14/30%	5/9%	0
Project Type																
Single Applicant	579/49%	0	0	1/100%	2/9%	41/87%	1/2%	37/46%	39/42%	25/81%	120/40%	190/62%	79/90%	31/67%	13/23%	0
Joint Venture	592/51%	0	0	0	20/91%	6/13%	61/98%	43/54%	54/58%	6/19%	180/60%	118/38%	9/10%	15/33%	43/77%	37/100%
Lead Size																
Small	509/43%	0	0	1/100%	9/41%	18/38%	1/2%	31/39%	60/65%	25/81%	87/29%	174/56%	41/47%	27/59%	12/21%	23/62%
Medium	182/16%	0	0	0	0	0	0	3/4%	16/17%	0	63/21%	59/19%	22/25%	5/11%	12/21%	2/5%
Large	480/41%	0	0	0	13/59%	29/62%	61/98%	46/58%	17/18%	6/19%	150/50%	75/24%	25/28%	14/30%	32/57%	12/32%

Totals: 1990-May 2004		
Totals	1171	100%
Single Applicant	**579**	**49%**
Small	325	56%
Medium	91	16%
Large	163	28%
Joint Venture	**592**	**51%**
Small	184	31%
Medium	91	15%
Large	317	54%

	Biotechnology		*Chemistry/Materials*		*Electronics/Photonics*		*Information Technology*		*Manufacturing (Discrete)*	
Total	302	26%	311	27%	289	25%	170	15%	99	8%
Project Type										
Single Applicant	228	75%	96	31%	120	42%	80	47%	55	56%
Joint Venture	74	25%	215	69%	169	58%	90	53%	44	44%
Lead Size										
Small	215	71%	42	14%	180	62%	38	22%	34	34%
Medium	59	20%	36	12%	29	10%	48	28%	10	10%
Large	28	9%	233	75%	80	28%	84	49%	55	56%

9. Commercialization (by area and lead size)

	TOTALS	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
Total # of Projects	736	27	67	61	59	54	37	79	64	8	103	88	29	21	28	11
Total Projects w/Comm.	**329**	**0**	**0**	**1**	**9**	**14**	**6**	**43**	**47**	**6**	**75**	**66**	**26**			
Technology Area																
Biotechnology	57/17%	0	0	1/100%	2/22%	1/7%	1/17%	8/19%	12/26%	2/33%	8/11%	16/24%	3/12%			
Chemistry/Materials	81/25%	0	0	0	2/22%	1/7%	2/33%	17/40%	3/6%	2/33%	18/24%	21/32%	8/31%			
Electronics/Photonics	72/22%	0	0	0	3/33%	8/57%	2/33%	15/35%	6/13%	2/33%	7/9%	5/8%	10/38%			
Information Technology	77/23%	0	0	0	1/11%	1/7%	1/17%	3/7%	17/36%	0/0%	26/35%	22/33%	2/8%			
Manufacturing (Discrete)	42/13%	0	0	0	1/11%	3/21%	0	0	9/19%	0	16/21%	2/3%	3/12%			
Project Type																
Single Applicant	201/61%	0	0	1/100%	5/56%	6/43%	2/33%	24/56%	34/72%	5/83%	42/56%	34/52%	21/81%			
Joint Venture	128/39%	0	0	0	4/44%	8/57%	4/67%	19/44%	13/28%	1/17%	33/44%	32/48%	5/19%			
Lead Size																
Small	196/60%	0	0	1/100%	6/67%	11/79%	3/50%	27/63%	36/77%	5/83%	34/45%	35/53%	15/58%			
Medium	32/10%	0	0	0	0/0%	1/7%	0	7/16%	3/6%	0	11/15%	6/9%	3/12%			
Large	74/22%	0	0	0	2/22%	2/14%	3/50%	8/19%	6/13%	1/17%	19/25%	19/29%	7/27%			
Other	27/8%	0	0	0	1/11%	0	0	1/2%	2/4%	0	11/15%	6/9%	1/4%			

No data available (1990-1992); Business Reporting System implemented in 1993

Totals: 1990-May 2004		
Totals	329	100%
Single Applicant	**201**	**61%**
Small	152	76%
Medium	19	9%
Large	29	14%
Other	1	0%
Joint Venture	**128**	**39%**
Small	44	34%
Medium	13	10%
Large	45	35%
Other	26	20%

	Biotechnology		*Chemistry/Materials*		*Electronics/Photonics*		*Information Technology*		*Manufacturing (Discrete)*	
Total	57	17%	81	25%	72	22%	77	23%	42	13%
Project Type										
Single Applicant	44	77%	44	54%	35	49%	56	73%	22	52%
Joint Venture	13	23%	37	46%	37	51%	21	27%	20	48%
Lead Size										
Small	49	86%	34	42%	45	63%	47	61%	21	50%
Medium	6	11%	10	12%	6	8%	8	10%	2	5%
Large	2	4%	32	40%	15	21%	15	19%	10	24%
Other	0	0%	5	6%	6	8%	7	9%	9	21%

10. Post-Award Attraction of External Funding* (by area and lead size)

	TOTALS	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
Total # of Projects	736	27	67	61	59	54	37	79	64	8	103	88	29	21	28	11
Total Projects w/Ext. Fund.	**329**	**0**	**0**	**15**	**44**	**43**	**26**	**36**	**34**	**7**	**53**	**54**	**17**			
Technology Area																
Biotechnology	88/27%	0	0	6/40%	15/34%	11/26%	8/31%	7/19%	11/32%	2/29%	10/19%	16/30%	2/12%			
Chemistry/Materials	76/23%	0	0	3/20%	13/30%	7/16%	4/15%	12/33%	2/6%	3/43%	12/23%	14/26%	6/35%			
Electronics/Photonics	68/21%	0	0	3/20%	8/18%	17/40%	5/19%	12/33%	4/12%	2/29%	6/11%	4/7%	7/41%			
Information Technology	68/21%	0	0	3/20%	5/11%	3/7%	5/19%	4/11%	11/32%	0	16/30%	19/35%	2/12%			
Manufacturing (Discrete)	29/9%	0	0	0	3/7%	5/12%	4/15%	1/3%	6/18%	0	9/17%	1/2%	0			
Project Type																
Single Applicant	217/66%	0	0	13/87%	31/70%	30/70%	16/62%	23/64%	25/74%	6/86%	30/57%	30/56%	13/76%			
Joint Venture	112/34%	0	0	2/13%	13/30%	13/30%	10/38%	13/36%	9/26%	1/14%	23/43%	24/44%	4/24%			
Lead Size																
Small	236/72%	0	0	15/100%	37/84%	33/77%	19/73%	26/72%	29/85%	6/86%	27/51%	34/63%	10/59%			
Medium	26/8%	0	0	0	2/5%	2/5%	1/4%	4/11%	1/3%	0	10/19%	4/7%	2/12%			
Large	47/14%	0	0	0	3/7%	7/16%	5/19%	5/14%	3/9%	1/14%	7/13%	11/20%	5/29%			
Other	20/6%	0	0	0	2/5%	1/2%	1/4%	1/3%	1/3%	0	9/17%	5/9%	0			

No data available (1990-1992); Business Reporting System implemented in 1993

Totals: 1990-May 2004

Totals	**329**	**100%**
Single Applicant	**217**	**66%**
Small	188	87%
Medium	13	6%
Large	16	7%
Other	0	0%
Joint Venture	**112**	**34%**
Small	48	43%
Medium	13	12%
Large	31	28%
Other	20	18%

Biotechnology

	88	**27%**
Project Type		
Single Applicant	69	78%
Joint Venture	19	22%
Lead Size		
Small	82	93%
Medium	2	2%
Large	3	3%
Other	1	1%

Chemistry/Materials

	76	**23%**
Project Type		
Single Applicant	47	62%
Joint Venture	29	38%
Lead Size		
Small	48	63%
Medium	7	9%
Large	19	25%
Other	2	3%

Electronics/Photonics

	68	**21%**
Project Type		
Single Applicant	38	56%
Joint Venture	30	44%
Lead Size		
Small	45	66%
Medium	9	13%
Large	11	16%
Other	3	4%

Information Technology

	68	**21%**
Project Type		
Single Applicant	51	75%
Joint Venture	17	25%
Lead Size		
Small	45	66%
Medium	7	10%
Large	8	12%
Other	8	12%

Manufacturing (Discrete)

	29	**9%**
Project Type		
Single Applicant	12	41%
Joint Venture	17	59%
Lead Size		
Small	16	55%
Medium	1	3%
Large	6	21%
Other	6	21%

* External funding includes funding from public and private sources received any time after the award announcement.

Appendix B
Significant Recent Studies

The ATP Economic Assessment Office measures the success of the Advanced Technology Program through a variety of evaluation studies, aided by leading experts. All the recent studies described in this appendix can be found at www.atp.nist.gov/eao/eao_pubs.htm.

Economic Studies

Technology Adoption Indicators Applied to the Flow-Control Machining Project. An idea from the 1995 ATP competition produced a new automobile finishing process called Flow-Control Machining (FCM), which increases the precision of cast-metal parts for interior fluid flows. This economic study develops a set of technology adoption indicators (TAIs) capable of selecting and analyzing possible spillover applications for FCM technology. When applied to engine manufacturers for lawnmowers and airplanes, TAIs revealed that the lawnmower industry is more likely to adopt this new technology, due in part to new EPA regulations, with significant projected savings in GDP.

NISTIR 6888 (Economic Study). May 2003. Hayden Brown (NIST) and Mark Ehlen (Sandia National Labs).

Inter-Industry Diffusion of Technology That Results from ATP Projects. This report describes the inter-industry diffusion of technology that might result if ATP-funded projects used U.S. input-output (I-O) tables to identify the fit of those projects within the U.S. industrial structure. These tables can also track the most direct path of benefits flowing to other industries. In industries represented by an ATP participant, the intensity of purchase activities by similar companies in that industry could provide a useful indicator of the likelihood of spillovers; such an indicator could be quantified by I-O tables. Rankings can be derived from 1998 I-O tables for 36 ATP projects that were funded from 1992-1996 and resulted in commercialization.

NIST GCR 03-848 (Economic Study). April 2003. Joel Popkin (JPC Economic Consultants).

Measuring the Impact of ATP-Funded Research Consortia on Research Productivity of Participating Firms: A Framework Using Both U.S. and Japanese Data. This study uses empirical methods to evaluate the effects of participation in ATP-funded consortia on the research productivity of consortia members. The authors developed a data set for one group of firms that participated in ATP-funded research consortia, and for a second control group that were never involved. Innovative output was measured using patent data. The findings revealed a positive relationship between the firms' intensity of participation in research consortia and their overall research productivity—participation in one additional ATP-funded consortium per year would increase a firm's patenting that year by as much as 8 percent. Japanese data included in the study validated the fact that consortia have a positive impact on research productivity.

NIST GCR 02-830 (Economic Study). December 2002. Mariko Sakakibara (UCLA) and Lee Branstetter (Columbia Business School).

Program Design and Firm Success in the Advanced Technology Program: Project Structure and Innovation Outcomes. In evaluating ATP, the increased innovation of participant firms serves as an important indicator of program success. This study measures innovation outcomes by the number of patents granted and by a statistical analysis of firms before and after ATP project participation. The study showed that ATP has a positive effect on innovation in firms, and participation in the program increases firms' patenting, relative to their patenting prior to the ATP award. The study also showed that joint venture participation and university collaboration have positive impacts on innovation, as measured by increased firm patenting activity.

NISTIR 6943 (Economic Study). December 2002. Lynne G. Zucker and Michael R. Darby (UCLA), and Andrew J. Wang (NIST/ATP).

Universities as Research Partners. This study seeks to gain a better understanding of the performance of university-industry research partnerships by surveying a sample of pre-commercial research projects funded by ATP. Although results must be interpreted cautiously because of the small sample size, the study finds that projects with university involvement tend to be in areas involving "new" science, and therefore the projects may experience more difficulty and delay—but also are more likely to end in success. This finding implies that universities are contributing to basic research awareness and insight among the partners in ATP-funded projects; therefore universities are important to U.S. innovation.

NIST GCR 02-829 (Economic Study). June 2002. Bronwyn H. Hall (UC/B), Albert N. Link (UNC/G), and John T. Scott (Dartmouth).

Winning an Award from the Advanced Technology Program: Pursuing R&D Strategies in the Public Interest and Benefiting From a Halo Effect. This study addresses two questions: (1) how a firm's R&D strategy relates to the goals of ATP and affects the chances of winning an award from the program; and (2) how winning an award affects a firm's success in raising additional funds for a proposed research project. Data from a 1999 survey show that award winners are more likely to behave in ways that enhance the transfer of knowledge to—and the reception of technology by—other firms. Award-winning companies are better networked than non-winning applicants and exhibit a greater willingness to share research findings. Award-winning companies are also more likely to form partnerships to open up new innovation pathways. The study finds that award-winning firms have greater success in attracting additional funding for their ATP projects from other sources.

NISTIR 6577 (Economic Study). March 2001. Maryann P. Feldman (Johns Hopkins) and Maryellen R. Kelley (NIST/ATP).

Policy Analysis Studies

Understanding Private–Sector Decision Making for Early-Stage Technology Development. This report examines trends in management of corporate R&D and how new market realities affect the ways that corporations manage and support early stage technology development (ESTD) activities. It is based on interviews with senior executives and investors from corporations across eight industry sectors and eight venture capital firms. Of $181 billion invested in R&D activities by U.S. firms in 2000, only $13 billion funded the types of ESTD activities that target delivery of radical innovations to market. Variations found across industries are shaped by forces such as the increasing sophistication required to develop new technological innovations, the increasing pressure on corporate R&D divisions to demonstrate ROI, and the importance of the lifecycle position of specific industries and individual companies.

NIST GCR-02-841B (Special Issues Study). September 2003. Nicholas Demos (Booz Allen Hamilton), and Philip E. Auerswald, Lewis M. Branscomb, and Brian K. Min (Harvard University).

Bridging From Project Case Study to Portfolio Analysis in a Public R&D Program: A Framework for Evaluation and Introduction to a Composite Performance Rating System. This paper presents a framework for evaluating both individual projects and a portfolio of projects in the "mid term"—3-5 years after project completion. It introduces a prototype evaluation tool, the Composite Performance Rating System (CPRS), designed for ATP but adaptable to other programs. CPRS uses uniformly collected indicator metrics to rate each of ATP's completed projects in what was added to the national scientific and technical knowledge base, the knowledge it disseminated, and the technology commercialized into new products or processes. The indicator metrics compute star ratings (0 to 4 stars) to provide a quantitative assessment of the first 50 completed projects in the ATP portfolio: 16 percent received 4 stars; 26 percent received 3 stars; 34 percent received 2 stars; and 24 percent received 0 or 1 star.

NIST-GCR 03-851 (Special Issues Study). August 2003. Rosalie Ruegg (TIA Consulting, Inc.).

A Toolkit for Evaluating Public R&D Investment: Models, Methods, and Findings from ATP's First Decade. This comprehensive report uses the large body of evaluation techniques and 45 selected studies developed by ATP during its first decade to provide an evaluation framework—a directory of methods, tools, techniques, principles, explanatory information, and best practices. These tools and techniques develop the body of knowledge about the behavior of participating companies, the degree of collaboration, spillover effects, interfaces with state and international technology programs, ATP's performance at large, and knowledge about evaluation itself. A cross-cutting look at study findings confirmed results from individual studies indicating that ATP is achieving its overarching objectives, leading to broadly distributed economic benefits:

- Findings on private firms' effects, drawn from 13 studies, indicate that ATP substantially expanded and enhanced the R&D activities of the companies examined and that the ATP funds complemented private R&D funds.
- A recurring finding from 10 studies showed high rates of collaboration within ATP projects, including joint ventures and single company projects. Of the first 50 completed projects, 84 percent showed a broad range of collaborative activities.
- Findings from 10 studies provided evidence that ATP projects generated outputs—in the forms of publications, patents, patent citations, collaborative linkages, and products—that will potentially lead to knowledge and market spillovers.
- Thirteen studies collectively attributed to ATP more than $15 billion in expected present value of social benefits from just a few projects, much greater than the total amount spent to date by the program.

NIST GCR 03-857 (Special Issues Study). July 2003. Rosalie Ruegg (TIA Consulting, Inc.) and Irwin Feller (AAAS and Pennsylvania State University).

Between Invention and Innovation: An Analysis of Funding for Early-Stage Technology Development. This study addresses the distribution of funding for early-stage technology development across different institutional categories and compares government programs with private sources in terms of magnitude. The study also looks at the difficulties that firms face when attempting to find funding for early-stage, high-risk R&D projects. To arrive at a reasonable estimate of the national investment in early-stage technology development, the authors relied on the observations of practitioners that were gathered during a series of workshops held in the United States. They also collected data available on early-stage technology development investments from other studies and from public statistical sources. Findings include:

- Most funding for technology development in the phase between invention and innovation heralds from individual angel investors, corporations, and the federal government—not from venture capitalists.
- Markets for allocating risk capital to early-stage ventures are not efficient. According to the authors, federal technology development funds complement, rather than substitute for, private funds.

NIST GCR 02-841 (Special Issues Study). November 2002. Lewis M. Branscomb and Philip E. Auerswald (Harvard University).

Survey Data Results

Different Timelines for Different Technologies: Evidence from the Advanced Technology Program. To address the variations seen in the commercialization of technologies from early ATP-funded projects, this study uses data collected through ATP's Business Reporting System to analyze differences in commercialization patterns for these technologies. Variations were apparent in the timing of initial revenues, commercialization in more mature and multiple applications, and diffusion of technologies. Based on business reports from 558 participants in 299 ATP projects funded between 1993 and 1998, business expectations and strategies were examined for nearly 1,200 commercial applications. Differences in technology type—information technologies, biotechnologies, manufacturing, and electronics—are also examined within an innovation lifecycle framework to illuminate differences in diffusion patterns.

NISTIR 6917 (Survey Data Results). November 2002. Jeanne Powell (NIST/ATP) and Francisco Moris (NSF).

Survey of ATP Applicants 2000. To help assess the effectiveness and impact of ATP, the Economic Assessment Office sponsored a survey of all applicants in the 2000 funding competition. The resulting evaluation tool aids in assessing overall characteristics of applicants and in comparing program effects on awardees and nonawardees. All for-profit company applicants to ATP in 2000 were included in the survey sample; other organizations, such as universities and non-profit organizations, were not included. Survey responses were obtained from a total of 346 companies, including 74 companies that were awarded funding as well as 272 companies not selected for an award. Survey findings confirm the significant impact of ATP.

NIST GCR 03-847 (Survey Data Results). June 2003, Westat (Rockville, MD).

Case Studies

Determinants of Success in ATP-Funded R&D Joint Ventures: A Preliminary Analysis Based on 18 Automobile Manufacturing Projects. This study explores the growing importance of collaborative ventures to the nation's economic strength, the factors that make them work, and the role of government in fostering collaboration. The focus is on 18 ATP-funded automotive industry joint ventures initiated between 1991 and 1997. Factors in success include trust, information sharing, an optimal number of participants, companies with complementary skills, personnel stability, cost containment, and a high level of company commitment. Findings suggest that ATP provides funding at critical stages, accelerates research, improves outcomes, and encourages partners to take on higher risk and longer-term research. ATP also helps joint ventures to overcome barriers to collaboration and helps projects run more smoothly, albeit with some loss of flexibility on the part of the companies.

NIST GCR 00-803 (Case Study). December 2001. Jeffrey H. Dyer (BYU) and Benjamin C. Powell (University of Pennsylvania).

Benefits and Costs of ATP Investments in Component-Based Software. From 1994 to 2000, ATP provided $42 million to support 24 projects under its focused program in Component Based Software for building large software systems by assembling readily available components. This study assesses the impact of the ATP-supported projects using quantitative and qualitative analyses. Results show that two-thirds of the funded projects achieved their technical objectives. Viewed as an investment portfolio, the 24 projects delivered social returns exceeding reasonable benchmarks for public or private investment. The authors calculate a net present value of $840 million and benefit-to-cost ratio of 10.5, suggesting that the expenditure of public funds was worthwhile.

GCR 02-834 (Case Study). November 2002. William White and Michael P. Gallaher (RTI).

Closed-Cycle Air Refrigeration Technology for Cross-Cutting Applications in Food Processing, Volatile Organic Compound Recovery, and Liquid Natural Gas Industries. ATP co-funded a 1995 joint venture to design, fabricate, and pilot test closed-cycle air refrigeration (CCAR), a new industrial technology that uses environmentally benign air as the working fluid. Market analyses showed the U.S. food processing industry to be a promising end market, where ultra-cold temperatures (–70°F to –150°F) help to improve food safety and reduce weight loss, dehydration from evaporation, and environmental emissions. Against a $2.1 million ATP investment and $2.2 million in corporate funds, the project has a net present value of $459–$585 million (2001 dollars), an internal rate of return of 83–90 percent, and a benefit-to-cost ratio of 220:1 to 280:1. The study concludes that CCAR technology would not have been developed without ATP funding.

NIST GCR 01-819 (Case Study). December 2001. Thomas Pelsoci (Data Research Company).

Low-Cost Manufacturing Process Technology for Amorphous Silicon Detectors: Applications in Digital Mammography and Radiography. This case study examines the 1995-2000 ATP-supported joint venture involving General Electric Global Research and PerkinElmer, Inc., to develop a low-cost manufacturing process for fabricating amorphous silicon detector panels used in digital mammography and digital radiography systems. The GE Medical Systems Senographe® 2000D system resulted from the ATP-funded project. This unit has proven to issue 20 percent fewer false positive results and therefore requires fewer patient recalls than conventional systems. Each unit is associated with $63,360 in medical savings per year, and the original $1.575 million ATP investment has resulted in technology estimated to be worth $219-$339 million (2002) dollars in benefits to health care industry users and patients.

NIST GCR 03-844 (Case Study). February 2003. Thomas M. Pelsoci (Delta Research Company).

Working Papers

A Study of the Management of Intellectual Property in ATP-Awarded Firms. Based on six case studies developed from interviews of ATP project participants, this paper examines the behavior of firms proposing research projects to ATP and whether such firms select research that minimizes the likelihood that other firms might benefit from resulting intellectual property. The six case studies represent two technology areas, and include single company projects and joint ventures. The findings suggest that intellectual property concerns do not affect the research that single company applicants propose but do affect a company's decision to apply as a single company applicant or joint venture. The findings also show that when firms apply as joint ventures, they may pursue strategies for maintaining control of their intellectual property so that diffusion is minimized.

ATP Working Papers Series 00-01. August 2003. Julia Porter Liebeskind (University of Southern California).

Catalyzing the Genomics Revolution: ATP's Tools for DNA Diagnostics Focused Program. The Human Genome Project began in 1990 as a multi-agency effort in the federal government that sought to determine the complete sequence of the DNA in the human genome by 2006. ATP participated in this effort with its Tools for DNA Diagnostics Focused Program, with competitions in 1994, 1995, and 1998; it also funded DNA tools projects in general/open competitions. Through 2002, ATP had committed more than $138 million to cooperatively fund 42 R&D projects on DNA tools. This working paper summarizes ATP's contributions to the field of DNA research, which include many innovative technologies along with the intellectual property portfolios of ATP-participating companies that have benefited an emerging industrial sector.

ATP Working Papers Series 04-01. July 2004.

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