

Technology Transfer



Bringing
Innovation to
NASA and the
Nation

November 2004

NATIONAL ACADEMY OF
PUBLIC ADMINISTRATION



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**NATIONAL ACADEMY OF
PUBLIC ADMINISTRATION**

for the National Aeronautics and Space Administration

November 2004

**TECHNOLOGY TRANSFER:
BRINGING INNOVATION TO
NASA AND THE NATION**

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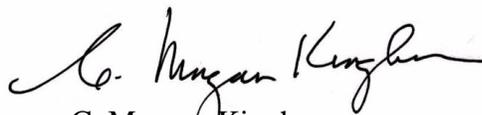
FOREWORD

Since its creation in 1958, the National Aeronautics and Space Administration (NASA) has developed a wide range of important technologies that the private sector has commercialized. These include such essential aspects of modern life as small computers, cellular communications, and lightweight and heat resistant materials. Despite these past contributions, NASA has not been as successful with its recent technology transfer efforts due to organizational changes, budget difficulties, and a lack of program focus. Equally important, private industry and universities often are the leaders in many technologies that NASA needs for its missions, which is a fundamental change from prior decades. Managing effectively in this new environment requires a different approach to technology transfer and a different set of skills.

The Innovative Partnerships Program (IPP) is responsible for NASA's technology transfer efforts. In 2004, IPP shifted its primary focus from commercializing NASA's technology ("spin-out") to a much greater emphasis on bringing technology from the private sector into the agency to meet mission needs ("spin-in"). NASA asked the Academy to conduct an independent review of the technology transfer function and determine how it should be organized to maximize benefits to NASA and the nation as a whole.

The Panel overseeing this Academy study recommends that the NASA Administrator make a stronger leadership commitment to technology transfer by establishing it as a core element of the agency's mission and moving the function to the Administrator's office. The Panel's fundamental conclusion is that technology transfer is destined to fail so long as it is viewed solely as the responsibility of an isolated group of IPP officials.

The Academy was pleased to undertake this study. I want to thank the Academy Fellows and other experts who served on the Panel. Their insights and guidance were excellent. I also thank NASA executives, staff, and other stakeholders for their time and cooperation. Finally, I extend my appreciation to the study team for its hard work and diligence in producing this important report.



C. Morgan Kinghorn
President

National Academy of Public Administration

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ACRONYMS

ATCC	Ames Technology Commercialization Center
AUTM	Association of University Technology Managers
BizTech	BizTech Huntsville, Alabama, is a small business incubator
CRADA	Cooperative Research and Development Agreement
CTC	Center for Technology Commercialization (Northeast Regional Technology Transfer Center)
EHB	Electronic Handbook
ETC	Emerging Technology Center
FAR	Federal Acquisition Regulation
FFRDCs	Federally Funded Research and Development Centers
FLC	Federal Laboratory Consortium for Technology Transfer
FNBC	Florida/NASA Business Incubation Center
FWR TTC	Far West Regional Technology Transfer Centers
GLITeC	Great Lakes Industrial Technology Center (Midwest Regional Technology Transfer Center)
GOCO	Government Owned and Contractor Operated
GOGO	Government Owned and Government Operated
HRTI	Hampton Roads Technology Incubator
IP	Intellectual Property
IPP	Innovative Partnerships Program
JSC	Johnson Space Center (Houston, Texas)
JPL	Jet Propulsion Laboratory (California)
KSC	Kennedy Space Center (Orlando, Florida)
LIFT	Lewis Incubator for Technology
MCTTC	Mid-Continent Technology Transfer Center
MSET	Mississippi Enterprise for Technology
NASA TechTracS	TechTracS database for tracking technologies
NCC	NASA Commercialization Center
NTRs	New Technology Reports
NREC	National Robotics Engineering Consortium
NTTC	National Technology Transfer Center
PCAST	President's Council of Advisors of Science and Technology
R&D	Research and Development
RTI	Research Triangle Institute (North Carolina)
RTTC	Regional Technology Transfer Centers
SBIR	Small Business Innovation Research Program
SERTTC	Southeast Regional Technology Transfer Center
STI	Scientific and Technical Information Program
STTR	Small Business Technology Transfer
TeCC	Technology Commercialization Center (Mid-Atlantic Regional Technology Transfer Center)
UH	UH-NASA Technology Commercialization Incubator
CTTI	Center for Training, Technology and Incubation

LLNL	Lawrence Livermore National Laboratory (California)
eNTRe	electronic new technology reporting system
NTTS	National Technology Tracking System
KIMS	Knowledge Integration and Management System
TechFinder	NASA's public technology transfer gateway
VA	Department of Veterans Affairs
WVHTC	West Virginia High Technology Consortium Foundation

EXECUTIVE SUMMARY

For the last half of the twentieth century, the National Aeronautics and Space Administration (NASA) was among the most successful organizations in history in developing new technology and making it available to both the private sector and other government organizations. Small computers; cellular communications; lightweight, heat resistant materials; telemedicine, and a broad spectrum of everyday products have all benefited from NASA research and development.

Technology transfer was mandated as a NASA responsibility in the National Aeronautics and Space Act of 1958. National leaders recognized that NASA would be heavily involved in creating technologies to achieve the agency's ambitious missions and that these technologies could have enormous consequences for the nation's economy. The NASA Administrator was required to provide the widest practicable dissemination of results of NASA's activities and to protect inventions to which NASA has title. Since then, Congress has crafted legislation designed to further protect federally developed intellectual property while at the same time making these innovations broadly available to benefit the nation.

For a number of reasons, NASA's current technology transfer programs are operating in a fundamentally changed environment from those earlier days and are not nearly as successful:

- The private and university sectors of the economy now conduct much more research and development (R&D) than the federal government, and often are the leaders in many of the technologies that NASA needs for its missions.
- The issues of technology and technology transfer are multi-national, and the development of space-related technologies has been globalized. The Apollo mission was essentially a U.S.-driven effort; today the International Space Station is an effort conducted by 16 nations.
- Small businesses are an increasing source of innovation for new technology.
- Congress, NASA, and the Office of Management and Budget (OMB) have different views about how to best accomplish technology transfer. This disagreement plays out through the budget process and has created significant uncertainty about the program throughout NASA's technology transfer network.
- Organizations in the technology transfer network operate at the margins of the agency's overall operations, lack executive support, and are likely to be at odds with each other.
- The technology transfer program has recently undergone major changes. In FY 2004, the Commercial Technology Program was terminated, and the program's emphasis was changed from a primary focus on diffusion of technology to the private sector ("spin-out") to a much greater focus on the infusion of technology into the agency to help meet mission requirements ("spin-in").

In January 2004, the Academy was asked by NASA to conduct an independent review of its technology transfer function and this report is a result of that study. While the report speaks to technology transfer in a broad context, the specific organization at the center of this study is the Innovative Partnerships Program (IPP). The overall goal of the study is to give all the stakeholders a common understanding of how NASA's technology transfer function* should be organized to obtain the maximum benefits for the nation.

The Panel and study team were impressed with the knowledge and commitment of the NASA staff they interviewed both in headquarters and in the field centers. Without their help, this study would not have been possible. An important overall observation from this study is that the technology transfer system in NASA has good people working in an environment that makes it very difficult for them to be successful.

After conducting a review of NASA's performance in technology transfer, the Panel found that:

- Most technology acquired by NASA is done outside the IPP.
- NASA lacks a comprehensive strategy for identifying technology needs and commercialization opportunities.
- The IPP network is fragmented; roles and responsibilities of component organizations overlap and are unclear.
- There are few technology transfer output measures and no outcome measures, which blurs accountability for results.
- Programmatic uncertainty is adversely affecting the organization.
- The IPP is generally successful at administrative aspects of technology diffusion; there is more difficulty in other aspects, such as brokering technology partnerships with the private sector.
- The IPP appears to have a very limited role in technology infusion/spin-in.
- Stakeholders and NASA managers have expressed significant dissatisfaction with the complex and lengthy intellectual property process.
- The IPP faces significant constraints—low agency priority, conflicting stakeholder views, declining budgets and staffing, and more.

The IPP as currently structured is not as successful as it could be in obtaining technology to meet mission requirements or in identifying commercial opportunities for NASA-generated

* The technology transfer function includes the IPP program and other processes that contribute to technology transfer, such as the Small Business Innovation Research Program (SBIR) and Small Business Technology Transfer (STTR).

innovations. The ultimate outcome is a program that meets neither the agency's needs nor stakeholder and public expectations. If NASA chooses to strive for excellence in technology transfer, major changes are needed.

The Academy Panel provides the following recommendations on the roles and responsibilities of the various entities involved with an awareness of the changes now underway at NASA. The Panel's goal is to support these changes where it can and offer suggestions that may further enhance the chances of success:

Recommendation # 1: Leadership Commitment

The NASA Administrator should support an agency-wide technology transfer effort by establishing that technology transfer is a core element of the agency's mission that requires the attention and support of NASA's leadership team, relevant program officials, and major contractors.

Recommendation # 2: Organizational Location

The headquarters technology transfer office and the programs under it should be relocated to the Office of the Administrator in order to give special emphasis to this agency-wide responsibility and to begin holding executives accountable for this function.

Recommendation # 3: Roles and Responsibilities for Spin-In

The associate administrators for each mission directorate, supported by the center directors and program heads in the centers, should be held responsible for making better use of technology outside NASA—both through acquisition and through partnerships—to meet the agency's mission needs.

Recommendation # 4: Roles and Responsibilities for Spin-Out

NASA should make the center directors responsible for the spin-out aspects of technology transfer, with the understanding that centers will support staffing and activities beyond those funded by headquarters.

Recommendation # 5: The External Network

The national network should be reformulated and streamlined to provide a more effective vehicle for program implementation.

Recommendation # 6: Websites and Information Systems

NASA should improve its websites and provide one easy-to-use portal for all technology transfer activities. The headquarters technology transfer office should also work with appropriate technical support to develop an integrated information system to automate its business operations, using an upgraded NASA Technology Transfer System (NTTS) as the base, and

make it the standard means for information reporting and information management throughout NASA for technology transfer.

Recommendation # 7: The Timeliness of the Intellectual Property Process

The headquarters IPP office, in cooperation with the Office of General Counsel, should develop processing-time performance standards for patent applications, licenses, and partnership agreements.

Recommendation # 8: Performance Metrics

NASA should develop a comprehensive system for evaluating its technology transfer efforts that utilizes a balanced scorecard for measuring outputs, assesses the long-term economic and social impacts of NASA technology transfer, and establishes individual performance standards for all officials who have a role in technology transfer.

For most of these recommendations, the Panel lists in Chapter 4 specific actions NASA should take to implement them.

CHAPTER 1

INTRODUCTION AND BACKGROUND

Technology transfer has been a mandated program for the National Aeronautics and Space Administration (NASA) since Congress created the agency through the Space Act of 1958.¹ On its website NASA observes that it has “accomplished many great scientific and technological feats in air and space. NASA technology also has been adapted for many non-aerospace uses by the private sector.”²

In 2004, the technology transfer program underwent significant changes. The Commercial Technology Program was terminated and replaced with the Innovative Technology Transfer Partnerships program (ITTP), which was subsequently renamed the Innovative Partnerships Program (IPP).³ Because of recent budget constraints, the President’s Moon and Mars Initiative, the Office of Management and Budget’s (OMB) concerns about the effectiveness of NASA’s commercialization efforts, and the fact that the private sector now conducts more R&D than the federal government, the program’s focus has been shifted. Initially, its primary focus was on commercializing NASA-developed technology. Now its primary focus is to identify technology outside NASA—in private companies and universities—that the agency’s scientists and engineers can use in their mission-related projects. IPP is still expected to meet its legislatively mandated spin-out requirements.

In February 2004, NASA and OMB requested that the National Academy of Public Administration (the Academy) conduct an independent external review of NASA’s technology transfer effort. This request is part of OMB’s efforts to periodically assess the value and effectiveness of government programs. The overall goal of the study is to give each of the stakeholders a common understanding of how NASA’s technology transfer function⁴ should be organized to obtain the maximum benefits for the nation.

STUDY GOALS, ISSUES, AND METHODOLOGY

This study was directed and overseen by a six-member Panel consisting of Academy Fellows and outside subject matter experts; the project study team consisted of staff from the Academy and the Logistics Management Institute (LMI). The study was conducted in two phases. The focus of Phase I was on the current organization of NASA’s technology transfer program; legislative, policy, organizational, and administrative constraints; and effective practices in other government agencies and private industries of relevance to NASA. The focus of Phase II was on the organizational structure that can best support both spin-in and spin-out activities, legislative

¹ 1958 Space Act, Section 305 (42 U.S.C. Sec. 2457).

² *NASA History Office Page*. 8 August 2004. <<http://history.nasa.gov/>>

³ The program name change took place during the course of this study, and for ease of understanding, the acronym IPP will be used in this report to refer to the technology transfer network.

⁴ The technology transfer function includes the IPP program and other processes that contribute to technology transfer, such as the Small Business Innovation Research Program (SBIR) and Small Business Technology Transfer (STTR).

and policy changes required to achieve the technology transfer mission, and the short- and long-term performance measures for assessing the program.

The Panel released a Phase I report in May 2004 that observed the following:

- Most technology acquired by NASA is done outside the IPP.
- NASA lacks a comprehensive strategy for identifying technology needs and commercialization opportunities.
- The IPP network is fragmented; roles and responsibilities of component organizations overlap and are unclear.
- There are few output measures and no outcome measures.
- Programmatic uncertainty is adversely affecting the organization.
- IPP is generally successful at administrative aspects of technology diffusion; there is more difficulty in other aspects, such as brokering partnerships.
- IPP appears to have a very limited role in technology infusion.
- Stakeholders and NASA managers have expressed significant dissatisfaction with the intellectual property process.
- IPP faces significant constraints.

Study Methodology

In addition to a wide range of background research and document reviews, the Panel and study team met with officials from the following:

- **NASA Headquarters.** An initial set of briefings from headquarters officials on major elements of the technology transfer program was received at the beginning of the study. Officials in the IPP, the Office of the General Counsel, and several mission directorates were also interviewed over the course of the study.
- **Congress and OMB.** Key congressional staffers and OMB officials were interviewed to gain an understanding of their expectations for NASA's technology transfer program.
- **Field Visits.** Extensive fieldwork was conducted for this study. Members of the Panel and study team visited 9 of the 10 centers,⁵ the National Technology Transfer Center, each Regional Technology Transfer Center, and the Research Triangle Institute.

⁵ The Panel held one of its meetings at Johnson Space Center.

- **Other Federal Agencies, Universities, and Private Industry.** For the best practices portion of this study, interviews were conducted with officials from 11 federal agencies: the Department of Energy (DOE), Department of Agriculture (USDA), Department of Commerce (DOC), U.S. Geological Service (USGS), Department of Defense (DoD), Department of the Air Force, Department of the Navy, Environmental Protection Agency (EPA), the National Institutes of Health (NIH), and the National Cancer Institute (NCI). To learn about effective practices in academia, the team focused on six large research universities considered to be among the top performers of university technology transfer: Harvard University, Massachusetts Institute of Technology (MIT), University of Michigan, Columbia University, University of Wisconsin (technology transfer performed by the Wisconsin Alumni Research Foundation) and University of California at Los Angeles (UCLA).

Issues Considered by the Panel

In assessing the results of the research and field visits performed by the Panel and study team, the Panel was mindful of several key issues the study was designed to address. These issues are:

1. **How aggressively should the technology transfer network market NASA innovations?** The relevant laws require NASA to protect its intellectual property, make known technologies with potential public and economic benefit, and work with interested parties who wish to exploit these technology opportunities. However, it appeared that NASA and its contractors were aggressively marketing some technologies, sometimes with little or no positive result. With limited and declining program resources and the new emphasis on infusion, where should the line be drawn between providing knowledge of the opportunities and selling those opportunities to potential buyers?
2. **What, really, should be the technology transfer offices' role in spin-in?** The study's scope of work statement asked the Panel to address the following questions: (1) what are some of the key lessons learned in designing good spin-in and spin-out programs, (2) how large are typical budgets for spin-in and spin-out, and (3) what type of organizational structure will best support the "spin-in" program? Again, with limited and declining resources and the existing statutory requirements centered on spin-out, are these program offices in a good position to play a major role in meeting NASA's technology needs?
3. **Should technology transfer be centralized or decentralized?** The study team's research reveals that, until recently, NASA headquarters provided only limited and somewhat ineffective program direction and oversight, while the field center technology transfer offices had a lot of autonomy and some independent funding sources to meet program goals in the differing environments at each center. Now the thrust is toward centralization, specific goals for each center office, and more accountability in an environment where headquarters-provided funds are still limited. As discussed below, the Panel found opportunities both to centralize and decentralize at the same time.

4. **Do opportunities exist for improved websites and more effective information and communication mechanisms?** With resources stretched thin and a network spread across the United States, is NASA taking full advantage of modern electronic means of communication and data processing? The answer appears to be “no” but promising opportunities do exist, and a lot has already been accomplished to put the needed systems in place to fully automate work processes and enhance communications.
5. **What are the skill requirements needed for spin-in and spin-out?** The study team’s research indicated that the skill requirements overlap, but they do differ, depending on whether the task is technology infusion or diffusion. Infusion requires an ability to be credible with both the innovators and technologists in NASA and private-sector companies and innovators of potential value to NASA, and to serve as an effective go-between. Diffusion, by contrast, is more process oriented and involves legal requirements for patenting and licensing internally generated innovations.
6. **How can the rest of NASA become involved in technology transfer?** The Panel’s Phase I presentation to OMB and NASA said, “technology transfer is everyone’s job in NASA.” The function was little considered by NASA program officials, and some did not even know a technology transfer office existed at their centers. However, without the cooperation and support of line officials in NASA and its major contractors, many innovations would not get reported or acted on. Staff would be unwilling to cooperate with technology transfer staff in defining requirements and taking advantage of partnership opportunities. The Panel considered what would provide the motivation for broader participation in an activity that admittedly is peripheral to NASA’s primary missions in space and of little direct benefit to the programs.
7. **How much organizational change would be required to maximize benefits to the nation?** Reorganizing any entity is usually time-consuming and disrupts ongoing program operations. Technology transfer has been shuffled around to different organizations with different program thrusts and generally had low priority wherever it landed. The network has taken years to create, whatever its limitations, and further change could be both disruptive and expensive. The Panel tried to fashion recommendations that would minimize this inherent turmoil but respond to the conclusion that major change is needed if NASA is to achieve excellence in technology transfer.

WHAT IS TECHNOLOGY TRANSFER?

There is no widely accepted definition of technology transfer. Generally speaking, however, technology transfer is (1) the sharing of knowledge and facilities among laboratories, universities, industry, and government and (2) commercializing those ideas in the form of goods and services.⁶ In this vein, the National Technology Transfer Center (NTTC) observes:

⁶ RAND Science and Technology Policy Institute, *Technology Transfer of Federally Funded R&D*. (Washington, DC: 2003).

The concept of technology transfer as a practical matter becomes clearer when one understands what technology transfer is designed to accomplish. For instance, the purpose of a federal technology transfer program is to make federally generated scientific and technological developments accessible to private industry and state and local governments. These users are then encouraged to develop the technology further into new products, processes, materials, or services that will enhance our nation's industrial competitiveness or otherwise improve our quality of life.

Technology diffusion, termed “spin-out,” is a process by which federally developed technologies are introduced to outside organizations, evaluated by them, and ultimately adopted in some form. Technology can be spun-out in two major ways. The first occurs when an agency transmits knowledge and technical expertise to a private organization or a university. The second occurs when an outside entity incorporates an agency-developed technology into its machinery, equipment, or components of a production process.

In a background paper for the Organization for Economic Cooperation and Development, Philip Shapira of the Georgia Institute of Technology and Stuart Rosenfeld of Regional Technology Strategies, Inc explain:

Technology diffusion involves the dissemination of technical information and know-how and the subsequent adoption of new technologies and techniques by users. In this context, technology includes "hard" technologies (such as computer-controlled machine tools) and "soft" technologies (for example, improved manufacturing, quality, or training methods). Diffused technologies can be embodied in products and processes. Although classic models of technological development suggest a straightforward linear path from basic research and development to technology commercialization and adoption, in practice technology diffusion is more often a complex and iterative process. Technology can diffuse in multiple ways and with significant variations, depending on the particular technology, across time, over space, and between different industries and enterprise types. Moreover, the effective use of diffused technologies by firms frequently requires organizational, workforce, and follow-on technical changes.⁷

Benefits from NASA Technology

A list of technologies developed as a result of the original Moon mission in the 1960s and 1970s that ultimately found their way into widespread civilian and military use is impressive: high-energy density propulsion systems; materials that could withstand stresses; re-chargeable batteries; fuel cells; cellular communications; small computers; micro electronics; cryo storage and telemedicine; passive and active thermal control devices; mylar, better freon, solid state

⁷ Philip Shapira and Stuart Rosenfeld, “An Overview of Technology Diffusion Policies and Programs to Enhance the Technological Absorptive Capabilities of Small and Medium Enterprises.” (Background Paper for the Organization for Economic Cooperative and Development: August 1996).

coolers; lightweight, high-temperature materials; stronger lightweight structures; better radar; and coatings and paints that survive sunlight.

NASA continues to develop technologies that benefit the nation, (see Chapter 3) and remains an important source of innovation and invention among federal agencies. Congress has traditionally been very supportive of NASA's technology transfer program. For example, in a letter to the OMB Director on January 16, 2004, twenty-two House members from both parties urged funding for the NASA Commercial Technology Program to be included in the President's FY 2005 Budget. Emphasizing that life on earth has benefited from an outpouring of space technology into the fields of health, transportation, computer technology, industrial products, and many other areas, the House Members said that the program's external network⁸ "ensures that all 50 states benefit from the invaluable industry knowledge, market-based insight, and local interactions with companies and academic resources essential to delivering technology partnerships that yield benefits to NASA, industry, and the American public." NASA's technology transfer efforts, they concluded, are an economic engine that not only creates jobs and businesses, but also increases the nation's competitiveness internationally.⁹

ORIGINS AND EVOLUTION OF TECHNOLOGY TRANSFER IN NASA

From its creation in 1958, it was recognized that NASA would be heavily involved in creating technologies for achieving the agency's ambitious missions, with Congress mandating in the Space Act of 1958 that the benefits of NASA-developed technologies be made available to the civilian sector of the nation's economy. Specifically, the NASA Administrator is required to provide the widest practicable dissemination of information concerning results of NASA's activities. The Administrator is also required to protect inventions to which NASA has title. The Agency's large business contractors are obligated to submit New Technology Reports (NTR's) of inventions made in performance of contracts with NASA. While the federal government owns inventions developed under contracts with large businesses, the Act gives the NASA Administrator authority to waive rights in inventions to large contractors upon written request for waiver. NASA reserves a royalty-free license to use these inventions on behalf of the federal government.

Subsequent amendments to this Act reaffirmed this mandate, but not until the Bayh-Dole Act of 1980 was technology transfer to be aggressively pursued. This Act mandates use of the patent system to promote the transfer and public availability of inventions arising from federally funded R&D. Small businesses, universities, and nonprofit organizations are permitted to elect title to inventions developed with federal funds. However, federal agencies are required to establish government rights in federally funded inventions. The law further provides government-wide authority to license government-owned inventions and to monitor and enforce contractor compliance. It also requires that rights in inventions be documented and recorded in a central

⁸ This network, discussed in more detail later, consists of the NTTC, six Regional Technology Transfer Centers; state affiliates, and the Research Triangle Institute.

⁹ In July 2004, report accompanying the House Appropriations Committee bill calls again for restoration of NASA's Technology Transfer Program in FY 2005, adding \$30 million of funding to the \$22 million request (\$6 million less than the \$58 million FY 2003 budget, thus not a full restoration).

database. This was a critical piece of legislation. *The Economist*—one of the most influential business and political publications across the globe—recently published an editorial entitled "Innovation's Golden Goose." The piece, which addresses issues affecting academic technology transfer, asserts:

The Bayh-Dole Act of 1980 is perhaps the most inspired piece of legislation to be enacted in America over the past half-century. Together with amendments in 1984 and augmentation in 1986, this unlocked all the inventions and discoveries that had been made in federal laboratories throughout the United States with the help of taxpayers' money. More than anything, this single policy measure helped to reverse America's precipitous slide into industrial irrelevance.¹⁰

A companion act, Stevenson-Wydler, provides that the transfer of federally owned or originated technology is a national priority and the mission of each federal laboratory. Under this Act, each federal agency operating or directing a federal laboratory must have a formal technology transfer program and must take an active role in transferring technology to the private sector, and state and local governments. Federal laboratories are also required to set aside a percentage of their budget specifically for technology transfer activities.

In July 1994, NASA published *Agenda for Change*, which states that the commercial technology mission is as important as any mission in NASA. It requires that each NASA program office and center be responsible for incorporating new commercial technologies NASA contractors develop during the contract's life cycle. NASA's large business contractors have been required to submit New Technology Reports (NTRs) that describe inventions developed while performing under NASA contracts.

The Innovative Partnerships Program

NASA has a headquarters operation and 10 field centers. Nine of these field centers are owned and operated by the government; the Jet Propulsion Laboratory is owned by the government but operated by the California Institute of Technology (Caltech). NASA centers employ 17,891 civil servants, with the majority of positions being scientific and technical in nature. NASA's annual budget is \$15 billion each year, of which approximately 60% is devoted to research and technology development.

Under federal law, each federal laboratory with more than 200 employees must have a research and technology office. In 2004, the component NASA had created to meet this requirement, the Commercial Technology Program, was terminated and replaced with the Innovative Technology Transfer Partnerships Program (ITTP), now the Innovative Partnerships Program (IPP). The mission of IPP is to create partnerships with industry, academia, and other government agencies to develop and transfer technology in support of the NASA enterprises. The IPP offices oversee the agency's technology transfer partnership programs as well as the Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs. IPP's goals are to reduce NASA's technology development life-cycle costs, transfer technology in support of the agency's mission, and enhance NASA's mission technology capabilities.

¹⁰ "Innovation's Golden Goose," *The Economist* (December 12 2002).

The IPP program is a complex organizational network consisting of six major components:

- **IPP Headquarters.** The IPP office in Washington, DC, is responsible for providing overall policy direction and management to the network. At the beginning of FY 2004, IPP was housed in Aeronautics; but it was moved to Exploration Systems following that mission directorate's creation in March 2004. Within Exploration Systems, IPP is in the Development Program's Research and Technology Development Division, reporting to the program director for Exploration Systems Research and Technology.
- **NASA Field Centers.** Each of the 10 NASA field centers has an IPP office, often called a Technology Transfer and Commercialization Office. These offices are responsible for ensuring the reporting of new technologies, making patent recommendations, developing marketing strategies for NASA technologies, negotiating the license of NASA technology to outside entities, establishing partnership agreements with private industries and universities, and communicating NASA commercial successes to the public. Under NASA Procedures and Guidance 7500.2, the General Counsel is responsible for protecting intellectual property rights in NASA technology assets, and for ensuring that the transfer of NASA technology and intellectual property conforms with applicable laws, regulations, and NASA Policies.
- **National Technology Transfer Center.** The NTTC, located in Wheeling, West Virginia, was established by Congress in 1989 to become a full-service technology management resource for federal agencies. NASA supports this effort by providing \$5.8 million in FY 2003,¹¹ or over a third of its total budget, through a cooperative agreement. The purpose of NTTC is to identify commercially promising discoveries, market these discoveries to American industry, and build partnerships to turn inventions into products.
- **Regional Technology Transfer Centers.** NASA has six RTTCs geographically dispersed around the country: Far West, Mid-Continent, Mid-Atlantic, Midwest, Southeast, and Northeast. They are intended to serve as the bridge between NASA and industry by providing information services, technology needs assessments, commercialization services, and technology marketing. NASA spends approximately \$7 million per year for this network, with the funding divided equally between each RTTC.
- **Research Triangle Institute (RTI).** RTI, International, is a contractor headquartered in Raleigh, North Carolina, with an expertise in assessing the marketability of new innovations and connecting technologies to markets. In conjunction with other network components, RTI identifies technology gaps, matches technology to needs, and assesses commercial markets. It has a task-based contract with NASA for \$2 million each fiscal year.
- **State Affiliates.** Each RTTC has an affiliate network that taps into private companies and provides information services; an affiliate organization is present in most states.

¹¹ NTTC has historically received between \$5.8 and \$7.3 million a year from NASA.

Affiliates have contacts with universities and companies in their states and regions. They are intended to increase the visibility of NASA's technology transfer efforts, provide an understanding of local and regional needs, serve as advocates of the program, and work with their RTTC on specific projects.

Figure 1-1 provides a visual depiction of this technology transfer program network.

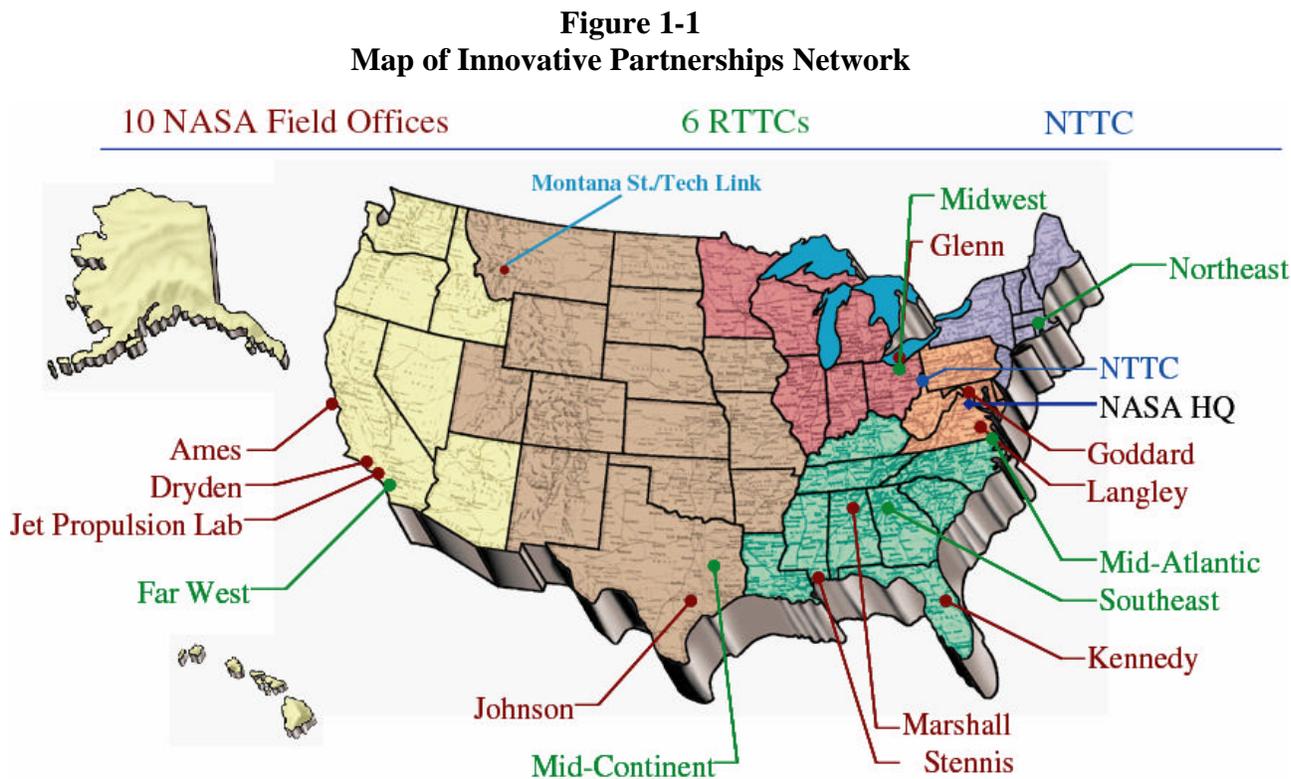
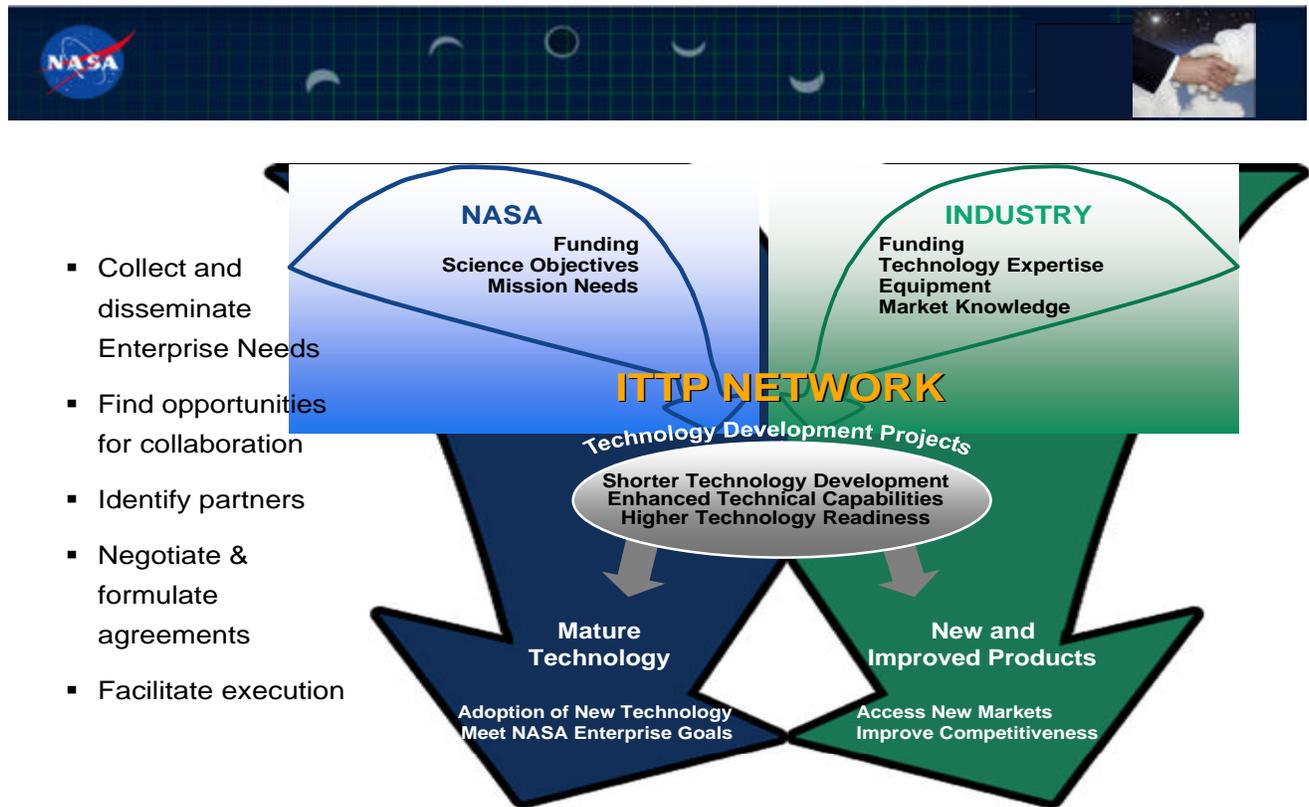


Figure 1-2 depicts the current IPP technology transfer process.¹² As this figure indicates, the IPP network plays a facilitative role by bringing the resources of NASA and private industry together to meet spin-in and spin-out goals. With spin-in, NASA's goal is to adopt new technology from the private sector that meets the needs of its mission directorates. With spin-out, private industry's goal is to access new markets and improve their competitiveness through new technology originally developed by NASA.

¹² Leonard S. Yarbrough, NASA Briefing Slides (IPP Office, August 2004).

Figure 1-2¹³
Innovative Partnerships Program's Technology Development Process



Transferring Technology through Partnership Agreements

The IPP works to transfer technology through partnership agreements that bring NASA and industry resources together to pursue common research activities. NASA can enter into six major types of partnership agreements:

- **Reimbursable Space Act Agreements** are agreements for the reimbursable use of NASA facilities, personnel, expertise, or equipment by a public or private entity that wants to conduct R&D. Under such an agreement, the outside entity transfers funds or other financial obligations to NASA, but NASA cannot transfer any of its own funds. No goods or services are provided to NASA; the agency provides data, facilities, and services to the paying party. In support of the technical organization, IPP staff and patent legal staff facilitate the negotiation of the terms, conditions, and schedule of payment. Rights to inventions are also negotiated. The field centers are authorized to enter into agreements involving up to \$10 million in reimbursable costs. For larger amounts, headquarters must give its approval.

¹³ Ibid

- **Non-reimbursable Space Act Agreements** are collaborative agreements between NASA and an outside entity in which the parties agree to contribute such resources as personnel, use of facilities, expertise, equipment, and technology to a joint R&D effort. No funds are exchanged; each party funds its own participation under the agreement. In order for NASA to participate, the proposed activity must be relevant to an agency mission or program activity, and the other party's contribution must be adequate relative to NASA's. Field centers are authorized to enter into agreements not exceeding 25 work years of effort per agreement, or \$5 million in equipment and/or facilities. For larger amounts, headquarters must give its approval.
- **Cooperative Agreements** are collaborative efforts between NASA and a private sector partner(s) to stimulate and support innovative new technologies and products for commercialization. This goal is accomplished through technology research, development, and/or deployment. For example, NASA and the private company may agree to jointly fund, research, and develop a high-risk technology for potential dual-use applications (that is, a technology that both parties can use for their own purposes). NASA may not use cooperative agreements to procure goods or services; the deliverables may include technical and status reports, data, and the like. With cooperative agreements, the private sector partner must provide a cash or in-kind contribution, with the general target being at least 30 percent. Cost sharing, payment schedules, and other financial arrangements are negotiable, and rights to patents are controlled by statute.¹⁴
- **Joint Sponsored Research Agreements** are collaborative research and development efforts authorized by the Space Act. Through these agreements, NASA provides resources—such as funds, equipment, information, intellectual property, and facilities—on a shared or pooled basis in order to advance mission goals and transfer the resulting technology to the private sector. The private partner must provide a cash or in-kind contribution in reasonable proportion to NASA's. The cost sharing, payment schedules, and other financial arrangements are negotiable. The collaborating partner may obtain title to inventions made under the agreement, with NASA retaining a limited purpose license for federal government use. With data, the industry partner's proprietary information is exempt from release under FOIA; NASA's information may also be exempt, depending on the circumstances.
- **Cost-Shared Contracts** provide a direct good or service to NASA. Under this contractual arrangement, NASA reimburses a portion of allowable costs, with the contractor responsible for ensuring that overall costs are reasonable and allocable. Rights to inventions and data are negotiable, subject to the same provisions as Joint Sponsored Research Agreements.
- **SBIR and STTR programs** provide federal seed money to small businesses and nonprofit research institutions to develop technology that meets a NASA mission need. These programs are funded in three phases, discussed in more detail in a later section.

¹⁴ Specifically, titles to inventions remain with the respective inventing parties, with the government obtaining a license to all subject inventions arising under the agreement.

- **Memorandums of Understanding (MOU)** are statements of policy, practice, or intention on a matter in which both NASA and an outside entity are concerned. No funds or other resources are exchanged; no goods or services are provided to NASA; and the terms of the agreement are not legally enforceable.

ORGANIZATION OF THIS REPORT

Chapter 2 identifies effective practices in private industry, universities, and other federal agencies. Chapter 3 assesses NASA's existing technology transfer programs. Chapter 4 includes recommendations for how NASA can achieve excellence in technology transfer and how NASA's programs can be reformulated to become more effective agents as NASA strives to fulfill its technology transfer mission.

CHAPTER 2

EFFECTIVE PRACTICES OF GOVERNMENT, INDUSTRY, AND ACADEMIA AND THEIR RELEVANCE TO NASA

This chapter discusses the challenges faced by other organizations with a major interest in technology transfer and the practices they use to meet those challenges. The chapter presents data on the outcomes of those efforts and present some possible performance measures to track the effectiveness of technology transfer activities. Lastly, it discusses how technology transfer practices used in government agencies, industry, and academia may apply to NASA.

WHY CONSIDER EFFECTIVE PRACTICES OF GOVERNMENT, INDUSTRY, AND ACADEMIA?

At NASA’s request, the Academy considered effective practices¹⁵ as a part of this external review because they provide a reference point to determine what NASA could do to improve its performance in technology transfer. In addition, information about effective practices provides a context for NASA when considering the opportunities available in technology transfer; benchmark measures of effectiveness; the people, resources, and processes needed to achieve excellence in technology transfer; and the benefits that will accrue to NASA if it is successful in its efforts.

The study team examined other government agencies to understand how organizations operating under similar legislative and operational constraints meet their challenges and contribute to achieving their agency missions. Commercial companies were studied in order to understand how they balance internal research with the need to infuse their organizations with external innovation. Universities were a useful source for understanding how research organizations with multiple objectives focus and manage their technology transfer services.

INFORMATION GATHERING

The study team used a variety of methods to gather information about technology transfer activities in government agencies, industry, and academia. The team interviewed managers and executives responsible for technology transfer in those organizations, specialists involved in the day-to-day operations of technology transfer, government researchers that generate the new technologies, and some consultants with experience working across government and industry.

The team conducted extensive interviews with NASA officials and contacted 11 government agencies: the Department of Energy (DOE), Department of Agriculture (USDA), Department of Commerce (DOC), U.S. Geological Service (USGS), Department of Defense (DoD), Department of the Air Force, Department of the Navy, Environmental Protection Agency (EPA), the National

¹⁵ NASA asked the Academy to address the question: “What are best practices in industry and government with respect to technology infusion (‘spin-in’) and technology diffusion (‘spin-out’)?” The term “effective practices” is used instead of “best practices” because our team’s research was limited to selected organizations and was not designed to judge which practices were “best” above all others.

Institutes of Health (NIH), and the National Cancer Institute (NCI). For most of these agencies, the team interviewed multiple individuals and followed up with additional questions after its initial discussions. The Panel illustrates its findings with examples from Energy, USDA, DoD, and NIH.

To provide insight from industry, the team contacted 15 large commercial firms with strong performance in R&D and intellectual property management (see Table 2-1), and many firms, large and small, that have worked with NASA on technology transfer. For illustration, this chapter features findings from Boeing, Dow Chemical, DuPont, EMC, Northrup Grumman, and Procter & Gamble.

Table 2-1. Large Firms Contacted for Purposes of Discovering Effective Practices

Agilent Technologies	IBM
Boeing Corporation	Northrup Grumman
Dow Chemical	Procter & Gamble
DuPont	Rockwell Scientific
EMC Corporation	SAIC
ExxonMobil	Siemens
Ford Motor Company	Unisys
General Electric	

To obtain effective practices in academia, the team focused on six large research universities considered to be among the top performers of university technology transfer: Harvard University, Massachusetts Institute of Technology (MIT), University of Michigan, Columbia University, University of Wisconsin (technology transfer performed by the Wisconsin Alumni Research Foundation) and University of California at Los Angeles (UCLA).

OTHER RESEARCH SOURCES

The team considered information on technology transfer from the following sources: Association of University Technology Managers (AUTM)—*Licensing Survey: FY 2002*; Department of Commerce—*Summary Report on Federal Laboratory Technology Transfer Agency Approaches, FY 2001 Activity Measures and Outcomes*; Economic Development Administration (DOC)—*Technology Transfer and Commercialization, Their Role in Economic Development*; the President’s Council of Advisors on Science and Technology, *Report on Technology Transfer of Federally Funded R&D*, May 15, 2003; and RAND Science and Technology Policy Institute, *Technology Transfer of Federally Funded R&D: Perspectives from a Forum*, 2003.

Unfortunately, accurate and comparable data on organizations’ expenditures for technology transfer were not available; therefore, the team was unable to make general comparisons of resource utilization. For government agencies, the resources devoted to technology transfer are typically contained in several parts of their budgets and are not readily identified. Universities and commercial companies were generally reluctant to provide proprietary information on how

much they invested in technology transfer, although the team was frequently able to make rough assessments of how many people were devoted to the activity.

ORGANIZATION OF FINDINGS AND SUPPORTING INFORMATION

This chapter presents the effective practices for technology transfer found within the federal agencies, industry, and universities with special attention paid to the effective practices found for spin-in activities. Next, it provides statistical comparisons of NASA reporting to other government agencies and to the universities identified in this chapter.

EFFECTIVE PRACTICES IN FEDERAL AGENCIES, INDUSTRY, AND UNIVERSITIES

As a result of the study team’s research, the Panel identified four effective practices commonly found within the organizations studied. Table 2-2 lists the effective practices and, for each, indicates the number of organizations that use it in their technology transfer programs.

Table 2-2. Crosswalk of Organizations to Effective Practices

Effective practice	Government agencies (DOE, USDA, DoD, NIH)	Industry (Boeing, Dow, DuPont, EMC, Northrup Grumman, Proctor and Gamble)	Academia (Harvard, MIT, Michigan, UCLA, Wisconsin, Cal Tech, Columbia)
1. Leadership commitment to technology transfer	* * * *	* * * * *	* * * * *
2. Focus on efficient processes and comprehensive service	* * *	* * *	* * * * * *
3. Use of staff with the right talents and experiences for the job	* * *	* * * *	* * * * *
4. Use of external capabilities to augment staff	* *	* * *	* * *

Note: Each asterisk represents one organization that expressed this effective practice during our interviews.

The following subsections contain the Panel’s findings about effective practices. For clarity of analysis, the Panel has distinguished between effective practices in government and effective practices in industry and academia. The Panel believes the distinction between government and industry/academia is important because government agencies, including NASA, operate under legislative authority and share many similar environmental dynamics not found in industry or academia.

Leadership Commitment to Technology Transfer

A recurring theme in our team’s interviews was the necessity for close involvement by senior leadership in technology transfer in order for it to be relevant within the organization. Strong

technology transfer performers possess the commitment and attention of their leadership. Leadership is critical to addressing the resistance common among program managers and scientists to external burdens judged to potentially interfere with research efforts. Program managers and scientists tend to resist technology transfer unless the commitment of the leadership is clear. Leadership commitment to technology transfer communicates that it is a priority for the organization and can add value to the organization's programs. For example, a government lab reported that "support of leadership is clear and this has helped to drive tech transfer efforts." Another federal laboratory director supports technology transfer because the products resulting from patent licensing agreements and cooperative research and development agreements assist in achieving the laboratory's mission. The leadership commitment is reflected clearly in assigned management performance objectives and incentives.

The DoD technology transfer director, who oversees 45 DoD laboratories presently authorized to perform technology transfer, indicated that the key differences between the successful and less successful DoD technology transfer performers are (1) management support ("the lab director and the technical director must be bought in") and (2) the technology transfer office's focus on mission requirements.

The organizational location of the technology transfer office is an indicator of leadership commitment to technology transfer. Locating those offices close to the highest levels of the organization is important; that location provides visibility to the technology transfer program, promotes understanding of leadership priorities, and reinforces the importance of technology transfer to the rest of the organization. At one government agency, the technology transfer director reported, "attending a different set of meetings based on the move to the director's office" and noted that the focus has changed from: "Is the function efficient?" to "Is the function relevant?" This organization reported an expectation that the organizational shift will place greater demands on technology transfer.

The team found that industry technology transfer offices typically are at the corporate officer level, equivalent to other officers responsible for the corporation's business lines. The box below provides one example of how the arrangement works and the resulting benefits.

Box 2-1. Example of Leadership Commitment To Technology Transfer

Procter & Gamble

At Procter & Gamble, the Vice President for Corporate Business Development oversees the technology transfer effort. The vice president, and staff reporting to him, attend CEO strategy reviews that allow them to understand the goals across the corporate business units. With this knowledge, technology transfer staff can develop a plan to support the business units. Business unit presidents are directly engaged to determine how the technology transfer can best serve them. This interaction provides a foundation for an interactive dialogue to identify opportunities for commercialization out and the transfer of technology into Procter & Gamble.

A commercial firm that did not experience as much success in technology transfer said that “business units have their own priorities, technology transfer plays second fiddle to business unit priorities, and telephone calls are not responded to quickly” and that “there is a corporate reluctance to spend discretionary funds unless it is tied to the core business.”

Within academia, university technology transfer offices are located within the organization of the provost, reflecting their significance in an environment with an academic and research focus. One university reported that the technology transfer office moved from under the vice president of finance to within the provost’s office. This university expects increasing demands to be placed on the office by the provost. Before, that office was an orphan within the finance office.

The relevance of this finding for NASA is that, to achieve excellence in technology transfer, it needs to ensure that the technology transfer function is viewed as an important contributor to the agency’s mission. The function needs to be placed appropriately in an organization with agency-wide responsibility so that it is seen as an integral part of the agency’s mission and not an external liability or part of the agency’s legal or financial functions.

Focus on Efficient Processes and Comprehensive Service

Strong performers in technology transfer understand that they must attend to their business processes. They recognize that their personnel and processes must add value to the organization and not be overly burdensome on their business partners and on their inventors.

Consistently, the organizations studied indicated the need to possess the full portfolio of capabilities necessary to perform technology transfer. When technology transfer offices have the internal capability with patent agents or patent attorneys, professional licensing, and technically savvy personnel, they are positioned to successfully engage the prospective external partner, move the process forward in a timely manner, and meet the objectives of both organizations. This capability also positions the technology transfer organization to successfully identify the innovations generated within the organization, whether they have commercial potential, and then make a smart decision on patent prosecution before entering the lengthy process of patenting.

Box 2-2. Example of Efficient Processes and Comprehensive Service

Wisconsin Alumni Research Foundation

WARF contains within its organization the attorneys, professional licensing staff, and a professional intellectual property staff needed to obtain patents and negotiate licensing agreements with commercial companies. WARF’s goal is to provide comprehensive service to commercial firms to make it is easy for the firm to work with WARF. WARF views its services as “cradle to grave,” with its licensing professionals out engaging prospective commercial customers for WARF’s intellectual property, supported by a legal counsel staff that ensures the deals preserve WARF’s interests. Licensing professionals work in coordination with the intellectual property managers who are all registered patent agents.

Another consistent attribute of successful programs was the need to support inventors, whether in government or university laboratories. Successful technology transfer offices work to accommodate the time constraints of inventors and their various interests in commercialization. In particular, government agencies and universities reported the general practice of ensuring that inventors are a core focus of their technology transfer offices. These offices minimize the paperwork burden on inventors and provide them with the support they request.

Corporations more frequently described the inventor’s disclosures and participation as a specific professional expectation and “part of their job.” In many government laboratories, in contrast, the invention disclosure and patent processes are not valued by management. Consequently, only the most motivated researchers are willing to invest the extra time and effort required to support the process. This conflict was particularly noted at several NASA facilities, where the traditional culture of open publication and public access to government-generated knowledge sometimes conflicted with the patent application process. The conflict with management priorities was even more pronounced in the case of license agreements, because commercial companies value access to government researchers, while government managers do not want to make them available. Without appropriate budgets and charge codes to support such activities, NASA managers have a significant disincentive to support technology transfer activities by their staff. The recent shift to full-cost accounting within NASA, and an associated focus on allocating staff time to projects, has aggravated this conflict.

Energy ensures service quality by standardizing the administrative aspects of technology transfer through the use of agency forms for CRADA terms and conditions and for conflict-of-interest and other disclosures. These standard forms reduce the processing time and bring clarity to the processes so that inventors and commercial partners know what to expect. For its efforts, Energy recently received the Licensing Executive Society Award for performance in technology transfer.

Box 2-3. Example of Efficient Processes and Comprehensive Service

U.S. Department of Agriculture

USDA has centralized policies and approvals and decentralized implementation. Centralization of policies and approvals ensures that commercial partners get a consistent answer across USDA. Policies and procedures are standardized and embedded in USDA’s agreements templates. With the standard templates, the eight regional technology transfer coordinators have the authority to enter into agreements with commercial partners. The technology transfer coordinator is the single point of contact providing service to the commercial partner. The central office collects metrics and time-stamps the data, enabling it to identify and mitigate bottlenecks to any partnership arrangement.

One Navy lab operating a small technology transfer office said that its primary management focus is updating agreement forms and processes that were “state-of-the-art” 10 years ago and streamlining a six-person approval process for partnering agreements.

NCI described a prior organizational structure with split functional responsibilities and reported that it was not a good system because scientists had to deal with too many people. NCI technology transfer is now structured so that every technology transfer specialist has a portfolio of laboratories or extramural programs to serve. This gives the technology transfer specialist direct connection to the researchers and their technologies, and it fosters the relationships with commercial partners.

Universities clearly expressed “service to faculty” as a principal focus of the technology transfer office. The universities’ technology transfer offices are clear that their missions are to support the faculty and identify commercialization opportunities of interest to the faculty. As one university indicated, “you may irritate your inventor if you put him or her off on the first invention, and you risk the opportunity that exists with subsequent inventions.”

One top-performing organization expressed frustration because its technology transfer organization lacks the legal authority to execute agreements. Competing with other organizations for legal council resources, their work often receives a low priority and sometimes causes conflict with the legal counsel when negotiating agreements.

Box 2-4. Another Example of Focus on Service to Customers

The University of Michigan

The licensing director at the University of Michigan indicated that at least half of her time (and that of her licensing staff) is spent serving faculty members. She cited the need to be in constant contact with the faculty in order to be successful in technology licensing. She indicated that the licensing specialists spend time individually with each faculty member to determine the faculty member’s interests in terms of participation in the licensing process and in potential financial rewards. Faculty objectives related to technology transfer vary widely, so it is critical to understand how involved the faculty member wishes to be in the process and what he or she wants to achieve as a result of the process (e.g., more research dollars, consulting, personal income, or publications).

Close interaction with the faculty has its benefits. It allowed the University of Michigan to understand that its disclosure documentation was too cumbersome and was inhibiting faculty disclosures. As a result, the university reduced the patent disclosure form from 10 pages to 1 1/2 pages, reducing the effort required by both the faculty member and the technology transfer office.

Staff with the Right Talents and Experiences

Industry and academic practitioners agree that employing people with the right talents and experiences for technology transfer is a critical factor to their success. The most successful

offices are staffed with experienced people capable of evaluating and marketing the intellectual property of the organization. Typically, these offices are staffed with personnel who were educated in a physical science, frequently have laboratory experience, and hold degrees in business or law.

Box 2-5. Example of Personnel with the Right Talents and Experiences

Dow Chemical

Dow Chemical utilizes licensing managers with technical degrees and commercial experience. The licensing managers are senior positions within Dow, and they understand the significance of the technology being developed by Dow. Licensing managers understand the market need and are strongly positioned to determine who in the marketplace is interested and for what purpose.

Dow's technology transfer office is also staffed with people who have the skills to take estimates of market opportunity and turn them into hard numbers, considering the existing technology risk factors. This ability is critical as it guides Dow to quantify what it can expect to obtain from licensing and, therefore, how much time and money to invest to commercialize the technology.

One university technology transfer director observed that it is critical to have a quality staff with the right capabilities in order to effectively engage the faculty and, in turn, deal with commercial firms. This requires the technology transfer professional to be sensitive to the academic environment on one side, while aggressively pursuing the terms of a deal with the commercial firm at the other end.

Another large commercial firm indicated that its technology transfer staffing model is moving toward a small group of experienced technical experts with business and marketing experience. In addition, the firm is encouraging each business unit to develop a few point people so there can be an integrated network of employees who can work the intellectual property and technology positioning for the organization.

These successful organizations assigned individuals to be responsible for maintaining contact with the research organizations or business units; they did not rely on those organizations to call them. The technology transfer contact point aims to become a known and respected person within the organization, with access to the expertise needed to provide the required services to the researcher.

Use of External Capabilities to Augment Staff

Consistent with good business practice and considering their core competencies, resources, and constraints, successful technology transfer offices typically augment their staff by contracting for certain technology transfer services. The services most commonly contracted are market assessments for new technologies, patent prosecution, and technology searches.

Several government technology transfer offices detailed the value of the technology marketing services delivered by RTI, TechLink,¹⁶ NTTC, and other marketing service providers. NCI uses a set of private law firms for its technology transfer efforts.

Commercial firms cited the value of external brokering companies, including Nine Sigma, Innocentive, and Yet2.com. Such companies broker technologies for inventing firms to potential commercial markets, as well as identify potential spin-in technologies. One large commercial firm indicated that a shakeout is occurring in the external brokering marketplace, such that the firms must now be full service, providing a knowledge-intensive approach to their traditional search capability.

Harvard University uses a set of local law firms skilled in patent issues to file its patent applications. Harvard judged that it was not as expensive and was faster than performing the function internally.

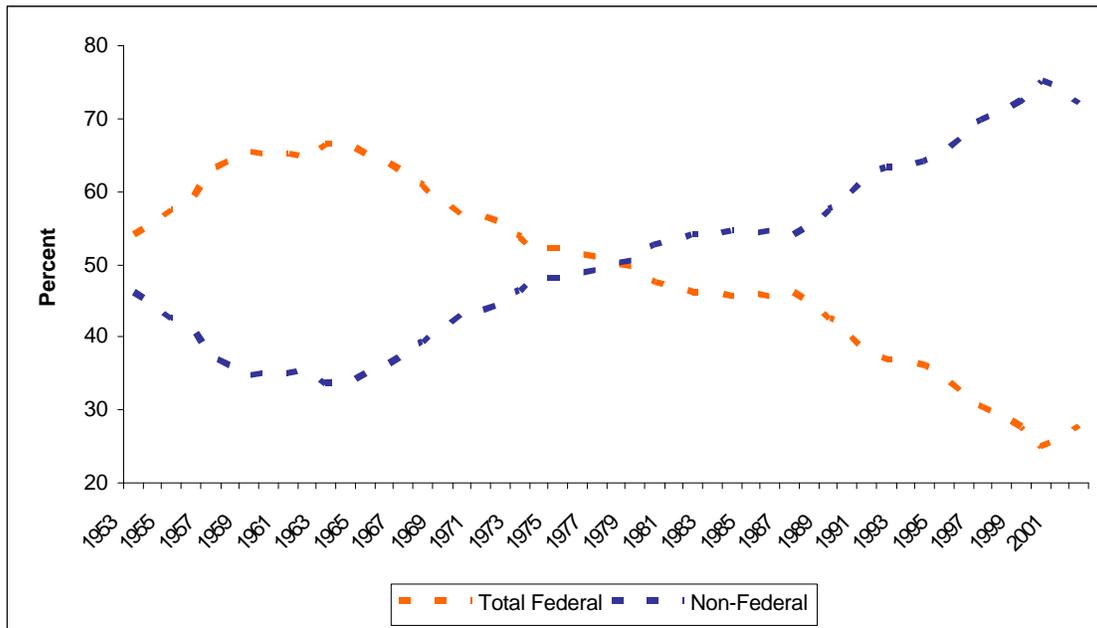
EFFECTIVE PRACTICES FOR THE PERFORMANCE OF SPIN-IN

In the 1950s, 1960s, and 1970s, federal R&D fueled innovation in the United States, constituting over half of the nation's R&D investment (peaking at 66.8% in 1964). Since 1978, federal R&D has trended generally downward, and the most recent figures (2002) indicated it is 27.8% of U.S. R&D (Chart 2-1).¹⁷ Therefore, as federal expenditures diminish, agencies need to foster an environment in which industry is willing to share its commercially generated technologies. This section describes the processes, practices, and characteristics that promote effective spin-in.

¹⁶ TechLink located at the Montana State University-Bozeman, was established in 1997 to match the technology needs of client companies, with resources found throughout NASA and the federal laboratory system. TechLink focuses on a five-state region that includes Montana, Idaho, Wyoming, South Dakota, and North Dakota. Working closely with public, private and university programs. TechLink provides ongoing support in the process of adapting, integrating and commercializing technology.

¹⁷ National Science Foundation, *National Patterns of R&D Resources: 2002 Data Update*, "Table 6—Trends in Federal and non-Federal R&D expenditures as a percentage of total R&D: 1953—2002." <http://www.nsf.gov/sbe/srs/nsf03313/start.htm>. Data for 2001 and 2002 are listed as preliminary.

**Chart 2-1. Trends in Federal and Non-Federal R&D Expenditures
(Calendar years 1953-2002)¹⁸**



The Cultural Shift to Embrace Spin-In

In an environment of rising consumer expectations, relentless competition and rapid technological change, innovation becomes more important than ever ... We are also thinking more broadly about what innovation is, where it comes from, who is responsible for it and how it can be commercialized.

Procter & Gamble Annual Report, 2004

Industry interviewees said that it is necessary to move from an internally focused R&D culture to one in which the best technology, whether the firm makes it or buys it, is embraced. This finding was particularly strong for the commercial firms with long and proud traditions of innovation. Commercial firms cited the need to reduce time to market, the need to reduce the cost to serve customers, and the need to efficiently accelerate the rate of innovation. Commercial firms recognize that technology partnering helps to address these needs. Procter and Gamble is driving towards the goal of capturing the best technology, whether the company makes or buys it, with aggressive targets set by the CEO for 50% of innovation to come from outside the company.

These commercial firms acknowledged the global competitive nature of their businesses. In order to preserve and increase their competitive position, they pursue partnership ventures that are less capital intensive than conducting the research internally. For example, one commercial

¹⁸ National Science Foundation, *National Patterns of R&D Resources: 2002 Data Update*, “Table 6—Trends in Federal and non-Federal R&D expenditures as a percentage of total R&D: 1953—2002.” <http://www.nsf.gov/sbe/srs/nsf03313/start.htm>. Data for 2001 and 2002 are listed as preliminary.

firm with a 100-year history of innovation indicated that it still believes “we can always do it ourselves better,” but recognizes that the firm is not the lowest cost provider and that it might be better to license in a technology.

One Fortune 100 company is trying to change its corporate view from “not invented here” to one that applies the best technology to a problem, regardless of whether the company makes it, buys it, or develops it for dual use with another firm. It has been a very difficult transition for the company to make.

Collaboration with Small Business

Use of SBIR by Selected Federal Agencies

Three government agencies reported using the SBIR program to insert technology into government programs. For these agencies, SBIR was judged a valuable resource that should be strategically aligned to support the technology needs of current programs.

Use of SBIR in this way is judged as a “win-win”: the small business is linked to a government program of record, and the federal agency realizes the benefit of increasing the industrial base to support its mission. However, some interviewees criticized these SBIR programs as not being innovative enough.

Partnering with Small Businesses

Commercial firms judge the small business community to be a very attractive source of innovation. The large firms the study team interviewed consistently stated that they are looking outside their organization for strategic technologies. Partnering with small businesses allows the large commercial firms to have a stake in a series of technologies rather than bet on one “silver bullet” that may or may not be successful.

The study team found that the large commercial firms are building their own in-house ventures groups to meet the technology needs of the organization. They do this by identifying small businesses that may fill a need and then taking an equity position in the company with the option to purchase the firm outright if the technology delivers the required capability and the large firm wishes to wrap it into their internal capabilities. In other venture capital instances, large firms are seeking technologies where the leverage of the large firms’ marketing and distribution network offers the potential of a 5- to 10-fold increase in market reach over the small firm’s existing market. Procter & Gamble achieved this improvement with a company called Dr. John’s Spin Brush. Dr. John’s approached Procter & Gamble with the desire to license the Crest brand name. Procter & Gamble recognized the opportunity, purchased the company outright and now has a 50% volume share of the powered brush market.¹⁹

¹⁹ Procter & Gamble, 2002 Annual Report.

TECHNOLOGY TRANSFER IN THE FEDERAL GOVERNMENT

Similar to NASA, government agencies with significant R&D programs perform technology transfer in order to ensure that the inventions resulting from publicly funded R&D reach the American public. With a few exceptions, federal agencies generally share similar authority from the Bayh-Dole Act, the Stevenson-Wydler Innovation Act, and a series of laws passed since 1980. Particular authority exists for NASA as a result of the Space Act of 1958.

Table 2-3 shows the federal R&D obligations for selected federal agencies and the total for the federal government for fiscal year 2001 through 2002.

**Table 2-3. Federal Obligations for R&D
by Major Agency and Performer, FY 2001-2002²⁰**

	FY 2001				FY 2002			
	<i>Total</i> (millions)	Federal Labs		Extra- mural	<i>Total</i> (millions)	Federal Labs		Extra- mural
		Intramural (\$000)	FFRDC (\$000)	Non- FFRDC (\$000)		Intramural (\$000)	FFRDC (\$000)	Non- FFRDC (\$000)
Defense	36,334	8,754	841	26,739	34,235	7,899	885	25,452
Energy	6,712	572	4,196	1,944	6,322	510	4,027	1,785
HHS	21,355	3,712	336	17,307	23,816	4,134	380	19,302
NASA	7,221	1,805	1,336	4,079	7,259	1,815	1,205	4,240
USDA	1,980	1,257	0	723	1,806	1,268	0	538
<i>Totals</i>	80,898	18,720	6,931	55,247	80,645	18,285	6,730	55,630

Table 2-3 shows that agencies vary in their total R&D effort and the amount of R&D performed by intramural²¹ performers or by federally funded research and development centers (FFRDCs).²²

²⁰ National Science Foundation, *National Patterns of R&D Resources: 2002 Data Update*, “Table B—Federal Obligations for Total Research and Development, by Major Agency and Performer: Fiscal Years 1951-2002.” Data for 2001 and 2002 are listed as preliminary.

²¹ Intramural is a commonly used term for research and development performed by federal government personnel and NSF defines intramural R&D to include actual intramural performance and costs associated with planning and administration of both intramural and extramural programs by federal personnel.

²² FFRDCs are entities established by the federal government to meet special long-term R&D needs that cannot be met effectively by existing in-house or contractor resources—they can be a university, a consortium of universities, not-for-profit organizations, or industrial firms. FFRDCs allow the federal government to use private sector resources and accomplish tasks that are integral to the mission and operation of the sponsoring agency. All FFRDCs are sponsored by an executive agency. The executive agency monitors and funds the FFRDC, and assumes responsibility for their overall use. In some cases, multiple agencies sponsor an FFRDC, but one agency still acts as primary sponsor. In addition to the Jet Propulsion Laboratory at Cal Tech, some other FFRDCs include Project Air Force at RAND, the Lawrence Berkeley National Laboratory at UC-Berkeley, and Aviation Systems Development at the MITRE Corporation.

Federal Sector Technology Transfer Performance

As a result of the Technology Transfer Commercialization Act of 2000 (P.L. 106-404), each federal agency reports its technology transfer performance occurring at the federal laboratories, for the year just ended, with their annual budget submission to the President and Congress in February. The Department of Commerce aggregates this information from all of the agencies reporting performance of technology transfer and issues a report to the President and Congress in the fall of the same calendar year. The report summarizes federal agency performance in technology transfer for the reporting year and the four prior years.

Using the information from the Department of Commerce collected²³ for fiscal years 2001 to 2003, the Panel offers an overview of technology transfer performance for NASA, DoD, DOE, USDA, and HHS, in the areas of cooperative agreements, patents, licenses, and license income.

NASA

NASA processes for technology transfer will be discussed in detail in Chapter 3. Table 2-4 presents NASA's performance in the areas of collaborative agreements, invention disclosures and patenting, licenses, and license revenue. NASA relies on Space Act Agreements for its collaborative relationships.

Table 2-4. NASA Technology Transfer Performance

NASA	2001	2002	2003
Collaborative Relationships for R&D			
Traditional CRADAs	1	1	0
New, executed in the FY	0	0	0
Non-traditional CRADAs, total active in FY	0	0	0
New, executed in the FY	0	0	0
Other Collaborative relationships, total active in FY	1,053	1,104	1,056
New, executed in the FY	496	537	385
Invention Disclosures and Patents			
New Inventions disclosed in the FY	696	775	736
Patent applications filed in the FY	152	166	163
Patents issued in the FY	159	128	136
Licensing			
All active licenses, number total active in the FY	328	357	521
New, executed in the FY	65	62	267
Invention Licenses, total active in the FY	292	290	295
New, executed in the FY	42	52	66
Other IP licenses, total active in the FY	36	67	226
New, executed in the FY	23	10	201
License Income			
Total income, all licenses active in FY	\$1,970,739	\$2,498,167	\$2,852,985

²³ Office of Technology Policy, U.S. Dept. of Commerce. Draft and unpublished. Source of information for Tables 2-4 through 2-8. The data will be published by Department of Commerce in the Fall 2004.

Invention Licenses	\$1,318,884	\$2,075,038	\$2,411,886
Other IP licenses, total active in the FY	\$651,855	\$423,129	\$441,099

Department of Defense

DoD technology transfer is decentralized and performed by each service and participating defense agency. The DoD's Office of Technology Transition serves as a supporting office for domestic DoD technology transfer by assisting with the identification of innovations that have potential for commercial application and providing clearinghouse services on the portfolio of DoD technological advances available to the private sector. The office hosts a TechTRANSIT website as an information source for DoD technology transfer, featuring information such as available DoD technologies, model agreements, and a DoD laboratory search tool.

The Office of Technology Transition reported that technology transfer has grown significantly in recent years with 45 technology transfer plans received from DoD labs in FY 2003.

Table 2-5. DoD Technology Transfer Performance

Department of Defense	2001	2002	2003
Collaborative Relationships for R&D			
Traditional CRADAs	1,418	1,376	1,523
New, executed in the FY	296	347	523
Non-traditional CRADAs, total active in FY	547	537	611
New, executed in the FY	163	102	107
Other Collaborative relationships, total active in FY	0	0	0
New, executed in the FY	0	0	0
Invention Disclosures and Patents			
New Inventions disclosed in the FY	1,005	1,122	1,332
Patent applications filed in the FY	809	829	810
Patents issued in the FY	619	617	619
Licensing			
All active licenses, number total active in the FY	288	471	364
New, executed in the FY	--	n/a	n/a
Invention Licenses, total active in the FY	283	350	361
New, executed in the FY	49	39	49
Other IP licenses, total active in the FY	5	121	3
New, executed in the FY	--	n/a	n/a
License Income			
Total income, all licenses active in FY	\$6,465,468	\$6,715,597	\$9,965,586
Invention Licenses	\$6,383,468	\$6,713,679	\$9,965,586
Other IP licenses, total active in the FY	\$82,000	\$1,918	n/a

Department of Energy

Energy specifies the priority of technology transfer, through DOE Order 482.1 issued to the 24 Energy laboratories. This order sets forth policies, procedures and oversight responsibilities for technology transfer in order to:

- Facilitate the efficient and expeditious development, transfer, and exploitation of Federally owned or originated technology to non-Energy entities for the public benefit and to enhance the accomplishment of Energy missions;
- Leverage Energy resources, through its programs and facilities, through partnering; and
- Ensure fairness of opportunity, protect the national security, promote the economic interests of the United States, prevent inappropriate competition with the private sector, and provide a variety of means to respond to private-sector concerns and interests about facility technology partnering activities.

All of Energy's 11 national laboratories and 13 other research facilities are authorized and presently perform "technology partnering activities" as outlined in DOE Order 482.1. Approved technology partnering activities include CRADAs, licensing agreements, work-for-other agreements, user facility agreements, technical consulting and personnel exchanges.²⁴

Of the 24 Energy facilities, 22 are government-owned, contractor operated facilities (GOCOs) that enjoy greater flexibility to perform technology transfer. The GOCO facilities operate under no restriction to license software, whereas government-owned, government operated laboratories (GOGOs) are prohibited from copyrighting and therefore cannot license software directly. However, GOGOs can be assigned a contractor's copyright, which can then be licensed. GOCO laboratories retain the rights to their intellectual property and are able to draw on the expertise of their operating organizations to leverage the benefit of their IP portfolio.

Cognizant secretarial officers (CSO) perform the oversight and management of technology partnering activities that occur at Energy laboratories and facilities. CSOs are assistant secretary or director positions in six areas (Defense Programs, Office of Science, Energy Efficiency and Renewable Energy, Fossil Energy, Nuclear Energy and Environmental Management), that control funding to the Energy laboratories and facilities.

Energy hosts a website (Technology Partnerships at <http://techtransfer.energy.gov>), that provides information on how to work with Energy, serves as a search tool to find Energy inventions available for licensing and provides links to Energy national laboratories and facilities.

²⁴ US Department of Energy, Office of Policy and International Affairs, *Annual Report on Technology Transfer and Related Technology Partnering Activities at the National Laboratories and Other Facilities—Fiscal Year 2003* (Washington, DC: 2004).

Table 2-6. Department of Energy Technology Transfer Performance

Department of Energy	2001	2002	2003
Collaborative Relationships for R&D			
Traditional CRADAs	558	680	661
New, executed in the FY	204	192	140
Non-traditional CRADAs, total active in FY	0	0	0
New, executed in the FY	0	0	0
Other Collaborative relationships, total active in FY	0	0	0
New, executed in the FY	0	0	0
Invention Disclosures and Patents			
New Inventions disclosed in the FY	1,527	1,498	1,469
Patent applications filed in the FY	792	711	866
Patents issued in the FY	605	551	627
Licensing			
All active licenses, number total active in the FY	2,005	3,459	3,687
New, executed in the FY	226	694	711
Invention Licenses, total active in the FY	1,162	1,327	1,223
New, executed in the FY	226	206	172
Other IP licenses, total active in the FY	843	2,132	2,464
New, executed in the FY	--	488	539
License Income			
Total income, all licenses active in FY	\$21,403,362	\$23,476,716	\$25,805,498
Invention Licenses	\$18,921,843	\$21,253,279	\$23,669,908
Other IP licenses, total active in the FY	\$1,870,071	\$2,223,437	\$2,135,590

Department of Health and Human Services (DHHS)

The major research components of DHHS, the National Institutes of Health (NIH), the Food and Drug Administration, and the Centers for Disease Control (CDC) perform technology transfer in order to protect the discoveries that occur in DHHS laboratories and ensure the widest dissemination of these discoveries. Table 2-7 below, highlights the performance reported by DHHS.

National Institutes of Health. The NIH office of technology transfer performs oversight of the technology transfer conducted by the 27 NIH institutes. Patent and licensing is centralized at NIH, including preparation of invention disclosures and technology transfer agreements, material transfer, CRADAs and clinical trial agreements. Each institute employs a technology development coordinator to oversee technology transfer agreements and the invention disclosure process for that institute. The technology development coordinator also serves as the institute liaison with the NIH Office of Technology Transfer. Several NIH institutes contract with the technology development coordinator at the national cancer institute to augment their internal capability in the performance of invention disclosures and technology transfer agreements.

Support work is specified by contractual arrangement between the institutes and the contracting institute retains the decision-making authority on the agreements with external parties.

NIH does patent and licensing work for the Food and Drug Administration and supports the development and implementation of technology transfer policy for the FDA, CDC and the Agency for Healthcare Research and Quality.

NIH established a website (<http://ott.od.nih.gov/index.html>) that provides information on model agreements for licenses, material transfer and CRADAs, technologies available for licensing, as well as contact information for technology development coordinators at each of the 27 NIH Institutes.

Centers for Disease Control. The CDC Technology Transfer Office (TTO) was established in 1988 and conducts the patenting and licensing of CDC inventions. TTO employs technology licensing specialists to prepare and negotiate CRADA licenses and coordinate patent licensing. CDC's TTO has a technology transfer website (<http://www.cdc.gov/od/ads/techtran/index.htm>) which lists the technologies available for licensing and the standard agreements and policies employed by CDC.

Food and Drug Administration. FDA protects intellectual property and enters into CRADAs and other partnerships as appropriate to fulfill its technology transfer mission. NIH represents FDA in the licensing of FDA patented technologies. FDA provides a website with process flows, policies to consider, existing CRADAs and other information.

Table 2-7. DHHS Technology Transfer Performance

Department of Health and Human Services	2001	2002	2003
Collaborative Relationships for R&D			
Traditional CRADAs	289	261	254
New, executed in the FY	61	90	54
Non-traditional CRADAs, total active in FY	209	209	173
New, executed in the FY	76	36	48
Other Collaborative relationships, total active in FY	0	0	0
New, executed in the FY	0	0	0
Invention Disclosures and Patents			
New Inventions disclosed in the FY	434	431	472
Patent applications filed in the FY	255	262	279
Patents issued in the FY	119	116	136
Licensing			
All active licenses, number total active in the FY	1,367	1,357	1,380
New, executed in the FY	--	220	211
Invention Licenses, total active in the FY	1,007	1,213	1,298
New, executed in the FY	212	198	199
Other IP licenses, total active in the FY	360	144	82
New, executed in the FY	--	22	12
License Income			
Total income, all licenses active in FY	\$46,722,000	\$52,882,331	\$55,198,722
Invention Licenses	\$41,322,000	\$51,868,102	\$54,570,939
Other IP licenses, total active in the FY	\$5,400,000	\$1,014,229	\$627,783

U.S. Department of Agriculture (USDA)

USDA delegated responsibilities for patenting and licensing its inventions to the Agricultural Research Service (ARS). The ARS Office of Technology Transfer (OTT) performs the duties of protecting intellectual property and managing technology transfer agreements with external organizations. ARS is organized with a centralized authority to sign CRADAs and licensing agreements. The office employs patent advisors to assist scientists with the identification of intellectual property and the necessary actions to prosecute patents, when appropriate. OTT has eight regional technology transfer coordinators in the field responsible for supporting ARS inventors and ensuring that agreements are coordinated with field management and do not interfere with any existing ARS agreements.

ARS hosts a technology transfer website with available patented ARS technologies, generic agreement forms, and points of contact.

Table 2-8. USDA Technology Transfer Performance

U.S. Department of Agriculture	2001	2002	2003
Collaborative Relationships for R&D			
Traditional CRADAs	217	222	223
New, executed in the FY	49	58	51
Non-traditional CRADAs, total active in FY	2	3	6
New, executed in the FY	0	1	4
Other Collaborative relationships, total active in FY	3,679	3,211	2,769
New, executed in the FY	1,040	1,416	1,480
Invention Disclosures and Patents			
New Inventions disclosed in the FY	118	151	121
Patent applications filed in the FY	83	90	60
Patents issued in the FY	64	53	64
Licensing			
All active licenses, number total active in the FY	255	267	270
New, executed in the FY	32	26	27
Invention Licenses, total active in the FY	255	267	270
New, executed in the FY	32	26	27
Other IP licenses, total active in the FY	0	0	0
New, executed in the FY	0	0	0
License Income			
Total income, all licenses active in FY	\$2,622,000	\$2,571,378	\$2,290,903
Invention Licenses	\$2,622,000	\$2,571,378	\$2,290,903
Other IP licenses, total active in the FY	\$0	\$0	\$0

STATISTICAL COMPARISON WITH GOVERNMENT AGENCIES AND UNIVERSITIES

Since each federal agency conducts R&D and technology transfer to serve different missions in different scientific areas, the benefits of comparisons among agencies are limited. The Panel also recognizes that agencies continue to refine their technology transfer data collection. Therefore, the most recent information is likely to be the most accurate. A more thorough analysis and examination into the sources of information would be required in order to make conclusive judgments about technology transfer performance among the agencies.

The Panel compared the federal agencies in a manner that neutralizes the substantial differences in size of federal laboratory R&D expenditure amounts. Table 2-9 and Table 2-10 offer two ratios for considering the invention disclosures and licensing income generated across the agencies.

Amount of Funded R&D per Invention Disclosure

A standard measure in the university technology transfer community is the amount of funded R&D per invention disclosure. The benchmark within the university community for excellence is between \$1 and \$2 million per invention disclosure. Table 2-9 shows the calculated amount of funded R&D per invention disclosure by federal agency.

Table 2-9. Federal Lab R&D Obligations per Invention Disclosure (\$ in Millions)

Fiscal Year	DoD	DOE	HHS	NASA	USDA
2001	\$9.55	\$3.12	\$9.33	\$4.51	\$10.65
2002	\$7.91	\$3.03	\$10.47	\$3.90	\$8.40

Table 2-9 shows that Energy was the best among the government agencies, with NASA being a close second and improving over the two-year period.

Licensing Income per Million Dollars of Federal Laboratory R&D

It is also useful to calculate the licensing income generated from federal laboratory R&D as a measure of value generated from R&D. Table 2-10 shows the calculated dollar amount of licensing income generated per million dollar of intramural R&D.

Table 2-10. Licensing Income per Federal Laboratory R&D (\$ in Millions)

Fiscal Year	DoD	DOE	HHS	NASA	USDA
2001	\$674	\$4,489	\$11,542	\$627	\$2,086
2002	\$757	\$5,175	\$11,715	\$827	\$2,028

Table 2-10 shows NASA performance roughly level with DoD and significantly lower than the other comparison agencies. HHS's leadership in this category is consistent with the amount of investment presently occurring in the area of biotechnology.

Ratio of Annual Invention Disclosures to Patents Issued

Table 2-11 shows the ratio of invention disclosure to patents issued. Acknowledging that an invention disclosure may not result in a patent for a year or two, the ratio still provides useful information concerning the level and quality of invention disclosures necessary to generate a patent.

Table 2-11. Ratio of Annual Invention Disclosures to Patents Issued

Fiscal Year	DoD	DOE	HHS	NASA	USDA
2001	1.62	2.52	3.65	4.38	1.84
2002	1.82	2.72	3.72	6.05	2.85
2003	2.15	2.34	3.47	5.41	1.89

NASA shows the highest ratio as compared to other federal agencies. It is unclear why NASA's ratio is so high. Possibly, NASA is more prudent in filing patent applications than other agencies. The quality of what is being reported also could be lower. Further analysis is needed to reach a definitive conclusion.

University Comparison

Universities conduct technology transfer to enable the commercialization of research for the benefit of the public, to realize the benefits of those inventions, to retain and attract faculty, and to draw close ties between their academic efforts and the work of industry.

The Association of University Technology Managers (AUTM) conducts an annual licensing survey of its members. Statistics from fiscal year 2002 are presented in Table 2-12.

Table 2-12. AUTM FY 2002 Survey Summary, Selected Universities

University	Sponsored Research (Millions)	Invention Disclosures	Patents Issued	Licenses & Options Executed	Gross License Income (Millions)
Cal Tech	\$384.00	403	102	50	11.218
Columbia Univ	\$407.41	207	60	55	\$15.57
Harvard Univ.	\$522.10	140	57	85	\$15.45
MIT	\$898.99	484	134	122	\$26.35
U Cal System	\$2,417.64	973	300	222	\$82.05
Univ of Michigan	\$655.98	237	56	61	\$5.35
WARF	\$662.10	308	87	156	\$32.06

Table 2-12 shows that universities are strong performers in technology transfer with considerable amounts of license income, patents issued and licenses executed.

**Table 2-13. Calculated Ratios for Universities
and Comparison to NASA and Government Agencies**

Fiscal Year 2002	Amount of R&D per Invention Disclosure (\$ Million)	License Income Per Million \$ R&D	Ratio of Annual Invention Disclosures to Patents Issued
Cal Tech	\$0.95	\$29,214	3.95
Columbia Univ	\$1.97	\$38,206	3.45
Harvard Univ	\$3.73	\$29,588	2.46
MIT	\$1.86	\$29,306	3.61
U Cal System	\$2.48	\$33,937	3.24
Univ of Michigan	\$2.77	\$8,149	4.23
WARF	\$2.15	\$48,423	3.54
NASA	\$3.90	\$827	6.05
Range Government Agencies	\$3.03 to \$10.47	\$757 to \$11,715	1.82 to 6.05

Table 2-13 shows that on the amount R&D per invention disclosure and license income generated per R&D funding, universities are at the upper end of performance compared with government agencies, generally, and NASA in particular. Universities show a narrower spread of ratios of invention disclosures to patents issued than government agencies.

The data on technology transfer presented in this chapter, and later in Chapter 3, can be interpreted in a variety of ways. The Panel believes, however, that NASA can benefit by analyzing its performance relative to other federal agencies, universities, and private industry in order to look for trends and to identify ways for improvement.

RELEVANCE OF EFFECTIVE PRACTICES TO NASA

Important Differences Among the Government Agencies When Considering Technology Transfer Performance

It is important to consider the differences between the government organizations studied and the role that R&D serves for those organizations. NIH and USDA conduct R&D that will result in inventions that will directly benefit the public, either through public disclosure or through patent and licensing action.

By contrast, at NASA and DoD, R&D and the innovations generated from R&D serve the operational mission of these agencies, first and foremost. The commercialization opportunities

that exist outside the mission area are valuable but secondary benefits. With a need to meet the operational mission, the availability of inventors for technology transfer activities is sometimes limited. Operational mission needs also spur these agencies to identify commercial innovations for spin-in to meet program objectives.

Energy has a particularly strong lever in technology transfer because 22 of its 24 laboratories are GOCO facilities. These laboratories enjoy several advantages in their technology transfer efforts:

- They own most of the inventions they generate.
- They experience no federal prohibition to licensing software; licensing does not require Energy approval.
- They can leverage the resources of their managing organization. For example, Battelle Memorial Institute runs four Energy laboratories, and the University of California runs two. Battelle Memorial Institute has 16,000 scientists and \$3 billion in annual R&D expenditures that can be leveraged to determine whether an invention disclosure from an Energy laboratory has commercial potential.

Important Differences among Government Agencies and Industry/Academia When Considering Technology Transfer Performance

Industry and academia provide an interesting framework for understanding the potential of technology transfer for NASA. However, the differences between government agencies and industry/academia must be outlined in order to set a context for this chapter's findings and their applicability to NASA.

Government agencies operate under a set of specific laws and regulations covering technology transfer. The extent to which these laws and regulations impose barriers to technology transfer by a federal agency can be debated. Regardless, large commercial firms and universities experience significantly greater freedom in the area of technology transfer than do federal agencies. Commercial firms and universities can enter into agreements with any organization they choose, for whatever purpose they choose (limited by restraint-of-trade and export control regulations), and under whatever terms they can negotiate.

Government agencies are mandated to commercialize innovations from federally funded R&D to ensure that U.S. society benefits. Government agencies must balance these efforts, and the resources necessary to fulfill these requirements, with competing missions within their agencies. Government agencies depend on the Administration and Congress for funding for their technology transfer efforts. Industry and academia transfer technology to increase revenue and reduce costs, and they can structure deals that maximize benefit to the organization. The discipline of competition moves these organizations to shift R&D to the areas with the maximum economic benefit. Technology transfer exists to support maximizing that benefit.

CONCLUSION

Leadership commitment, service to customers, staffing with talented people, and the use of external capabilities to augment staff are the four essential elements for successful technology transfer. As one federal government representative said, “it all begins with leadership commitment.” Based on our study team’s research, leadership commitment can be viewed as the foundation for success in technology transfer with every organization examined, except one, indicating that this commitment is critical..

Leadership commitment raises the visibility of technology transfer and creates an environment conducive to attracting and retaining talent. Organizations with leadership commitment to technology transfer usually provide sufficient funding for patenting and licensing and the personnel with the necessary capabilities for effective technology transfer performance.

CHAPTER 3

NASA'S TECHNOLOGY TRANSFER FUNCTION AND THE INNOVATIVE PARTNERSHIPS PROGRAM

This chapter presents the results of the study team's research, interviews, and fieldwork conducted during the spring and summer of 2004. Here the IPP and related programs are described as the study team found them. Because this work was done during FY 2004, the team did not evaluate the significant changes that NASA had made, for example, from the former Commercial Technology Program to the IPP. Over the course of this study, NASA also has decided to make some significant additional changes to the IPP. The Panel did not fully consider these changes in its analysis, however, for two reasons: (1) NASA is still in the planning stages and (2) it will not implement any major changes until later in FY 2005. Where appropriate, the Panel has tried to take current planning into consideration in crafting this report. Although this chapter focuses primarily on the FY 2004 programs, it does not ignore such critical historic changes as IPP's changing mission and its declining budget and staffing.

The first two sections describe how NASA acquires and disseminates technology across the board in the context of the IPP. This is followed by a description of how NASA's culture affects technology transfer, the constraints on the programs, an assessment of the IPP network, the IPP offices' organizational placement at headquarters and the centers, multiple websites and information systems, IPP's limited role in spin-in and related topics, improvements needed in the intellectual property process, and performance measurement. In summary, the Panel believes the results of the work strongly indicate that, if NASA wants to achieve excellence in technology transfer, major changes are needed that sometimes differ from and go beyond those now planned.

AGENCY-WIDE TECHNOLOGY ACQUISITION

OMB has urged NASA to rely much more heavily on technology from the private sector to meet its mission needs. Accordingly, it is encouraging IPP to place much more emphasis on spin-in, while also fulfilling its spin-out responsibilities as mandated by the Space Act of 1958. NASA already acquires a lot of its technology from the private sector. No formal estimates have been made of the gap between what it is currently using and what it should be using, and policymakers differ on how much NASA and other federal agencies should rely on the private sector for goods and services. The Panel believes, however, that there are significant opportunities available for NASA to make additional use of outside technologies, especially university-developed technology, much of which is funded by NASA and other federal agencies.

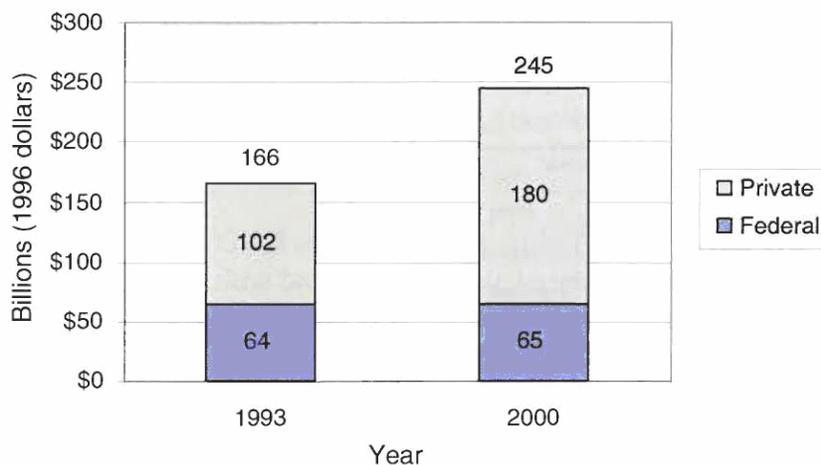
Evolving Roles in Technology Development

The technology world has changed dramatically since NASA was established in 1958. At that time, the federal government's investment in R&D dwarfed the private sector's, with the federal government spending approximately \$2 for every \$1 of private investment in the 1950s.

Because the agency's 1960s mission to the Moon was new and unique, NASA was forced to develop most of its own technology; the aerospace industry was still to evolve.

The situation is dramatically different today. As discussed in Chapter 2 and shown below in Figure 3-1, the nation is no longer as dependent on the federal government for R&D. Indeed, private industry's share of total R&D investment is not only much larger than the federal government's, but it continues to grow.

Figure 3-1. Private vs. Federal R&D Spending²⁵



In 1993, total R&D investment in the United States was \$166 billion, with the federal government's contribution being \$64 billion, or 38 percent of the total. By 2000,²⁶ total R&D investment had increased to \$245 billion, virtually all due to increased private expenditures. The federal government's investment of \$65 billion was approximately 25 percent of that investment. The Department of Defense is the largest federal sponsor of R&D, accounting for almost half of the total federal R&D funding.²⁷

With its increased proportion of overall R&D investment, it is no surprise that private industry now dominates many technology areas. In fact, the private sector is the acknowledged leader in many of the important technologies, such as nanotechnology and robotics, that NASA needs to accomplish its mission.

In part due to this rapidly changing world, IPP has reformulated its mission toward creating joint research ventures with industry, academia, and other government agencies to spin-in technology

²⁵ Department of Defense, Office of the Under Secretary of Defense for Defense Procurement and Acquisition Policy, *Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment* (Washington, DC: January 2003).

²⁶ This is the latest year for which final data is available. Data for 2001 and 2002 are still preliminary.

²⁷ Department of Defense, Office of the Under Secretary of Defense for Defense Procurement and Acquisition Policy, *Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment* (Washington, DC: January 2003).

that supports NASA's mission directorates. The overall impact of IPP in this area, though, will necessarily be limited because most technology from the private sector is acquired by NASA programs through such major procurement actions as definitive contracts and GSA Federal Supply Schedule orders. In FY 2003, NASA spent \$13.273 billion (84.8% of its budget) on procurement awards.²⁸ Of this amount, only 8% was spent on grants, cooperative agreements, and Space Act Awards.²⁹

Even if IPP's spin-in or dual-use partnerships are effectively utilized, they will never be more than a small part of NASA's overall use of private-sector technology. In interviews with the study team, NASA project managers emphasized their need for "proven technology" to meet their near-term mission needs and their reluctance to use spin-in and dual-use partnerships to produce technologies that are unproven in meeting mission needs. They want to either procure the technology or develop it themselves.

Further complicating matters for IPP officials is that neither headquarters nor the centers have a comprehensive strategy for determining or publicizing agency-wide technology needs. Without a clear understanding of enterprise and center technology needs, it is unreasonable to expect the IPP network to perform spin-in effectively. As one official explained to the Academy study team, the NASA strategy has been "like sending people to the supermarket without telling them what to buy."

Recognizing this as a legitimate challenge, NASA has begun to take some initial steps to define its technology needs. At headquarters, the IPP has established "mission account managers" to work with officials in certain mission directorates to identify critical technology gaps that IPP may be able to fill. The account manager for the Science Mission Directorate, for instance, has worked with the directorate's chief technologist to identify their top technology needs, which are optics technologies and advanced detectors.³⁰

Based on this information, the IPP network will now conduct market assessments to identify partnership opportunities. Specifically, it is expected to accomplish the following:

- Understand the state of the art in the technology area
- Conduct a gap analysis to identify technology barriers that need to be overcome to meet these needs

²⁸ NASA defines procurement awards broadly as "any contractual action to obtain supplies, services, or construction that increases or decreases funds, including: letter contracts or preliminary notices; definitive contracts; orders under GSA Federal Supply Schedule; intra-governmental orders; grants; Cooperative and Space Act Agreements; supplemental agreements, change orders, administrative changes, and terminations."

²⁹ National Aeronautics and Space Administration, Office of Procurement, *Annual Procurement Report: Fiscal Year 2003* (Washington, DC: 2004).

³⁰ Within optics, the top technology needs are lightweight optical material; optically flat and uniform surfaces; wavefront sensing and wavefront control; and segmented, deployable structures. Within advanced detectors, the top technology needs are increased array sizes, increased sensitivities, uniform high quality response, low noise electronics, and new semiconductor materials.

- Determine what research is being done in these areas by other federal agencies, private industries, and universities
- Identify potential partners for the Space Science Directorate

At the center level, Goddard, JPL, and Kennedy have also been working to more systematically identify their technology needs. For example, Goddard has worked with the Northeast RTTC to identify seven high-priority technology areas, such as high-sensitivity detector systems, modular space systems, and applied nanotechnology. Each of these broad technology areas are broken down into a slightly more specific set of technology needs for which spin-in partnerships could be useful. Similarly, Kennedy has adopted a “top 40 list” of technology needs, but its Technology Transfer Office expressed concerns to the study team that the list is too general to be used for spin-in purposes.

In headquarters interviews and field visits, a central concern expressed to the study team was the understandable difficulty that IPP officials face in translating such broad technology needs into an actionable level that can result in partnership agreements. In response, the headquarters office has been negotiating a “work package agreement” with each center’s technology transfer office that, among other things, requires them to participate in program-wide mission action teams in order to ensure that the program’s strategic focus is on the needs and objectives of key mission areas. Box 3-1 describes this process.

Box 3-1. Role of the Mission Account Teams

The Mission Account Teams will include representatives of the center’s IPP office, the external network, and the requisite mission directorate. The team will be charged with the following:

- Defining “actionable” Mission Directorate Technology Needs
- Identifying opportunities and strategies for technology transfer and partnership development in particular technology areas
- Developing action plans for the selected opportunities
- Submitting quarterly reports
- Adopting other communications and information strategies that will allow for coordination and collaboration across NASA

The Exploration Systems Directorate is implementing a new technology acquisition strategy for future exploration initiatives. The Human and Robotics Technology Program has developed an integrated planning mechanism that includes all three elements of IPP (SBIR, STTR, and the external network). IPP at headquarters will be tasked with identifying the particular technologies and/or innovations from nongovernmental sources needed by the agency to surmount challenges

to the Missions to the Moon, Mars and Beyond. It is also tasked with working closely with Project Prometheus and the Centennial Challenges.³¹ In the summer of 2004, IPP issued a NASA Research Announcement and a Broad Agency Announcement for an initial round of NASA research, technology development, and demonstration projects within the human and robotics area. But these projects are only for the Exploration Systems Directorate; a connection between this global enterprise planning and center activities must be established.

Spin-In Partnerships Have a Limited Role in Overall Technology Acquisition

Spinning-in technology from the private sector and universities is a complex process that, at a minimum, involves several major steps:

- Identification of a technology need
- Decision to meet that need, if possible, through a spin-in partnership
- Identifying outside entities with a technology or technologies that could be adapted to meet this need
- Formation of a partnership agreement between the outside entity and NASA
- Actual development of the technology to meet NASA's mission requirements

Many of these steps, of course, are outside of IPP's control. For example, it is scientists and engineers on a particular project—not IPP officials—who must make the initial decision to even pursue a spin-in partnership. And, at this point, IPP officials have little influence over this decision because they are not involved with the front end of project planning at any center. If the managers of a particular project ask IPP officials to try to meet a technological need through a spin-in partnership, the IPP officials must (1) understand the technological capability that is required, (2) be aware of the technology available outside NASA that might meet this need, and (3) understand whether and how this technology can be adapted to meet mission requirements.

Although the Panel fully supports NASA making more use of innovative technologies from private industries and universities to meet mission needs, the study team's research indicates that spin-in partnerships will inevitably play a limited role in NASA's overall use of private sector technology. The study team's research also indicates that IPP itself cannot be the major catalyst for spin-in within NASA for several reasons:

³¹ Project Prometheus's purpose is to develop technologies necessary to enable new science missions that are not possible today—in particular, reactor-based systems and radioisotope-based systems that will be used for the Jupiter Icy Moons Orbiter and other propulsion missions. Centennial Challenges is NASA's program of prize contests to stimulate innovation and competition in solar system exploration and ongoing NASA mission areas. Awards are made on actual achievements, not proposals, which NASA believes will stimulate novel solutions to its mission problems from non-traditional sources of innovation in universities, industry, and the public at large.

- IPP does not have sufficient standing in any of the centers.
- IPP personnel do not typically have the requisite technical backgrounds.
- NASA does not have a comprehensive list of technology needs, so it is difficult for the IPP officials to know where to focus their attention.
- IPP personnel are not currently involved at the project planning stage in any of the centers.

In the team's headquarters interviews and field visits, they found virtually no line official support for an IPP role in spin-in outside of the Exploration Systems directorate. At the centers, in particular, program executives feel that their scientific and technical personnel either already know what technology is available or can find out rather easily. The Panel believes that this is frequently true, but it is not always the case. Researchers may not be aware, for example, of how technologies outside their major field could be used to meet their needs on a particular project; nor are they always aware of technologies from companies with which they do not already have an established relationship. In many cases, too, they may not have had the time to keep up with the fast-moving changes in highly dynamic technologies such as information technology and nanotechnology. It is reasonable to assume, therefore, that gaps in technological awareness exist, even among very accomplished scientists and engineers. What is not clear is whether IPP officials will be able to fill this gap by identifying some high-priority, valuable technologies that NASA's researchers could not have found themselves.

NASA'S TECHNOLOGY COMMERCIALIZATION AND DISSEMINATION PROCESSES

NASA-generated technology and scientific information is made available to private industries, universities, and other public agencies in a variety of ways. In addition to being transferred through formal Space Act Agreements and licenses, it is transferred when NASA's scientists and engineers publish research papers, make presentations at academic and professional conferences, and collaborate informally with other researchers. It is also transferred when NASA releases its technology to the general public through TechFinder.

The IPP officials dedicated to technology transfer generally play a *facilitative* role by finding partners, identifying commercialization opportunities, and negotiating Space Act Agreements and licenses. In broad outline, NASA's technology commercialization process consists of several major steps:

- The center IPP offices, along with their RTTCs, market their technologies through Technology Opportunity Sheets; trade shows; direct mailings; and other venues to solicit commercialization interest from industry and universities.

- The NASA center with a patent on the technology may host a “technology briefing” for interested parties, providing them with technical information as well as an overview of the agency’s patent and copyright licensing processes. Such a briefing will be publicized online, in the Federal Laboratory Consortium’s *Newslink*, and through various mailings.
- Industries and universities interested in commercializing the technology will submit commercialization plans and, in some cases, licensing applications.
- The NASA center will review the proposed commercialization plans, selecting the best based on pre-established evaluation criteria.
- The industry or university selected as a partner will negotiate the patent or copyright license agreement and/or a Space Act Agreement. All licensing agreements must be approved by the NASA General Counsel in headquarters. Reimbursable and non-reimbursable Space Act Agreements must be approved by the General Counsel at headquarters or the Chief Counsel at the center, depending on the amount.³²

NASA has adopted a wide range of mechanisms for informing the public about the technology opportunities it has available. Each center’s Technology Opportunity Sheets are published in a book-ring binder available to the public. In addition, they are featured in one of three publications (*Innovations*, *Spinout*, or *TechBriefs*) and posted online through TechFinder.³³ RTTC officials also contact companies through direct mail, fax, tradeshow, or other personal contact to inform them about licensing and partnership opportunities in the companies’ area of interest.

The study team was told that the IPP network made a conscious effort in FY 2004 to be more strategic with its outreach strategies. In the past, IPP officials tended to set up booths at various tradeshow, but found that this was not a very effective way to reach target companies because NASA was often seen as simply one more vendor trying to sell a product at these events. Instead, it has begun to develop symposiums for pre-identified industry officials on a specific technology area, such as medical technology. For example, NASA headquarters led a cross-agency team to conduct the NASA Medical Technology Summit in Pasadena, California. RTI served as lead agent within the external network and was responsible for developing the Summit program. The NTTC provided logistics planning and supported national marketing for the event, while the Far West RTTC conducted targeted marketing to companies within the Southern California region. Featuring over 20 NASA technologies from seven NASA centers, the event attracted 130 corporate decision-makers from major medical companies such as Baxter, Chiron, Johnson & Johnson, and Medtronic. After the summit, NASA researchers and interested industry representatives held one-on-one meetings, with the intent to develop partnerships to commercialize emerging medical technologies. A similar event was organized in Boston. The

³² The Chief Counsel for each center can approve reimbursable agreements under \$10 million, and non-reimbursable agreements of no more than 25 work years of effort per agreement or \$5 million in equipment and/or facilities. Any agreement valued at over these amounts must be approved by the General Counsel in headquarters.

³³ The NTTS notifies registered potential licensees when a new invention in their chosen area of interest is available. With this system, an e-mail is sent to subscribers including a brief description of the invention, potential commercial uses, and information indicating where they can obtain more information on the invention. Those requesting information are required to sign a Confidentiality Agreement prior to receiving an application.

summit planning committee consisted of the RTTCs, NTTC, RTI, IPP at headquarters, and seven NASA centers. The event was successful enough that the network is planning to host the summit in other locations.

HOW THE NASA CULTURE AFFECTS TECHNOLOGY TRANSFER

Several facets of NASA’s organizational culture make it more difficult to successfully transfer technology into or out of the agency: (1) technology transfer is not core to the agency’s mission,³⁴ (2) IPP officials are not viewed as “part of the team” and are often at odds with one another, and (3) the agency’s approach to technology transfer is very insular.

Technology Transfer Is Not Core to the Mission

Although the Space Act of 1958 mandates technology transfer as a function of the agency, NASA officials simply do not view it as core to their mission, nor is it central to most of their ongoing programs. Among other things, NASA officials are currently focusing on the shuttle return to flight initiative, the International Space Station, the new space exploration mission, and the Hubble space telescope. And now, given the President’s new focus on space exploration, NASA is working on plans to send humans back to the Moon and eventually to Mars and beyond. By the end of the decade, NASA plans to develop a new spacecraft (the Crew Exploration Vehicle) for exploration.

Technology transfer, especially spin-out, tends to get lost in meeting these mission requirements. Whether some of the agency’s technology gets commercialized is simply not a major focus of line officials and project managers; and they are not rewarded or promoted on this basis. Consequently, center spin-out partnership agreements are done on a “noninterference basis”³⁵—almost as an afterthought—which has not been a solid basis for collaborating with industry or universities.

IPP Officials Are Not Viewed as “Part of the Team”

The headquarters and center technology transfer offices, discussed in more detail below, have been given formal responsibility for technology transfer within NASA. But they are typically isolated from much of the rest of NASA, to a large extent because technology transfer is viewed as incidental to the agency’s mission. The IPP field offices have experienced significant reductions in headquarters funding, and their personnel are frequently regarded as lacking the necessary technical skills to truly understand and assess the center’s technologies, especially in regard to the new spin-in mission. In some centers, the study team encountered outright hostility to the IPP officials, while project managers and technologists in at least one other center said they were unaware such a program existed.

³⁴ This is not atypical for federal agencies with an operational mission.

³⁵ The noninterference requirement, written explicitly into Space Act Agreements, means that NASA scientists and engineers may not be able to work with private industry on technology commercialization if their supervisors need them for some mission need.

NASA's Insularity

In interviews with NASA officials, some concerns were expressed about the agency's rather insular approach to technology transfer. For example, NASA has not made a conscious effort to infuse best practices adopted by other federal agencies into its technology transfer programs. Although NASA is a member of the Federal Laboratory Consortium, the study team was told that it had not been a very active participant. Within the IPP network itself, the lines of communication to share technology needs and best practices are frequently fragmented and confusing. The Northeast RTTC expressed concerns that NASA has not made enough effort to tap into the nation's universities for technology, facilities, and partnerships for commercialization opportunities or potential spin-in partnerships. The Northeast is an especially fertile ground for NASA in this regard because the agency provided the region's many outstanding universities with \$181.9 million in funding in FY 2003.³⁶ The Northeast RTTC has started providing no-cost assistance on university intellectual property resulting from NASA-funded research. It will conduct technology assessments, identify companies that can benefit from technology, and work to develop joint university ventures to infuse the technology into NASA's missions. Similar programs were not found at the other RTTCs, perhaps because universities do not play as much of a role in technology development in their regions.

In summary, the study team's headquarters interviews and field visits indicate that NASA could infuse more innovative technologies into its operation by reaching out to other agencies and to private industry and major universities.

ASSESSMENT OF THE IPP NETWORK

The IPP's mission is to create partnerships with industry, academia, and other government agencies to develop and transfer technology in support of the NASA programs. IPP's goals are to reduce NASA's technology development life-cycle costs, transfer technology in support of the agency's mission, and enhance NASA's mission technology capabilities. The mission is worthy, and the goals make sense. The critical issue is how they are implemented.

IPP Generally Successful at Administrative Aspects of Technology Transfer

The technology transfer process involves such basic administrative tasks as processing NTRs, filing patent applications, and developing partnership agreements. The centers' IPP staffs, for example, are generally the "Office of Record" for Space Act Agreements, which requires them to assign an official number to each agreement, maintain a copy of all executed agreements, and maintain the records in TechTracS for performance reporting. Although concerns were expressed to the study team that it takes too long to process agreements, the IPP officials were generally perceived as successful at the basic administrative aspects of technology transfer. That is, the IPP offices in the centers are regarded as appropriate of a place within NASA as any to house responsibility for completing Space Act Agreements, ensuring compliance with New Technology Reporting requirements, and the like.

³⁶ This figure includes SBIR/STTR, set-asides, contracts, grants, cooperative agreements, and Space Act Awards.

Where IPP officials appear to have more difficulty is in the broader responsibilities of technology transfer: working with NASA researchers to understand their technologies, finding outside partners, and identifying good candidates for licenses in companies and universities. Many NASA officials, especially those in the centers, said that the IPP program cannot perform these tasks effectively until it has a more balanced skill mix. IPP personnel have three major types of professional backgrounds: business professional, engineering, and law. The study team was told that over half of the personnel in the IPP network have business, marketing, and legal/paralegal backgrounds, but that, especially for spin-in, the balance needs to shift more toward engineers with significant expertise in the types of technology NASA needs for its missions.

Fragmented External Network with Unclear Roles and Responsibilities

The IPP has a complex organizational network consisting of the six major components that were listed in Chapter 1: the headquarters office, the field center offices, the NTTC, the RTTCs, RTI, and the state affiliates. In its fieldwork, the study team found the external network³⁷ to be highly decentralized and fragmented. They found no careful sorting out of who should do what based on staff expertise and experience. They also discovered that the external network had been receiving limited direction from the headquarters IPP office, largely because headquarters has had little control over the various components:

- The center technology transfer offices have been reporting to the centers’ chains of command, not to headquarters.
- The RTTCs have been reporting to various centers, not to headquarters.
- The NTTC has been managed through a cooperative agreement, not a performance-based contract.

The roles and responsibilities of each component in the external network are overlapping and unclear, as Table 3-1 describes.

Table 3-1. Roles and Responsibilities of Organizations in the External Network

ACTIVITY	NTTC	RTTCs	RTI
Commercial Assessments	✓	✓	✓
Commercial Strategy and Technology Marketing	✓	✓	✓
Information Services for the Public	✓	✓	✓
Partnership Facilitation and Development	✓	✓	✓
Technology Mining	✓	✓	✓
Training	✓		
Website Management	✓		

³⁷ As used in this report, the “external network” means the NTTC, the six RTTCs, the state affiliates, and RTI.

The NTTC, RTTCs, and RTI all seek to connect the outside world of private industries and universities to NASA. Each performs commercial assessments, marketing, and partnership development. Each markets NASA's technology and sends leads to the field centers. This significant overlap was also found by NASA's Inspector General in an earlier review:

The missions of NTTC and RTTCs are similar. The RTTCs help U.S. firms access, assess, and acquire NASA and other federally funded technologies for commercial and industrial applications. According to the cooperative agreement, NTTC's mission is to "facilitate the transfer to, and the commercial use by, the U.S. private sector of federally sponsored research and technology ... to enhance and strengthen U.S. economic growth." The similar mission statements create confusion about the role of the respective organizations. Several NTTC Advisory Board members indicated that they were uncertain about the NTTC mission relative to that of other technology transfer components ... Some members stated that NTTC was performing the same role as the RTTCs.³⁸

Within this overlapping set of functions, the approach of the external network members is often quite varied. Some RTTCs appear to be transitioning to spin-in, while others are still doing mostly spin-out. Those focusing on spin-in are approaching it in different ways. The Far West RTTC is developing a complex theoretical model to use to identify potential spin-in technology areas and companies. Others are using their existing set of contacts in the belief that spin-in and spin-out are "two sides of the same coin": that is, companies that have been commercializing NASA's technology may also have technology of their own to contribute to the agency's mission.

The National Technology Transfer Center

The study team's fieldwork indicates that NTTC has been underutilized, with many in the NASA headquarters and centers questioning whether NTTC can make a significant substantive contribution to their technology transfer efforts. Although NASA contributes close to \$6 million (\$5.8 million in FY 2004) per year for the NTTC, or about a third of NTTC's budget,³⁹ NASA has made little use of it for commercial assessments, marketing, or partnership development. Many field center officials said they had attempted to rely on NTTC for these tasks in the past, but that the results were unsatisfactory.

Similar concerns were expressed in the Inspector General report⁴⁰:

- NTTC's mission is unclear, similar to the RTTCs, and not fully integrated into NASA's technology transfer organization. NASA has provided unclear guidance, which has "caused confusion and has reduced NTTC's effectiveness."

³⁸ Office of the Inspector General, *National Technology Transfer Center: Audit Report* (Washington, DC: September 1998).

³⁹ NASA historically has provided between approximately \$6 million to \$7 million per year for NTTC.

⁴⁰ Office of the Inspector General, *National Technology Transfer Center: Audit Report* (Washington, DC: September 1998).

- NTTC's performance reporting and data are not sufficient for NASA to fulfill its oversight responsibilities.

NASA and NTTC have a long and somewhat complicated history, with a certain amount of mistrust and miscommunication on both sides. NASA officials have tended to resent the fact that money for NTTC is earmarked in their budget, thus reducing the agency's discretion to manage its technology transfer programs and ability to make its own contracting decisions. Due to the political sensitivities surrounding their relationship, NASA has always used a cooperative agreement rather than a performance-based contract. NTTC, for its part, believes that it has long been undervalued by NASA. In our team's field visit, NTTC officials said they have a range of skills that NASA has not fully tapped, reporting that other federal agencies have made much more extensive use of NTTC's skills and have been generally pleased with its services. They said they often had to "look for work" from NASA; they also said that NASA was their least engaged client in the development of NTTC's Annual Operating Plan.

In August 2004, NTTC underwent significant changes. It reduced its staff by 24 positions. In partnership with Wheeling Jesuit University and the West Virginia High Technology Consortium Foundation (WVHTC), it also announced the formation of a collaborative plan to increase commercialization, technology transfer, and entrepreneurship in northern West Virginia. Under the plan, the NTTC is transitioning several of the technology transfer programs it has operated for federal agencies to the WVHTC Foundation. The full implication of these changes for NASA is not yet known. NASA is currently evaluating its relationship with NTTC. In the meantime, it has extended its cooperative agreement with NTTC through January 2005. Other options include conducting a major competition for the entire external network or moving NASA's technology transfer activities to the WVHTC.⁴¹

The Regional Technology Transfer Centers

In our team's field visits, they observed that the six RTTCs were not acting as a coordinated national network, but instead were focused on their particular regions. One reason for this is that each RTTC's contract provides guidance that 85% of its activities are to be spent on companies and technologies within their region. This regional approach, however, can lead to unacceptable results in a global technology market: an RTTC may be unaware of a potential spin-in technology outside its region that its local center could use, and it may be unaware of a potential spin-out company that could use a technology its center has developed. RTTCs sometimes view NTTC and RTI as competitors.⁴² NASA headquarters officials have been working to improve the overall coordination of the network by instituting monthly conference calls with the NASA centers and the RTTCs. They have also sponsored several national network meetings. RTTC officials indicated that these activities have made them feel more connected to one another and to NASA.

⁴¹ A central concern with moving NASA's technology transfer activities to WVHTC is that this organization appears to be focused on a specific geographic area instead of the nation as a whole.

⁴² The Inspector General also found that the RTTCs and RTI "believe that NTTC was taking over their functions," thus increasing competition and reducing the network's overall effectiveness.

Because the RTTCs report to various centers, they are utilized in very different ways. In some cases, they appear to function as a general service support contractor to the center technology transfer office, though their role was always intended to be more substantial. Some RTTC officials expressed concerns that they were not being utilized effectively by their centers: they said, for example, that they had to spend a considerable amount of time asking for work and trying to prove their value. Many RTTC officials also said that they had received limited cooperation from the scientists and engineers within the centers.

From a performance management standpoint, the relationship between the RTTCs and their center offices does not establish a clear line of responsibility or accountability for performance. The center offices have not been establishing a set of performance objectives for the RTTCs at the beginning of the fiscal year, and the RTTCs have been receiving a set amount of money each year regardless of their performance. The appropriate division of responsibility between the center office and the RTTC for generating partnerships and licenses is also unclear. The RTTCs generally believe they are only responsible for finding a lead for NASA that is ready, willing, and able to partner with the agency or license its technology. Thus, the RTTCs believe they should not be held responsible for whether the lead actually results in a partnership or a license because they do not control these processes (a partnership agreement, for example, could get “lost in the bureaucracy” at NASA). The centers, by contrast, indicated that the leads themselves have sometimes been problematic, which is why NASA did not execute a partnership agreement or license with them.

ORGANIZATIONAL PLACEMENT IN HEADQUARTERS AND THE CENTERS

Technology transfer is an agency-wide responsibility, yet it is housed in one mission directorate: Exploration Systems. Directorate officials have defended this arrangement as being advantageous to IPP because the Mission to Moon and Mars has been identified by the President as NASA’s new mission. The Associate Administrator of Exploration Systems has been very supportive of the IPP, making its leadership an integral part of his team and involving them in the directorate’s technology planning activities. IPP officials had not been this involved in the past.

Being placed in Exploration Systems, however, remains problematic. First, it ensures that IPP officials will have only limited access to higher level decision-makers elsewhere in headquarters. Second, it indicates that technology transfer is not a priority for NASA as a whole, but rather something for which one part of the agency should be responsible. That further isolates technology transfer from the other agency missions. Third, it increases the likelihood—especially given the shift toward spin-in—that IPP will become “captured” by Exploration Systems. Many in the field centers expressed concerns that the goals in their center work package agreements are skewed toward this one mission directorate. And, finally, IPP is buried four levels down within the directorate. Instead of reporting directly to the Associate Administrator for Exploration Systems, IPP reports to the program director for Exploration Systems Research and Technology, which is in the Development Program’s Research and Technology Development Division.

Concerns were also expressed about IPP’s organizational placement within the centers. As Table 3-2 shows, IPP offices are usually isolated from the programs that they must have close working relationships with in order to perform spin-out and spin-in effectively.

Table 3-2. Center Technology Transfer Offices Reporting Relationships

NASA Center	Reports To	Major Programs
AMES	External Relations and Development Directorate	<ul style="list-style-type: none"> • Aerospace/Thermal Protection Systems • Astrobiology and Space Research • Aeroflight Dynamics • Informational Technology and Nanotechnology • Project Management and Engineering
DRYDEN	Public Affairs, Commercialization, and Outreach	<ul style="list-style-type: none"> • Research Engineering • Flight Operations
GLENN	External Programs Directorate	<ul style="list-style-type: none"> • Aeronautics Directorate • Aeropropulsion Research • Research and Technology • Space Directorate
GODDARD	Applied Engineering and Technology Directorate	<ul style="list-style-type: none"> • Applied Engineering and Technology • Space Sciences • Flight Programs & Projects
JET PROPULSION LAB	Earth Science and Technology Directorate	<ul style="list-style-type: none"> • Engineering and Science • Planetary Flight • Solar System Exploration • Astronomy and Physics • Earth Science and Technology
JOHNSON	Public Affairs	<ul style="list-style-type: none"> • Flight Crew Operations • Mission Operations • Engineering Directorate • Space Shuttle • International Space Station • Space and Life Sciences
KENNEDY	Spaceport Engineering and Technology Directorate	<ul style="list-style-type: none"> • Shuttle Processing • International Space Station • Launch Services • Spaceport Engineering and Technology
LANGLEY	Program Development and Management Office	<ul style="list-style-type: none"> • Earth and Space Science • Space Access and Exploration • Aerospace Vehicle Systems • Airspace Systems
MARSHALL	Customer and Employee Relations Directorate	<ul style="list-style-type: none"> • Space Transportation • Science Directorate • Flight Projects • Engineering Directorate
STENNIS	Program Integration Office	<ul style="list-style-type: none"> • Rocket Propulsion Testing • Earth Science Applications

Only three IPP offices (Goddard, JPL, and Kennedy) are under a major program directorate. Some technology transfer officials in the field centers said that they would be more effectively integrated with program operations if they reported to their chief scientist or engineer within their centers, or to the head of their center's major program directorate. Similarly, some said that technology transfer, as an agency-wide and center-wide mandate, should report to the center director. During our fieldwork, the only IPP office that reported to the director was at Johnson, but this changed during Johnson's reorganization in August 2004. Some headquarters officials focused on another aspect of the center reporting relationships: because the technology transfer officials report to such different places within each center, they said, made it more difficult for headquarters to provide overall program direction, which contributes to a lack of program coherence.

MULTIPLE WEBSITES AND INFORMATION SYSTEMS

NASA's technology transfer activities are accessed and described in one form or another on numerous websites—some are easy to use; others are not. Each NASA center has its own technology transfer website as do several offices at headquarters, the RTTCs, and the NTTC. To help carry out its day-to-day operations, as well as provide public access to NASA technology transfer opportunities, NASA also has developed several information systems under the umbrella name NASA Technology Transfer Systems (NTTS). There are also other information systems relevant to technology transfer. These include the center's internal systems for performance reporting, financial management, and human resources as well as such external systems as the database maintained by NTTC. Use of NTTS, which originated at Kennedy, is largely voluntary. Together there are significant opportunities to improve internal communications and data management as well as the websites available for public use.

Searching for NASA Technology Transfer

Company researchers interested in working with NASA technology might go to an Internet search engine to find where on the web they could find such opportunities. To see how easy it is to access the NASA sites, the study team performed a search using the search engine Google, inserting the term "NASA technology transfer." Google returned 11 pages of websites; the first five entries were:

1. JSC Technology Transfer & Commercialization Office
2. NASA solutions—NASA, Marshall Space Flight Center Technology
3. COSMIC—NASA's Partner for Software Technology
4. NASATECHNOLOGY.com—a site featuring "hot technologies" listed by subject area.
5. NASA Commercial Technology Network, featuring programs and initiatives of the NASA Commercial Technology Division, which no longer exists.

NASA's technology portal, its main technology transfer webpage, appears far down the list.

The team also tried the main NASA website (www.nasa.gov) and found no reference on the homepage to technology transfer or any related topic. Under "About NASA," there is a link to "NASA Technology," which takes the user to the annual publication *Spinoff*. The homepage of *Spinoff* lists the following NASA-related pages:

- NASA homepage
- STI program homepage
- Technology portal
- Commercial technology network
- Technology resources
- Commercial technology directory
- NCTN directory

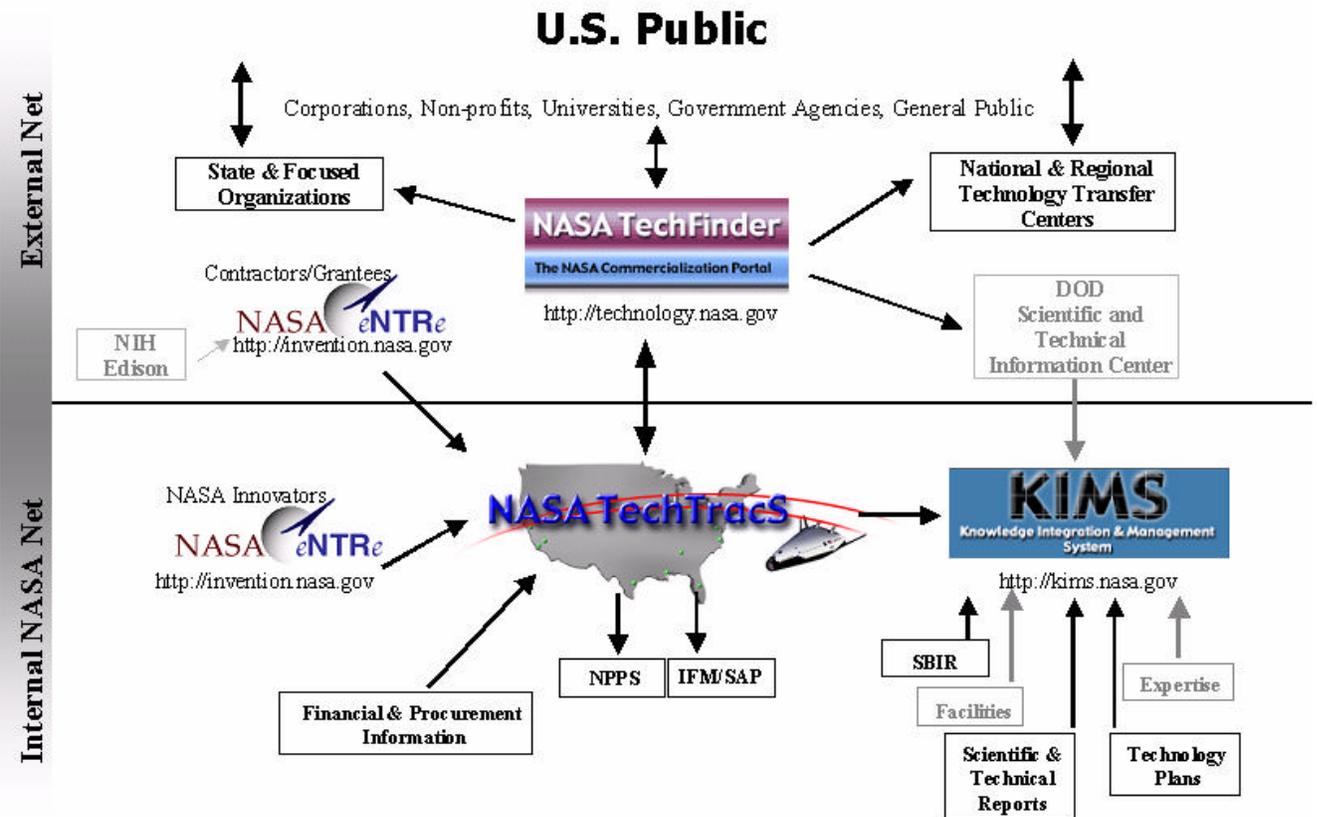
In short, determined researchers can find the right websites for technology transfer, but it will not be easy or user-friendly to do so. Officials in headquarters acknowledged that many of the websites are confusing and explained that these are being addressed. An IPP outreach team has been formed to develop a comprehensive plan to streamline the websites; NASA communications policy officials also will work to increase control over access and improve the user-friendliness of the all the websites. This is still a work in progress as this is written.

Another action that may improve the coordination of websites is the planned consolidation of the 36 file servers and related software, including one at each field center, into 10 servers. Most of these are located at Langley. The NTTC file server is to remain separate.

NASA Technology Transfer Systems

NASA Policy Directive 7500.2 established NASA TechTracS as the agency-wide technology transfer and commercialization information system. Figure 3-2 shows TechTracS to be part of NTTS.

Figure 3-2. NASA Technology Transfer System



NTTS supports the entire technology transfer process and is regarded as NASA’s one system that catalogs all of its technological assets. NTTS is intended to be a closely integrated set of information systems; but, as discussed below, falls far short of that goal. The four major components comprising NTTS are the following:

- eNTRe—the Electronic New Technology Reporting system provides a tool for electronically capturing and submitting NTRs.
- TechTracs—this center-based component of NTTS provides the day-to-day backbone of the NTTS while providing each center a major productivity tool for accomplishing its technology transfer activities.
- KIMS—the Knowledge Integration and Management System provides NASA enterprise, center, and program managers with up-to-date information on the technology transfer status of their activities.
- TechFinder—this is the public technology transfer gateway; providing access to NASA’s technology assets.

Figure 3-2 shows that the NTTS is not a stand-alone, isolated system. Applicable data from other existing NASA repositories is also integrated with NTTS databases. Such an approach leverages other key NASA information assets while facilitating a single interface point for the external commercial technology community, and providing a key asset for NASA internal scientists, researchers, engineers, and technologists.

NTTS provides a basic set of tools designed to automate the fundamental processes of technology transfer. For example, eNTRe provides a means for NASA innovators to fill out the New Technology Disclosure Report (Form 1679) electronically. That record can then be used for the various reviews and processing required by the NASA patent application process. Some innovators in the field centers told the study team that the form was awkward to fill out electronically in the Microsoft Word format provided. Only 10 percent of these forms are prepared this way; the rest are paper-processed. Knowledge Sharing Systems, the contractor responsible for eNTRe is introducing a user-friendly format, but there is no requirement for innovators or technology transfer staff to use it.

Technology transfer staff often told the study team that they found these systems to be user-unfriendly. Since there was no requirement to use the systems, many center offices did not do so. Kennedy Space Center and Marshall Space Flight Center use these systems extensively. Marshall staff said that proper training is all that is needed to make technology transfer officials, innovators, and others comfortable with using the systems.

Access issues also prevented some parts of the external network from making full use of these systems. For example, the RTTC staff members are given only read-only access to TechTracS, and they are not allowed to perform data entry.

TechFinder is the primary component for industry, small business, and academia to discover what NASA technologies are potentially available to them for licensing or other use. The study team was told, however, that TechFinder has a limited search capability, and that this prevents it from being as useful as it could be. Use of this system also requires support from NTTC, whose job it is respond to e-mail inquiries from the public.

NTTC's Information Systems

According to the NTTC's website, it is a "full-service technology-management center, providing access to federal technology information, knowledge management and digital learning services, technology assessment, technology marketing, assistance in finding strategic partners, and electronic-business development services." Technology mining is one of the services offered. NTTC lists numerous NASA technologies, based primarily on input from the NASA centers with which NTTC has a relationship, and it provides a toll-free number for anyone interested in getting detailed information on a specific technology listed. The inquiring party must call this number to obtain further information and have a case number established.

NTTC has access to all NASA tech transfer databases, including TechTracS and TechFinder, and it offers two forms of technology research:

1. Free—NTTC provides specific information on a given technology on a one-time basis.
2. Paid—For a fee of \$100 a month or \$1,000 a year, NTTC provides continuing access to about 700 databases of technology in government agencies, universities, and elsewhere. The National Institute of Standards and Technology and SBIR databases are included.

NTTC also maintains a database of NASA “hot technologies” at www.nasatechnology.com. This website features technologies that NTTC and NASA are actively marketing.

The study team was told that NTTC has a qualifications process for the contacts it receives through its toll-free number, website, TechFinder, and other sources. The inquiring parties must fill out a questionnaire on the company’s resources, finances, and facilities that is then kept on file at NTTC. For inquiring parties deemed qualified, the NTTC staff prepare a narrative description based on the questionnaire, which is forwarded to the appropriate NASA field center technology transfer office for follow-up. It is their responsibility to make the connection between the NASA innovator and the inquiring party.

Electronic Handbook Initiative

At its third meeting in August 2004, an IPP official briefed the Panel on IPP’s plans to develop and use an “electronic handbook” (EHB), an Internet-based administrative tool, for compiling NASA technology needs and disseminating those needs via the Internet to interested parties in support of IPP’s spin-in mission. An EHB is being used in the SBIR and STTR programs for the paperless processing of grant applications, reviews, and awards. It could provide a medium for IPP’s external agents to “shop around” NASA’s technology needs in search of alternative solutions to meet those needs. This medium could be used to search for potential technology solutions already existing in NASA. The EHB also may be used as a medium to negotiate proposal language for spin-in partnership agreements.

The EHB for IPP is being developed by a computer scientist at Goddard at the request of the IPP director, using a charge code provided by IPP. There is no formal project plan or list of deliverables. The timeframe is uncertain, but the study team was advised that a prototype may be available by the end of this calendar year.

The Goddard computer scientist said there are now multiple and competing databases of NASA innovations, including TechTracS and the NASA Technology Inventory. All provide limited information on a list of NASA innovations—they are basically “catalogs of technology,” he said.

An EHB for technology transfer would be much broader in scope and create paperless processes for most or all of the work now done by the various offices in the network—center technology transfer offices, RTTCs, NTTC, and so on. When asked about the relationship between these databases and the EHB, the computer scientist said the databases could be folded into the EHB, but no decision has been made to do so. In fact, one senior contractor official responsible for TechTracS was unaware the EHB development for IPP was underway.

Lists of technology needs would be developed at the centers using the EHB because that is where sufficient specificity exists. The IPP enterprise account managers at headquarters will be working to identify technology needs. This will provide assurance that the needs identified at the centers will match headquarters priorities. The process will work something like that for the SBIR program where subtopics are specified at the field centers but checked at headquarters. When asked whether this will be the same method of collecting technology needs that Academy staff found when doing their fieldwork, an IPP official acknowledged it was. Basically, he said, the technology transfer offices need to build confidence among center program officials that they can be credible alternative sources of technology to meet program needs.

One of the big challenges in using this EHB would be to find a match between a NASA technology need and a competent, interested supplier of the technology. Two issues that must be resolved include:

- How to create a “match”—that is, connect the supplier with the NASA technologist and enter into an appropriate agreement.
- How to fund the match. SBIR contracts provide a funding source, but other matches would have to be funded by some other means, such as a contract, grant, or partnership agreement.

Technology transfer offices at the NASA centers are being asked to rewrite their procedures into the format of the EHB. Each user is a participant in the design of the EHB, and each will have a customized component of the EHB in which to work. Essentially, the Goddard designer will integrate the various methodologies now used and come up with a consensus on how the EHB should be organized. The unique aspect of his approach is the combination of the software and the consensus-building process of creating this web-based tool. One of the issues raised during this process was that NASA has had problems entering data into existing databases. The designer said this would not be a problem with the EHB because it would be an integral part of how everyone on the network does his or her job.

In sum, NASA has numerous, sometimes uncoordinated electronic tools to help carry out the IPP mission. Without a mandate to use these systems, proper training, the necessary access, and business processes designed to take full advantage of these electronic capabilities, NASA will fall far short of realizing their potential. Task agreements being negotiated with the centers’ technology transfer offices at the time of this study require the use of NTTS for intellectual property management and for providing a list of available technologies for outreach purposes. This is an important first step, but not the only one needed. In such a far-flung network, both organizationally and geographically, information is a vital asset to be exploited. It is crucial to consistency, communications, coordination, and efficiency.

LITTLE CONNECTION WITH SBIR/STTR

As a practical matter, the study team did not find much of a connection in the operations of the IPP and the SBIR/STTR programs, even though they both fall under the same executive in

headquarters. Congress established the SBIR program in 1982 and the STTR program in 1992. The purpose of these programs is to increase opportunities for small firms and universities to participate in government R&D, to improve national economic competitiveness, and to increase employment. NASA has both an SBIR and an STTR program.⁴³ Congress mandates that a fixed percentage of 2.5% of each qualifying agency’s extramural R&D budget be dedicated to SBIR and that 0.3% be used for STTR.

Small businesses with 500 or fewer employees, or nonprofit research institutions, are eligible to participate in these programs. The primary benefit of an SBIR/STTR project is the ability of a small business or nonprofit research institution to obtain federal seed money to develop their technical ideas with no loss of control, equity, or intellectual property rights. The federal government retains royalty-free rights to use products and data developed under SBIR/STTR contracts; but the outside entity continues to own any resulting data and may establish copyrights, elect to retain title to inventions, and obtain patent protection.

SBIR and STTR are conducted in three phases. Phase I establishes the feasibility and technical merit of a proposed innovation. At the end of the first phase, NASA evaluates the innovation based on scientific and technical merit, expected value to the agency, and commercial potential. The most promising innovations advance to Phase II for a major R&D effort. Phase III is the infusion of the Phase II results into regular NASA programs or marketing to other government agencies or the private sector. Phase III projects must be funded from a source other than SBIR or STTR.

Table 3-3. Key Elements of SBIR and STTR Programs

	SBIR	STTR
Maximum Contract Amount	Phase I: \$70,000 Phase II: \$600,000	Phase I: \$100,000 Phase II: \$600,000
Phase I Duration	6 months maximum	12 months maximum
Cooperative Agreement	Not applicable	Cooperative agreement required between research institution and small business
Work Plan	Work plan must detail what will done, where, and how	Small business must perform at least 40% of the work; research institution must perform at least 30%
Historical Proposal-to-Selection Ratio in NASA	Phase I: 7 to 1 Phase II: About 40% of the successfully completed Phase I projects	Phase I: 4 to 1 Phase II: About 40% of the successfully completed Phase I projects

⁴³ Federal agencies with R&D budgets exceeding \$100 million must establish an SBIR program; those with R&D budgets exceeding \$1 billion must also establish an STTR program.

NASA implements this program by having the mission directorates and centers determine the topic and subtopic areas that form the basis for the solicitation to small businesses and nonprofit research organizations. SBIR/STTR officials in headquarters not only determine the priorities among and within the topic areas, but also establish the basic criteria for evaluating the proposals. Based on these criteria, Goddard serves as the project manager for evaluating proposals, ranking them, and making award recommendations.⁴⁴ These recommendations are forwarded to headquarters, which makes the ultimate selection determinations. This process is disconnected from the executive responsible for IPP, even though SBIR/STTR technically reports to him. Some Exploration Systems officials would like to redesign SBIR/STTR to make it more centralized (the evaluation would be done at headquarters), but a lot of resistance to this has emerged, partially because of concerns that headquarters officials may not have the expertise necessary to perform the technical evaluation of proposals.

NASA has funded the National Alliance for Small Business Opportunities, which provides commercialization assistance such as coaching, mentoring, and capital access to the agency's SBIR/STTR companies as they complete Phase II. California Polytechnic State University piloted the program by screening 44 Phase II graduating companies, accepting 9 into the program, and providing funding to 2. The Southeast RTTC is working to develop a similar program in its region. At this point, it has accepted six companies and created a process for working together.

The study team's interviews and fieldwork indicate that, as complimentary programs, IPP and SBIR/STTR can achieve objectives jointly that neither can do separately; but they must be properly designed, managed, and coordinated for this promise to be realized. Both bring important resources to the table; in fact, the SBIR/STTR has a significantly larger budget than IPP. In FY 2004, for example, the total budget for IPP was \$78.6 million, a significant sum of which (\$44 million) was a congressional earmark for special projects. The budget for SBIR in FY 2004 was \$112.7 million, of which \$19.5 million was for Phase I and \$93.1 million for Phase II; the budget for STTR was \$13.5 million, of which \$9.2 million was for Phase I and \$4.3 million for Phase II.

The study team was told that, ideally, IPP officials should work with SBIR/STTR officials at the front end as they prioritize among the topic and subtopic areas, thus ensuring that small businesses and nonprofit research institutions focus their energy on developing high-priority technologies. As SBIR/STTR projects near completion, IPP officials would ensure that their results were infused as much as possible into NASA's future projects and, like the California and Southeast pilot studies, assist with commercialization opportunities. IPP officials could also evaluate the technologies generated by SBIR/STTR projects from other federal agencies to determine whether any of these would be beneficial for NASA and, if so, work to infuse those technologies. SBIR/STTR officials, for their part, could use IPP's connections outside the agency to find partners to fund Phase III projects. SBIR/STTR officials could also work jointly with IPP on any assistance to small businesses to commercialize the technologies they develop in Phase II and III, which would ultimately contribute to the goals of both programs.

⁴⁴ All centers participate in evaluating SBIR/STTR proposals, but Goddard is the lead.

DISCONNECTED FROM THE ENTERPRISE ENGINE

The FY 2004 budget established the Enterprise Engine as a new pilot program for NASA to partner with venture capital firms and American industry. Funded at \$5 million and reporting directly to the Administrator, the Enterprise Engine is a vehicle to sponsor innovative, dual-use technologies to help NASA achieve its mission and enable its partners to position these dual-use technologies for future commercial use. It is designed to identify innovations to meet NASA's mission requirements, to stimulate innovation from a new community of technologists beyond NASA's existing partner community, and to bridge cross-directorate innovation requirements.

The underlying principles of the Enterprise Engine, and the rationale for it, were first presented in 2002 by Dr. Scott Pace, then Deputy Chief of Staff at JPL.⁴⁵ The Enterprise Engine has been endorsed by the Aldridge Commission, which recommended that Congress and NASA increase the potential for commercial opportunities by providing incentives for entrepreneurial investment. The idea is that these investments would emphasize NASA mission-driven technology pull rather than external market-driven technology push. The Enterprise Engine's plan at the beginning of FY 2004 was to sponsor five partnerships, but none have been completed so far. As a new approach to technology transfer, the Enterprise Engine was deliberately designed to function separately from IPP, but many IPP officials believe that more of a connection between the two programs is needed, even if they remain in different organizations.

NEED TO STREAMLINE AND IMPROVE THE INTELLECTUAL PROPERTY PROCESS

In visits to the field centers, our study team was told repeatedly that the intellectual property (IP) process needs to be streamlined and improved. Concerns were expressed in two major areas: (1) the length and complexity of the process and (2) the division of responsibility between technology transfer officials and attorneys.

Frustration with Lengthy Approval Processes

Many technology transfer officials, researchers, and private companies expressed frustration with the length of time it takes to file patent applications, process Space Act Agreements, negotiate licenses, and form partnerships between NASA and outside entities. This was identified as a significant barrier to technology transfer efforts, and largely an unnecessary one: the paperwork could be processed much quicker, the team was told, if the approval process were streamlined and automated. Timeliness in the filing of NTRs and relevant patents as well as negotiating licenses with interested companies is critical to achieving success in technology transfer.⁴⁶ Interviewees said that the time it takes for NASA to process Space Act Agreements, file patent

⁴⁵ "Innovation Catalyst Initiative Presentation" to the NASA Advisory Council (Washington, DC: September 2002).

⁴⁶ Under the Bayh-Dole Act, small entities such as small businesses, universities, and nonprofits may retain title to inventions developed under federal funding agreements. They have up to two years from disclosure to elect title. Large entities may also request a waiver of title within eight months of disclosure. In some cases, these legislatively mandated rights can cause delays in filing patent applications.

applications, and license technologies is a significant barrier to the commercialization of NASA-developed technologies.⁴⁷

In Appendix F, Figure F-1 maps Kennedy Space Center's commercialization process for a NASA technology from the time it is initially reported to the time, if applicable, it is patented by the agency and licensed to a company. Although each center's process varies in some ways, Kennedy's was identified as being representative. The process can involve as many as 18 major steps, with five key players: the innovator, the IPP office, a commercialization support contractor, the patent counsel, and a commercialization team.

Of course, not all technologies proceed through these steps. The field centers are ultimately responsible for determining whether to patent a technology. If they decide not to pursue a patent or other means of intellectual property protection, the NTR is released to the public through the NTTS. If the field center decides to seek intellectual property protection, the NTR is forwarded to a patent specialist and the patent procedure is begun. A case file is established and all records pertaining to the technology and its patent process are maintained by the NTTS. These records are not accessible to persons outside NASA.

In visits to some centers, concerns were expressed that the criteria for a patent are subjective and differs somewhat across the centers.⁴⁸ Glenn awards some patents as a way to recognize and reward inventors,⁴⁹ while the other centers patent technology if there is a commercial potential. Some scientists and engineers expressed concerns that, in some cases, patents are pursued for researchers who already have a strong relationship with the technology transfer officials and the attorneys, or those who are the most persistent about wanting a patent for their invention, regardless of technical merit or commercial potential.

Once the patent application has been filed, NASA can license it to a company. In Appendix F, Figure F-2 maps the lengthy process by which licensing agreements are negotiated and signed. The process can involve as many as 23 steps, with five key players: the General Counsel, the Patent Counsel, the Commercialization Manager, the license applicant or applicants, and other NASA headquarters officials.

The processing time can be especially problematic for technologies in which the technology life cycle is relatively short—under one year, for example. In such cases, it is often easier for a private company to develop the technology itself, from beginning to end, than to wait for NASA's licensing process. In other cases, promising technologies can literally “die on the vine” because private companies are unwilling to wade through what they see as an overly burdensome, highly bureaucratic approval process.

⁴⁷ Obviously, the amount of time it takes to file particular patents as well as to negotiate and execute particular licenses will vary to a certain extent depending on such factors as the complexity of the technology involved, the cooperation of the inventors, and the proposed licensee's desire to negotiate terms. The concern here is with the overall timeliness of these processes.

⁴⁸ Some criteria have had to be established because NASA cannot afford to patent every new technology. In addition to the filing fees, maintenance fees must be paid at three-and-a-half years, seven-and-a-half years, and eleven-and-a-half years for a patent to remain enforceable. The patent expires 20 years after it was first filed (or 14 years from issue for designs).

⁴⁹ These filings are funded by the inventor's technical organization.

The various partnership agreements also take a considerable amount of time. It takes an average of 14 months, for example, to complete a reimbursable Space Act Agreement. Although each center's internal approval processes do vary in some ways, the process at Ames for approving a reimbursable Space Act Agreement appears to be fairly representative. It must be approved by 9 officials: the innovator, 3 supervisory-level officials in the innovator's directorate, the technology manager in the center's IPP office, the center IPP director, the chief counsel, the patent counsel, and a financial management official. In some cases, the center's deputy director must sign the agreement.

In order to streamline the partnership agreement process and make it simpler, some centers have developed a standard template for Space Act Agreements. Some are beginning to use the Space Act Agreement Maker, a user-friendly software package that allows all organizations within the center to be able to develop these documents. At Marshall, the individual programs will be responsible for the facilitation, cost, review, and execution of Space Act Agreements; the IPP office will remain the Office of Record.

Division of Responsibility between IPP Officials and Attorneys

Many technology transfer officials also expressed serious concerns that an appropriate division of responsibility for the intellectual property process has not been established among themselves and the attorneys and General Counsel, both in their centers and at headquarters. In some cases, they said, the attorneys have not been simply conducting a legal review of deals, but have been evaluating them from a business standpoint. In these situations, the attorneys have focused on issues such as whether additional royalties could be received. The study team was told that this involves attorneys in areas beyond their expertise and has sometimes required that negotiations be reopened, frustrating the outside entities and reducing their willingness to partner with NASA. The perception in the private sector that NASA can be bureaucratic, slow-moving, and unresponsive was identified as a significant barrier to technology transfer, especially for small companies that cannot afford to move slowly.

The Office of the General Counsel⁵⁰ and IPP have responsibility for different aspects of the agency's intellectual property. The General Counsel has overall responsibility for administering the agency's IP law program, which includes (1) protecting IP rights in NASA technology assets and (2) assuring that the transfer of technology and IP conforms to applicable laws, regulations, and policies. IPP makes the agency's technology available to outside entities through licensing agreements that the attorneys must approve. It is also charged with identifying and infusing technology from American industry into the NASA Enterprises, through the development of dual-use joint venture agreements, including Space Act Agreements and cooperative agreements and certain partnership contracts and grants.

⁵⁰ NASA's intellectual property attorneys provide a wide range of legal services. For example, the General Counsel's survey of field offices in 2002 indicates that determining IP rights, filing and prosecuting patent applications, and negotiating and processing licenses occupies only about 50% of the IP attorneys' time.

At no center do the patent attorneys work for the IPP office.⁵¹ Instead, they report through the center's General Counsel managerial chain. Many technology transfer officials expressed frustration that, as a result, they found themselves "at the mercy of the attorneys" and had no way to hold them accountable for delays. One center specifically told the study team that the number of patents filed each year was limited by the number of attorneys available to process them.

The General Counsel and IPP recently signed a Memorandum of Agreement in which they agreed to review technology transfer functions (specifically, technology needs and strategic alliances as well as regulatory requirements) in order to develop a policy document that establishes a clear delineation of responsibilities for these areas. NASA officials are currently undertaking this review and anticipate that the resulting document could be used in a variety of ways. For example, it may serve as a baseline for transforming existing functions and/or responsibilities, or it may show that existing resources need to be realigned. Regardless of how these responsibilities are ultimately divided, it is clear that IPP officials and attorneys must work together in a spirit of cooperation and effectively coordinate their respective tasks in order for smooth and timely negotiations to occur.

TECHNOLOGY TRANSFER PROGRAM PERFORMANCE

As the study team traveled around the country, it learned about some important success stories—technologies that have been transferred to industries and universities, thus contributing to economic development and improving the quality of life for millions of people. Box 3-2 lists one story for each field center.

⁵¹ When the Panel and study team visited Johnson Space Center in April and June 2004, the patent attorneys worked for its Technology Transfer and Commercialization Office, as they had for many years. JSC recently underwent a significant reorganization, however, and now the patent attorneys report to the General Counsel.

Box 3-2. Selected NASA Technology Transfer Success Stories

Ames formed a partnership to develop **NX Knowledge Network**, which incorporated the center's NETMARK software with Xerox's global research centers. By using Xerox's technology and expertise, NASA is expected to save R&D tax dollars of approximately \$2.5 million. In return, NASA licensed the NETMARK software to Xerox in April 2004, and the company will launch a commercial version of it by the end of the year.

Dryden has partnered with AeroVironment, Inc., to develop a **high-flying solar wing** for airplanes. The company is working to develop commercial uses for these wings and expects that they will eventually be able to serve as a platform for disaster relief and crop monitoring.

Glenn developed the **fuel-efficient technology**, such as GE90 high-bypass turbofans, that is currently used in jet engines. Glenn also developed **quiet engine technology** that has made today's airplanes much quieter than those flying in the 1960s.

Goddard developed the **Charge Coupled Device**, which is the key component in a digital camera that has made it easier to detect breast cancer through noninvasive means. The camera scans the breast structure with X-rays, identifying suspicious tissues more clearly and efficiently than other means. With more than 500,000 women undergoing breast biopsies each year, this technology has improved public health and reduced annual health care costs.

Jet Propulsion Laboratory partnered with Los Angeles-based Universal Detection to mutually develop a **bio-terror smoke detector**. This technology combines the spore detection technology developed by JPL's scientists with Universal's aerosol capture device, and it will provide continuous on-site detection and real-time reporting of anthrax and other bacterial contamination.

Johnson's technology used in space shuttle fuel and oxidizer pumps has formed the basis of the **MicroMed DeBakey heart pump**, which is undergoing human trials with patients awaiting heart transplants. The heart pump is intended to be a bridge to a heart transplant, and in some cases as a long-term device that helps patients move toward recovery and a more normal life.

Kennedy developed the **Control Monitor Unit**, an advanced computer software tool, for the International Space Station. This technology was licensed to Command and Control Technologies Corporation, a Florida-based company, that enhanced the software to produce an automated spaceport launch control system now used in several states. The system launches vehicle control systems, range control, ground support equipment control and monitoring, avionics integration and testing, avionics simulations, satellite checkout, and telemetry processing. NASA is also using this technology to create new Space Shuttle checkout and launching products and procedures.

Langley developed two new **lightweight, transparent, UV-resistant polyimides** for space applications that improve the optical transparency and long-term thermal stability for solar arrays, reflectors, and thermal control systems. Langley developed a dual-use partnership with SRS Technologies, Inc., and licensed this technology to the company. SRS has invested over \$400,000 in corporate capital for facilities, equipment, and personnel. SRS worked with Langley to develop this technology into large thin-film elements to use on space-based antennas, solar sails, power augmentation panels, and advanced solar propulsion. *R&D Magazine* awarded this technology one of its prestigious "R&D100 Awards."

Marshall entered into a partnership with Vision Research Corporation to adapt the **ocular screening technology** from its space telescopes into the company's screening system to detect eyesight problems in school children. Vision Corporation placed these systems in pediatric offices and health clinics throughout the United States.

Stennis partnered with World Precision Instruments, Inc., to produce **UltraPath**—a portable, yet robust, system to verify observations from space by examining colored dissolved organic matter, which is a major component of land runoff that affects ocean color in coastal waters. WPI has developed a commercial version that efficiently analyzes the optical absorption of water samples at sea.

In addition to qualitative success stories, NASA also reports quantitative data on its technology transfer performance. Table 3-4 presents data on each NASA center's performance over a four-year period, from FY 2000 to FY 2003, on several key indicators: invention disclosures, patent applications filed, patent applications received, and licenses executed. As this table shows, the performance of the centers on these indicators varies considerably and does not follow a predictable or readily explained pattern. JPL is by far the center with the largest number of invention disclosures. JPL, Marshall, Glenn, Langley, and Johnson stand out as the centers with the largest number of patents filed and granted. JPL, Langley, Kennedy, Ames, and Goddard stand out as the centers with the most licenses.

Table 3-4. Performance Metrics, NASA Technology Transfer for FY 2000-2003

Center	Invention Disclosures	Patent Applications Filed	Patents Granted	Licenses Executed
Ames	575	38	19	21
Dryden	144	7	10	0
Glenn	518	84	55	7
Goddard	440	37	32	20
HQ	30	0	1	4
JPL	1321	108	138	58
Johnson	596	69	59	12
Kennedy	444	38	18	24
Langley	669	76	73	33
Marshall	715	90	57	15
Stennis	71	3	4	4
NASA Total	5,523	550	466	198

Table 3-5 presents data on NASA's royalties and Space Act Awards by center over the same four-year period. As the table shows, Langley and Johnson are the centers with the most royalty revenue generated from licenses, while JPL is the center with the most revenue from Reimbursable Space Act Agreements.

Table 3-5. NASA Royalties and Space Act Awards, FY 2000-2003

Center	Royalties Received (\$000)	Space Act Awards (\$000)
Ames	\$327	\$346
Dryden	3	41
Glenn	36	602
Goddard	150	377
HQ	11	3
JPL	626	1552
Johnson	1383	467
Kennedy	310	749
Langley	1536	472
Marshall	371	368
Stennis	113	51
NASA Total	\$4,863	\$5,028

NASA’s Performance Compared to Other Federal Labs

Many believe that NASA has not had as much success with technology transfer as it should given (1) its overall R&D budget and (2) the technology transfer investment since the early 1990s. Table 3-6 shows that NASA ranks fourth in total R&D spending by federal laboratories. Only the Defense, Energy, and Health and Human Services have a higher level of spending than NASA. Indeed, NASA’s R&D spending constituted 13.6% of the federal labs’ overall intramural obligations in FY 2002.

Table 3-6. FY 2002 Budget Resources for Federal Lab R&D Spending, Ranked by Budget Level⁵²

Department	FY 2002 Total Obligations (million \$)	FY 2002 Obligations Federal Labs* (million \$)
Defense	\$34,235	\$8,784
Energy	6,322	4,537
HHS	23,816	4,514
NASA	7,259 (9.8%)	3,020 (13.6%)
Agriculture	\$1,806	1,268
Total	\$73,438	\$22,123

⁵² All figures include spending for basic research, applied research, development, R&D facilities, and equipment. Budget authority and obligations measure spending in different ways. Budget authority is frequently cited in national statistics on federal R&D, but generally does not distinguish spending on federal lab activities from extramural performers (universities, for example). Both types of figures are cited here.

* “FY 2002 Obligations—Federal Labs” is the sum of spending for federal research by “intramural” performers and FFRDCs. This sum is taken as a measure of federal lab spending and used above to rank the departments.

As Table 3-7 shows, NASA’s share of total invention disclosures (19.4%) was somewhat higher than its overall share of federal lab R&D spending in FY 2000 (13.6%).

Table 3-7. Distribution of Invention Disclosures, Selected Years⁵³

	FY 1995		FY 2000		FY 2002	
	Number in FY	Share of Total	Number in FY	Share of Total	Number in FY	Share of Total
INVENTION DISCLOSURES						
Defense	1,168	34.5%	991	29.0%	1,122	28.2%
Energy	1,758	52.0%	1,371	40.1%	1,498	37.6%
HHS	307	9.2%	375	11.0%	431	10.8%
NASA	517	15.3%	574	16.8%	775	19.4%
Agriculture	133	3.9%	109	3.2%	151	3.7%
	=====	=====	=====	=====	=====	=====
Total	3,883	100.0%	3,420	100%	3,977	100%

As Table 3-8 shows, NASA’s share of total patent applications declined from FY 1995 to FY 2000 (from 9.4% to 5.4%), but increased to 8.1% by FY 2002.

Table 3-8. Patent Applications by Department, Selected Years⁵⁴

	FY 1995		FY 2000		FY 2002	
	Number In FY	Share of Total	Number in FY	Share Of Total	Number in FY	Share of Total
PATENT APPLICATIONS						
Defense	759	43.6%	774	38.5%	829	40.3%
Energy	571	32.8%	788	39.2%	711	34.5%
HHS	166	9.5%	263	13.1%	262	12.7%
NASA	164	9.4%	109	5.4%	166	8.1%
Agriculture	80	4.6%	78	3.9%	90	4.4%
	=====	=====	=====	=====	=====	=====
Total	1,740	100.0%	2,012	100.0%	2,058	100.0%

Table 3-9 shows that NASA’s share of patents received (8.7%) was lower than its overall share of federal lab R&D spending (13.6%).

⁵³ US Department of Commerce, Office of Technology Policy, *Recent Trends in Federal Lab Technology Transfer: FY 1999-2000 Biennial Report*, (Washington, DC: 2001).

⁵⁴ Ibid.

Table 3-9. Patents Received by Department, Selected Years⁵⁵

	FY 2000		FY 2002	
	Number in FY	Share of Total	Number in FY	Share of Total
PATENTS RECEIVED				
Defense	553	40.6%	617	42.1%
Energy	515	37.8%	551	37.6%
HHS	132	9.7%	116	7.9%
NASA	99	7.3%	128	8.7%
Agriculture	64	4.7%	53	3.6%
	=====	=====	=====	=====
Total	1,363	100.0%	1465	100%

As Table 3-10 shows, NASA's share of income from invention licenses rose between FY 2000 and FY 2002, from 1.1% to 2.5% respectively. These numbers are significantly lower than its overall share of federal lab R&D spending (13.6%). HHS totals skew this data because HHS has a large number of medical licenses that generate a significant amount of upfront fees and royalties. Even after taking HHS out of the analysis, however, NASA's share is the lowest of the five agencies; it is lower than Defense (7.9%) and Agriculture (3.0%).

Table 3-10. Distribution of Annual Income from Invention Licenses by Department, Selected Years⁵⁶

Department	FY 1995		FY 2000		FY 2002	
	Dollar Value	Share of Total	Dollar Value	Share of Total	Dollar Value	Share of Total
Defense	\$646,000	2.5%	\$2,213,000	3.3%	\$6,713,679	7.9%
Energy	\$3,455,000	13.4%	\$12,710,000	19.0%	\$21,253,279	25.2%
HHS	\$19,727,000	76.4%	\$48,592,000	72.7%	\$51,868,102	61.4%
NASA	\$349,000	1.35%	\$762,000	1.1%	\$2,075,038	2.5%
Agriculture	\$1,635,000	6.3%	\$2,555,000	3.8%	\$2,571,378	3.0%
		=====	=====	=====	=====	=====
Total	\$25,812,000	100.0%	\$66,832,000	100.0%	\$84,471,476	100.0%

As Table 3-11 shows, NASA's share of total active invention licenses has risen from 5.7% in FY 2000 to 8.4% in FY 2002. These numbers are lower than NASA's overall share of federal lab R&D spending (13.6%), but higher than Agriculture's.

⁵⁵ Ibid.

⁵⁶ Ibid.

Table 3-11. Distribution of Active Invention Licenses by Department, Selected Years (1)⁵⁷

Department	Number in FY 2000	Share of Total	Number in FY 2002	Share of Total
Defense	189	6.5%	350	10.2%
Energy	1,094	37.7%	1,327	38.5%
HHS	1,222	42.1%	1,213	35.2%
NASA	173	5.7%	290	8.4%
Agriculture	225	7.8%	267	7.8%
	=====	=====	=====	=====
Total	2,903	100.0%	3,447	100.0%

Establishing Performance Targets for FY 2005

The IPP network traditionally has not begun each fiscal year with a set of performance targets for the expected number of patents, licenses, technologies transferred, royalty income, and so on. Recognizing that a clear set of performance targets should be established at the beginning of each fiscal year, NASA headquarters officials have been negotiating Work Package Agreements with each NASA center. These agreements establish specific expectations for spin-in, spin-out, IP management, and outreach activities.

Table 3-12 shows the FY 2005 performance targets, which headquarters officials have acknowledged are ambitious, that were initially posed for each center. The actual targets for each center are currently being negotiated.

Table 3-12. Summary of FY 2005 Proposed Targets

Center	Spin-in	Estimated Value	Spin-out	Estimated Value	Events*
Ames	8	\$3,000,000	6	\$1,000,000	2
Dryden	2	\$600,000	1	\$300,000	-
Glenn	10	\$2,000,000	5	\$1,000,000	2
Goddard	10	\$2,000,000	5	\$1,000,000	2
Jet Propulsion	12	\$12,000,000	10	\$5,000,000	4
Johnson	4	\$1,200,000	3	\$600,000	2
Kennedy	3	\$1,200,000	3	\$1,200,000	1
Langley	7	\$4,900,000	3	\$1,200,000	3
Marshall	6	\$3,600,000	3	\$1,500,000	2
Stennis	3	\$1,500,000	3	\$1,500,000	1
<i>Total</i>	77	\$34,000,000	41	\$14,400,000	

* Non-additive, as centers may appear at the same events.

⁵⁷ Ibid.

Difficulty Establishing Outcome Measures

Neither the economic impacts of NASA commercialized technologies nor the benefits to the agency of the technologies are routinely or systematically assessed. Success stories and other vehicles tell of individual impacts, and there are specific studies that look at particular areas, such as the 1998 study of NASA Life Science’s technology transfer.⁵⁸ However, the program has not developed bottom line measures of success. NASA is certainly not the only agency struggling with the development of appropriate performance measures for technology transfer. While it is easy to count the number of patents and licenses, or the amount of royalties, it is much more difficult to determine (in a methodologically defensible way) the long-term economic and social impacts of NASA technologies. Trying to do so raises difficult questions of cause-and-effect—that is, what should be counted as an impact.

A recent Academy study of NIST concluded that “most government research programs either target economic impact as the final outcome or as the means to achieve a social objective.” The study also notes, “assessments may be an institutionalized process with a number of both retrospective and prospective studies undertaken each year, the results of which are then used systematically in program evaluation and resources allocation.”⁵⁹

A 2003 report by the President’s Council of Advisors on Science and Technology observed: “Metrics need to take into account a wide range of steps in a highly complex process, as well as the ultimate product or service, but should not constrain the continued evolution or development of new technology transfer approaches.”⁶⁰ The Council’s report also contained several recommendations pertaining to technology transfer metrics:

- Federal agencies, government laboratories, and the Department of Commerce need to formalize their oversight of and accountability for technology transfer.
- The Department of Commerce should document best practices for technology transfer, as well as refine a set of metrics to better quantify practices and their effectiveness.
- Individual agencies and government laboratories need to provide regular transaction process reviews to reduce the complexity of technology transfer transactions and time required to complete them.

Some organizations have taken steps to try to routinely measure economic impacts. The Great Lakes Industrial Training Center, NASA’s Midwest Regional Technology Transfer Center, reports on the economic impacts of technology transfer to the Great Lakes Region. It considers measures such as costs saved, sales increased, and new investment. While not directly analogous to NASA technology transfer, the NIST Manufacturing Extension Partnership program as well as

⁵⁸ Henry R. Hertzfeld, “Measuring the Economic Returns from Successful NASA Life Sciences Technology Transfers.” (Washington, DC: 2004).

⁵⁹ National Academy of Public Administration Panel. *The Manufacturing Extension Partnership Program: Report 2, Alternative Business Models*. (Washington, DC: May 2004).

⁶⁰ President’s Council of Advisors on Science and Technology, *Report on Technology Transfer of Federally Funded R&D: Findings and Proposed Action*. (Washington, DC: May 12, 2003).

the Small Business Administration' Small Business Development Center program contract with third parties to annually assess the economic impacts of the business services they provide, including effects on profitability, employment and sales. The Panel believes NASA should create a mechanism for making such evaluations of the technology transfer program.

Measuring Outputs in the IPP

All federal agencies with research labs are required to report performance annually to the Department of Commerce⁶¹ on a number of technology transfer measures. DOC, in turn, produces an annual summary of federal lab technology transfer performance in these areas. Included in this report are measures of the principal mechanisms for transferring technology (see Appendix H).

While measuring outcomes is necessary to ensure that the IPP is meeting its public policy goals, measuring *outputs* is also necessary to determine whether the organization is operating efficiently and effectively. The DOC report outlines many of the most important output measures of technology transfer. However, a more dynamic use of output measures that helps to link them to both the NASA mission and to each other could be considered through the use of a balanced scorecard approach to such measures.

One of the most important considerations for any system of measures is the chain of accountability for the results attained. Despite the fact that technology transfer is a NASA-wide responsibility, the only officials with any accountability for technology transfer outputs are in the IPP chain of command. Even within this limited focus, the Panel found little evidence of rigorous performance standards being set for organizations or individuals, except in the recent Work Package Agreements discussed above. Since outcomes are neither routinely nor systematically evaluated, there is no real accountability for the results of NASA's efforts. In order for NASA's technology transfer program to be successful, the agency will need to establish output and outcome measures and ensure that the organizations and individuals with a stake in the processes be held responsible for results.

CONCLUDING OBSERVATIONS

The IPP network is under enormous stress at this point, and it faces significant constraints:

- **Technology transfer is a low priority for NASA.** The Panel realizes that technology transfer is usually peripheral to the missions of federal agencies to some extent, especially in agencies with an operational mission. While the Panel would never suggest that technology transfer be NASA's top priority, the agency has a statutory mandate to

⁶¹ *The Annual Report on Technology Transfer: Programs, Plans, Activities, and Achievements* responds to a statutory requirement for an annual "agency report on utilization" [15 USC 3710 (f)] under the federal-wide reporting process established by the Technology Transfer Commercialization Act of 2000. All federal agencies that direct one or more federal laboratories or conduct other activities under Section 207 and 209 of Title 35, United States Code, are subject to the requirements of this statute.

fulfill a spin-out function; and the Panel believes it needs to tap into technology developed by private industries and universities through acquisition and spin-in partnerships. As it is, the IPP officials themselves now characterize their mission as “bringing value back to NASA,” which indicates that even they do not see the traditional spin-out mission as a high priority.

- **Key stakeholders have different views on the appropriate organizational structure and mission for NASA’s technology transfer program.** OMB wants the program to focus primarily on spin-in; Congress wants it to focus primarily on spin-out. NASA headquarters wants to streamline and reorganize the external network; Congress supports the existing structure. Even key stakeholders within NASA are far from united on the appropriate mission for technology transfer: headquarters, for example, wants the field centers to reorient themselves toward the development of spin-in partnerships, while centers favor traditional spin-out activities such as licensing. Further complicating matters is the fact that senior leaders within NASA have provided very little guidance and support for IPP’s technology transfer activities.
- **The significant programmatic uncertainty, combined with the budgeting and staffing cutbacks, is adversely affecting the program.** The President’s FY 2004 budget included no funding for the external network, but Congress restored it. The President’s FY 2005 budget also includes no funding for the external network, but both the House and the Senate Appropriations Committees earmarked funds for parts of the network. It is difficult for IPP officials to maintain a stable program when they do not know whether the external network will exist from year-to-year. Meanwhile, significant staffing and budget cuts are occurring in NASA’s headquarters and center technology offices. The center technology transfer offices, for example, are downsizing significantly—in some cases between 50% and 75%. In FY 2005, Marshall will go from 23 full time equivalents funded by IPP to between 3 and 6; JSC’s will drop from 9 to 3. Goddard’s full time equivalents have already dropped from 24 to 12 in FY 2004, and additional personnel cuts are anticipated. Not surprisingly, many of the best support contractor employees are beginning to leave for jobs elsewhere. Other centers face similar situations. The center offices are trying to get additional funding for personnel through their centers’ general and administrative accounts; but it is not clear how many positions will be funded this way. This only increases the program uncertainty.
- **The IPP network is fragmented and diffuse, and the skill mix of the present program does not lend itself to spin-in.** The geographically distributed network—a largely unaccountable NTTC combined with six different contractors running six RTTCs and managing multiple state affiliates—is an ineffective way to organize NASA’s technology transfer function. The overall skill mix within the network is also a significant concern. Although some technology transfer offices in the centers have some staff with significant technical expertise, as do some of the RTTCs, the Panel’s general conclusion is that the IPP network must significantly enhance its level of technical competence in order to meet its spin-in objectives. The Panel is very concerned that the IPP is being set up to fail if too many ambitious spin-in objectives are established for it, or if IPP officials promise to deliver too much.

NASA's Proposed Transformation for IPP

NASA plans to take steps to transform its technology transfer programs. In July 2004, NASA's Operations Council approved a shift in technology transfer program focus and goals centered on:

- Boosting NASA technical strength via infusion of external technology solutions (spin-in)
- Boosting America's economic strength via new technology, new products, and increased exports (spin-out)

The new emphasis is on spin-in, facilitated by a centralization of program responsibility, diminution of field center technology transfer office autonomy, and strong emphasis on program goals and accountability. The Panel applauds the IPP program director's initiative as a step in the right direction; but we believe that technology transfer would remain a somewhat isolated activity within NASA, without the support needed from the federal centers and other mission directorates, even if this new direction is fully implemented. Moreover, the IPP office—no matter how specific negotiated work agreements and performance measures may be—does not have line responsibility for the field center technology transfer offices. The directors of these offices report to the center directors, usually through some subordinate office at the center, and they receive some of their funding from the centers. This is unlikely to change.

The next chapter provides the specific steps the Panel believes are necessary to enhance the technology transfer function's chances of achieving its full potential.

CHAPTER 4

HOW THE TECHNOLOGY TRANSFER PROGRAMS CAN BE REFORMULATED TO BE EFFECTIVE AGENTS FOR NASA

The Academy was asked to review NASA's technology transfer *function*, and the Panel provides recommendations in this final chapter in this broad context. However, much of the discussion in this chapter, plus most of the recommendations, focus on the activities administered by the IPP headquarters office and its affiliated network. Previous chapters have documented that IPP is a complex organizational network operating in a volatile budget environment. It is responsible for making NASA-developed technologies available to American industries, and identifying and infusing technology from American industry into the NASA mission directorates. Achieving improvement in technology transfer across NASA requires strong support—from NASA's senior leadership, Congress, and OMB—as well as a deft touch from the program's leadership team. The IPP continues to deal with the perception that technology transfer lacks mission relevance

In the past few years, NASA's technology transfer programs have undergone substantial change, and more change is planned. As part of the new Exploration Systems Directorate, the IPP and SBIR/STTR programs' courses are being modified to fit the mold of the President's Moon/Mars initiative. On a smaller scale, the Administration and Congress continue to differ on funding and program emphasis. OMB and NASA's leadership want more emphasis on technology infusion and a restructured program network more attuned to the NASA mission and program needs. Thus, this study has "chased a moving target" in a contentious environment.

CONTEXT AND BACKGROUND

Before discussing the steps the Panel believes NASA should take to improve technology transfer, it is important to consider the overall NASA environment in which such changes would be taking place:

Missed Opportunities

Current technology transfer efforts at NASA are largely a story of missed opportunities. Some of the difficulties being experienced have to do with how this function is organized, managed, and supported by the agency; others result from a changing environment and expectations for technology transfer. While the agency has enjoyed tremendous success in the past, the IPP today is trapped in a reinforcing cycle in which technology transfer offices, the NTTC, the RTTCs, and other members of the network continue to operate at the margins of the agency's overall operations and are as likely to compete with each other as to cooperate in successful technology transfer. When these features are coupled with the widespread view that technology transfer is not central to the NASA mission and is primarily the responsibility of the IPP network, success becomes problematic. As a result, the agency is not as successful as it could be in obtaining technology to meet mission requirements or in generating commercial opportunities for NASA-

generated innovations. The ultimate outcome is a program that meets neither the agency's needs nor stakeholder and public expectations.

Congressional and Administrative Dissonance

Congress, NASA, and OMB have different views about how best to accomplish technology transfer. These differences then play out through the budget process, and have created a great deal of uncertainty throughout the network that has weakened the IPP. This ambiguity was a common element of the interviews and site visits conducted by the study team. The uncertainty has caused some skilled employees to leave the program and made the jobs of those who remain more difficult.

The Aldridge Report

The Aldridge Commission report⁶² recommended changes that could have important consequences for NASA technology transfer. While endorsing the President's vision, it also observed:

- NASA's relationship to the private sector, its organizational structure, business culture, and management processes—all largely inherited from the Apollo era—must be decisively transformed to implement the new, multi-decade space exploration vision.
- The successful development of identified enabling technologies will be critical to attainment of exploration objectives within reasonable schedules and affordable costs.
- Congress should increase the potential for commercial opportunities related to the national space exploration vision by providing incentives for entrepreneurial investment in space.
- International talents and technologies will be of significant value in successfully implementing the space exploration vision. Tapping into the global marketplace is consistent with NASA's core value of using private sector resources to meet its mission goals.

Of particular importance to this study is the Aldridge Commission's emphasis on improving how NASA secures technology and the changes needed to be undertaken to accomplish this.

One of the Commission's key recommendations is that NASA consider reconfiguring its field centers as FFRDCs in order to facilitate innovation, work more with the private sector, and stimulate economic development. Only JPL—an operating division of the California Institute of Technology—has been operating under such an arrangement. On July 30, 2004, NASA posted a notice announcing it “is interested in receiving comments and ideas from all sources regarding the possible reconfiguring of its centers, including whether to transform its centers to FFRDCs or

⁶² President's Commission on Implementation of United States Space Exploration Policy, *Moon, Mars, and Beyond: A Journey to Inspire, Innovate, and Discover*. (Washington, DC: June 2004).

other alternative management structures, that would enable its centers to become more flexible and nimble in implementing the agency's mission in the most effective manner possible."⁶³ JPL is considered a highly successful center in technology transfer. In interviews with JPL staff and discussions with other IPP staff, much of this success was attributed to the additional flexibilities provided by being an FFRDC, such as JPL's ability to take an equity position in start-up technology companies and its ability to compete with the private sector for talented personnel because of various staffing flexibilities.⁶⁴

Clearly, the technology transfer function will be directly affected by the decisions made regarding the Aldridge Commission's recommendations. Any steps taken by the agency to change the organizational structure or business processes of IPP need to carefully consider the Commission's recommendations.

The Context within Which NASA Technology Transfer Operates Has Changed

NASA is among the most successful organizations in history in terms of the impact of the technology it has transferred to the private sector and other government organizations. The original Moon mission in the 1960s, for example, led to widespread civilian and military technologies such as rechargeable batteries, fuel cells, cellular communications, small computers, cryo storage, telemedicine, and lightweight high-temperature materials. The original Moon mission also contributed to the guidance and tracking accuracy of modern-day global positioning systems.

The impact of these earlier transferred technologies on modern society is enormous. NASA technology has continued to generate important commercial opportunities (the DeBaakey Heart Pump, for instance, is based on the Space Shuttle main engine turbo pump), and the NASA insignia is still a strong "brand" that attracts the interest of commercial enterprises, but technology transfer efforts and outcomes are not nearly as robust as they once were.

For a number of reasons (see Chapter 3), NASA technology today is operating in a fundamentally changed environment. NASA, itself, does not do nearly as much in-house advanced research and technology development as it did in earlier years. Contrary to earlier experiences, the private and university sectors of the economy now conduct much more research and development than the federal government. Additionally, the private sector does not have as high a demand for technologies developed from space exploration activities and is the acknowledged leader in many of the technologies such as Information Technology and nanotechnology that NASA needs for its missions.

Simply put, both the supply and demand for NASA technology have changed. While technology transfer remains a potentially important mechanism for helping NASA accomplish its mission and for generating commercial opportunities in the U.S. economy, the approach taken needs to consider this changed environment for this potential to be realized. In addition, some thought needs to be given to reconciling the inherent conflict between a technology transfer function

⁶³ <<http://prod.nais.nasa.gov/cgi-bin/eps/bizops.cgi?gr=D&pin=04#111423>>

⁶⁴ The salary limitations imposed by Civil Service regulations, for example, do not apply to FFRDCs.

focused on meeting NASA mission needs, primarily through infusion, versus one centered on maximizing economic and social benefits to the nation, primarily through technology diffusion.

PANEL RECOMMENDATIONS

Mindful of the changes now underway, the Panel provides the following recommendations on the roles and responsibilities of the various entities involved. The Panel's goal is to support these changes where it can and offer suggestions that may further enhance their chances of success. However, these recommendations were arrived at independently, keeping in mind the study goal of providing all of the stakeholders a common understanding of how NASA's technology transfer function should be organized to maximize its benefit to the nation.

Leadership Commitment

Recommendation # 1: The NASA Administrator should support an agency-wide technology transfer effort by establishing that technology transfer is a core element of the agency's mission that requires the attention and support of NASA's leadership team, relevant program officials, and its major contractors.

To this end, NASA should take the following specific actions:

- Establish meaningful performance standards for accomplishing the agency's technology transfer mission for the associate administrators of each mission directorate, the center directors, and other senior managers within NASA
- Hold these executives accountable, in their annual performance appraisals, for meeting these standards
- Establish a robust set of incentives (financial, scientific, career development, and so on) for NASA scientists and engineers to perform technology transfer

As noted in Chapter 2, leadership commitment to technology transfer was the most common characteristic among the organizations with strong performances. Leadership support is essential because technology transfer, while typically not part of an organization's core mission, clearly should support the organizational elements that do perform the core mission. Otherwise, technology transfer organizations are marginalized and perceived as impediments to an organization's core mission. The lack of such support for NASA's technology transfer programs was readily apparent during the study team's interviews at headquarters and visits to the centers.

Leadership commitment to technology transfer communicates that it is important for the organization and can add value to its programs, as PCAST has recognized:

Leadership that recognizes and embraces the importance and accountability of technology transfer must come from the highest government levels, including the President and cabinet secretaries. We recommend that the President request that all

agencies specifically commit to technology transfer in their individual mission statements.⁶⁵

Despite the promise of technology transfer, this function has been Balkanized and shifted around from place to place within NASA. Presidents and NASA administrators allude to the economic benefits of innovations stimulated by the technical challenges of NASA's space missions, but their statements have not been translated into specific support for carrying out the actual tasks of technology transfer, especially the technology commercialization planning, contractor compliance on new technology reporting, and the creation of a fully qualified network to broker innovations in and out of NASA.

Leadership support for the IPP has improved following its transfer to the Exploration Systems Directorate, but these programs are still three levels down from the associate administrator, and the NASA administrator has been silent about this function in recent years. Center directors interviewed by the study team expressed mixed support for their technology transfer offices—none indicated it was one of their priorities.

NASA cannot succeed at technology transfer if the senior leadership within the agency does not have a strong sense of ultimate responsibility for this function. If technology transfer is viewed as solely the responsibility of an isolated group of technology transfer officials, it is destined to fail.

Organizational Location

Recommendation # 2: The headquarters technology transfer office and the programs under it should be relocated to the Office of the Administrator in order to give special emphasis to this agency-wide responsibility and to begin holding executives accountable for this function.

The headquarters technology transfer office should be responsible for providing overall policy direction and oversight, as well as establishing comprehensive and fully integrated technology transfer information management and communication mechanisms.

The Panel understands there are some advantages of having the technology transfer programs located in the Exploration Systems Directorate. This is the home for NASA's new mission and long-term vision—the return to the Moon and exploration of Mars and places beyond. The Associate Administrator is seen as influential in planning NASA's future and in transforming its culture and operations to meet this challenging new mission. The downside is the resulting perception that technology transfer is confined to this one mission directorate and that its resources have been absorbed by a single program component, Human and Robotic Technology.

Because technology transfer is an agency-wide function, the Panel believes it belongs in an office with agency-wide responsibility. Ideally, that would be the Administrator's office, which is where the Enterprise Engine was located at the time of this study. Given the Administrator's

⁶⁵ The President's Council of Advisors on Science and Technology, *Report on Technology Transfer of Federally Funded R&D*. (Washington, DC: May 15, 2003).

other priorities, the technology transfer program director need not report directly to the Administrator. The Deputy Administrator or Chief of Staff would be prime candidates to whom the program could report.

Roles and Responsibilities for Spin-In

Recommendation # 3: The associate administrators for each mission directorate, supported by the center directors and program heads in the centers, should be held responsible for making better use of technology outside NASA—both through acquisition and through partnerships—to meet the agency’s mission needs.

The mission directorates in headquarters should be primarily responsible for spin-in because (1) they have responsibility for fulfilling the missions and (2) they have the strategic view needed for a more systematic identification of technology needs.

To this end, NASA should take the following specific actions:

- The directorates should work with the other parts of NASA to identify agency-wide and mission directorate-wide technology needs.⁶⁶ Once these needs are identified, the IPP office, the center technology transfer offices, and network affiliates would identify potential partnership opportunities and work with the directorate and center program offices to craft mutually agreed-upon partnership agreements, where appropriate. NASA must also work to effectively integrate the spin-in strategies with the ongoing procurement of goods and services for these to lead to significant mission cost savings.
- NASA should make better use of SBIR and STTR as spin-in mechanisms. The agency should integrate the planning and operations of these programs with other IPP responsibilities and the directorate-identified technology needs in a much more systematic and comprehensive way. At a minimum, these programs should be co-located at the field centers, preferably under a single technology transfer executive.
- NASA should continue to pursue the Enterprise Engine as a separate initiative until its potential has been established, but program responsibility should be transferred to the headquarters office responsible for technology transfer within the next three years.

Although OMB’s desire for NASA to use more technology generated by the private sector makes sense, it is important to realize that spin-in partnerships will never be more than a small part of NASA’s overall use of private sector technology. An IPP directed to identify promising spin-in technologies beyond the normal procurement process does not have the NASA-wide management support, the resources, or the skills necessary to effectively perform spin-in on its own. Because project managers must have “proven technology” to meet their near-term mission needs, they prefer either to generate it in-house or to procure it. Spin-in partnerships are most appropriate for meeting longer-term mission needs.

⁶⁶ The Exploration Systems mission directorate already has a sophisticated needs identification process underway.

For NASA to be successful at spin-in, it needs a comprehensive, agency-wide understanding of its technology needs that only the mission directorates and centers can provide. The mission directorates and centers also need to know what technology is available outside NASA that may meet these identified needs or that can be successfully adapted. The IPP, in turn, can identify where partnership opportunities exist, as well as potential sources of supply.

There currently is no comprehensive process in place to systematically identify mission directorate and center technology needs. To the extent that such needs are identified, they generally are in broadly-defined categories. The study team has reviewed proposed IPP business process changes that detail how NASA plans to systematically identify center and enterprise technological needs, but they do not specify how the identified needs will be reduced to specific, actionable levels. Such specificity is essential in order for successful partnerships to be developed.

The effective coordination of the top-down identification of technology needs with the bottoms-up project management approach at the centers will likely remain a challenge, but the Panel believes this is the best way to organize this function. Given IPP's limited resources and skills for spin-in, it should focus on developing partnership opportunities identified by the mission directorates and finding niche technologies that represent "small wins" for NASA. Such partnerships should not be conceived as the agency's principal mechanism for bringing in technology from outside sources, but rather as a useful adjunct to the procurement process.

As discussed in Chapter 3, the study team found little connection between IPP and SBIR/STTR program management and operations, even though both are technology transfer components, and they are in the same headquarters organization. The IPP and SBIR/STTR programs are complimentary, and they can help each other achieve objectives that cannot be attained separately. Topic selection for SBIR and STTR should be informed by the technology needs being gathered by the directorates and centers. Also, as SBIR and STTR projects are concluded, IPP staff should see that the results are infused in NASA's programs to the extent possible. These projects also could be a source for additional partnership opportunities to meet identified needs.

The Panel found the Enterprise Engine initiative, which is focusing on establishing NASA relationships with young companies and teams to bring in new technology, to be an intriguing new approach to technology infusion. The Panel was impressed with the promise of this initiative, and it understands the need to keep it separate from other technology transfer functions at the start. That said, the Panel believes the Enterprise Engine should eventually be placed within the technology transfer program office because it is funded by IPP and is closely related to other technology transfer activities, especially those related to spin-in. The Enterprise Engine is now in the Administrator's office, so the merger would be facilitated if the IPP office also were located there, as recommended above.

Roles and Responsibilities for Spin-Out

Recommendation # 4: NASA should make the center directors responsible for the spin-out aspects of technology transfer, with the understanding that centers will support staffing and activities beyond those funded by headquarters.

In addition, NASA should take the following specific actions:

- Have the headquarters IPP office formulate policy and provide oversight of the center technology transfer offices carrying out the spin-out responsibilities
- Limit the aggressive marketing of new innovations, instead relying more heavily on an improved TechFinder website and related publications as the primary point of entry for interested entrepreneurs
- Have the center directors place additional emphasis on (1) encouraging program directors to formulate technology commercialization plans and (2) enforcing contract requirements for new technology reporting by the center's major contractors.

Commercializing technology involves legal requirements for patenting, structuring licensing agreements for internally generated innovations, and ensuring compliance with NTR regulations. The field center technology transfer offices have performed these roles for many years. Rather than further centralizing these responsibilities, the Panel believes that accountability should be clarified by making the center directors responsible under headquarters policy guidance and oversight. Under their center director's supervision, the technology transfer offices would take the lead on all spin-out activities not delegated to a contractor. The center directors would be provided funds from headquarters for joint and center-wide technology transfer initiatives, and the centers would provide the additional necessary funds for their spin-out tasks. Headquarters would establish a clear set of performance metrics that would be used to evaluate the center directors' performance on technology transfer.

The Panel believes that it makes sense to give the center directors formal responsibility for spin-out for several reasons. First, the inventors who submit their NTRs are at the centers, and the center technology transfer offices—not headquarters—already have primary responsibility for managing the agency's intellectual property portfolio. Second, the centers' program officials with whom the study team met generally believed that their technology transfer offices contributed much more to spin-out than to spin-in. Third, the centers have an incentive to transfer technologies to the private sector because licenses provide royalties to their inventors and extra revenue for their programs.

The External Network

Recommendation # 5: The national network should be reformulated and streamlined to provide a more effective vehicle for program implementation.

To this end, NASA should take the following specific actions:

- Use one national contractor to perform market research, be the primary link to private industry and universities,⁶⁷ and serve as a communication link between the centers to ensure that they are aware of each other's ongoing technology transfer activities. The contractor should also be responsible for overseeing the efforts of the state affiliates.
- Provide overall policy guidance and management oversight to the national contractor
- Establish an appropriate relationship between this national contractor and NTTC. To help assure accountability and performance, NTTC should operate under a performance-based contract with NASA.

The national contractor would need to have access to the needed expertise, respect for its technological knowledge, entrée into private companies and universities, and the ability to facilitate partnership deals. The contractor could also retain, as it deems appropriate, parts of the existing RTTC network to perform clearly defined tasks relevant to their expertise. In this model, the contractor would organize the national network—with a streamlined regional operation or operations organized by subject matter—taking full advantage of the NTTS and related information systems, as well as the NTTC.

The Panel understands that the NTTC has shifted some of its federal agency responsibilities to another organization and significantly reduced its staff. Therefore, it is unclear how NTTC will operate in the future, and the Panel is unable to suggest just how NTTC might be deployed in a reformulated NASA network. This may be a propitious time for an examination of NTTC's government-wide role by the Federal Laboratory Consortium or other appropriate body in the context of the recommendation from the 2003 PCAST report for the federal government to centralize information on technology transfer into a single, accessible location.⁶⁸

In reformulating the network, the Panel believes that NASA should rely much more heavily on information technology in its day-to-day operations and in disseminating information about its technologies (what IPP officials refer to as “passive outreach”), particularly if the emphasis on spin-in is to continue. NASA should make the existing Techfinder website more user-friendly and improve its search engine, using it as the agency's technology gateway to the public, along with printed publications like Spinoff and Tech Briefs. Private companies, university officials, and other interested parties could use the improved website to learn about technology commercialization and utilization opportunities. Write-ups of NASA-generated innovations

⁶⁷ Batelle and RTI, for example, now perform some of these functions within the NASA program.

⁶⁸ President's Council of Advisors on Science and Technology, *Report on Technology Transfer of Federally Funded R&D* (Washington, DC: May 2003).

should provide quick and easy access to a technology manager, contractor office, and/or innovator.

Concerns have been expressed that this is not an effective technology transfer strategy, but the Panel considers it appropriate given the resources available for technology transfer, and the fact that this is its major discretionary component. Even passive outreach can require substantial effort by NASA technology transfer officials. TechFinder allows interested users to email inquiries about specific technologies. Prompt responses—something the study team was told is sometimes lacking—would position technology transfer staff and network affiliates to become brokers between interested entrepreneurs and NASA or contractor staff responsible for the listed innovations.

At the same time, the Panel understands that technology transfer is a person-to-person contact activity, so some sort of external network that is properly designed and managed would be useful to NASA.

Websites and Information Systems

Recommendation # 6: NASA should improve its websites and provide one, easy-to-use portal for all technology transfer activities. The headquarters technology transfer office should also work with appropriate technical support to develop an integrated information system to automate its business operations, using an upgraded NTTS as the base, and make it the standard means for information reporting and information management throughout NASA for technology transfer.

To make the best use of information technology, NASA should:

- Understand whether and how its various information systems support the business processes that underlie technology transfer activities
- Undertake a business analysis to map technology transfer activities, user characteristics, reporting requirements, and reference services to the functions of the various information systems already in place
- Assess and standardize, where needed, user support functions and data definitions used by various systems and processes

These assessments must take place before any efforts are made to streamline, integrate, or create information systems to support the technology transfer functions of the future.

NASA should view its information systems as an asset for accomplishing technology transfer functions, but currently it does not make good use of its websites and databases either for external or internal stakeholders. Many concerns have been expressed about the existing systems

for data processing and communication. TechTracS is used to varying degrees by the centers. Many complain it is not user friendly, and the RTTCs only have “read-only” access for centers in their region, which inhibits network-wide cooperation. NASA also has duplicative reporting mechanisms (TechTracS, internal websites and other data calls from headquarters to the centers). In addition, NASA has multiple technology portals that likely are confusing to the public. These need significant improvement, especially given the declining resources and personnel available to maintain them. The net result is that the public must navigate through a confusing array of websites in order to learn about technology opportunities with NASA, and most agency technology transfer officials do not use the TechTracS database and other tools for performing their work. Existing websites at the centers and elsewhere in the network could be retained, but they need to be rationalized and accessed through a central portal.

Timeliness of the Intellectual Property Process

Recommendation # 7: The headquarters IPP office, in cooperation with the Office of General Counsel, should develop processing-time performance standards for patent applications, licenses, and partnership agreements.

To this end, NASA should take the following specific actions:

- Each office involved with the intellectual property process should be provided a processing-time expectation for their respective roles and be held accountable for fulfilling them.
- NASA should keep statistics on the timeliness of each element (i.e., processing step) of the intellectual property process and assess performance under the new Memorandum of Agreement signed by the General Counsel and the IPP Director in August 2004.

The filing of NTRs and relevant patents, where applicable, are the backbone of the technology transfer spin-out process. Timeliness in accomplishing these tasks and negotiating licenses with interested companies is critical to achieving success for both NASA and the companies involved. Chapter 3 detailed the frustrations of participants in these processes and the complexity involved. The IPP office and NASA’s Office of the General Counsel both have key responsibilities here. The significant amount of time it takes for NASA to process Space Act Agreements, file patents, and license technologies has been a major barrier to the commercialization of NASA-developed technologies. Obviously, the amount of time it takes to file particular patents as well as to negotiate and execute particular licenses will vary depending on the complexity of the technologies involved, the cooperation of the inventors, and the proposed licensee’s desire to negotiate terms. The concern here is with the overall timeliness of these processes. By gathering data on processing time, NASA officials will be able to identify areas that may require improvements. The Memorandum of Agreement recently entered into between IPP and the General Counsel may begin the process of clarifying roles and responsibilities and may help facilitate the workflow. Full automation of applicable documents through the NTTS also could speed the process. Separation of the patent attorneys from the technology transfer offices at

some of the centers may have the opposite effect unless a good working relationship is established between the technology transfer office director and the center counsel's office.

Performance Metrics

Recommendation # 8: NASA should develop a comprehensive system for evaluating its technology transfer efforts.

To this end, NASA should take the following specific actions:

- Use a balanced scorecard approach to develop output measures such as processing times for licensing agreements, number and quality of partnerships generated, number of leads generated, and success stories. These short-term, tactical measures would allow IPP managers to set annual goals, measure organizational efficiency, and ensure accountability. Whatever measures are chosen should be linked, through the strategic planning process, to NASA's broader strategic goals.
- Assess the long-term economic and social impacts of NASA technology transfer. The agency could pilot test an approach adopted by some other federal agencies (NIST and the Small Business Administration), in which third parties conduct annual surveys of their program participants to determine long-range impacts of services.
- Implement organizational and individual performance standards for all relevant officials—including directorate and center leaders—with a role in technology transfer.

NASA needs to develop a clear set of performance measures for technology transfer. These measures must be designed carefully, both from the perspective of the types of metrics employed as well as the people who will be held accountable for achieving them. The metrics should evaluate both short-term and long-term impacts of technology transfer and establish a chain of accountability.

Creating metrics that accurately measure technology transfer outcomes is a difficult undertaking. As stated in a report from the President's Council of Advisors on Science and Technology: "Metrics need to take into account a wide range of steps in a highly complex process, as well as the ultimate product or service, but should not constrain the continued evolution or development of new technology transfer approaches."⁶⁹

Being able to accurately measure the short-term outputs of technology transfer (licenses, royalties, and so on) as well as long-term outcomes (economic impacts) is critical to managing a successful program. An ancillary issue in this regard is the need for a chain of accountability—as reflected in organizational goals and individual performance standards—for the areas being measured. This combination of a good system of metrics coupled with accountability for attaining them are essential ingredients for a successful program.

⁶⁹ The President's Council of Advisors on Science and Technology. *Report on Technology Transfer of Federally Funded R&D: Findings and Proposed Actions*. (Washington, DC: May 2003).

A balanced scorecard would be a useful approach to technology transfer performance management. This approach helps to translate an organization's strategic objectives into a set of performance measures. Scorecards have been used to evoke strategic thinking at multiple levels of an organization, increase self assessment and management, demonstrate the contribution of support functions to the organization, and encourage and reward planning.⁷⁰

In addition to providing a means for linking IPP performance to NASA strategic goals, the scorecard is also a means for establishing accountability for the outputs themselves. This is important not only for staff members in the IPP network, but also for those elements in NASA that are responsible for the technologies that are transferred into or out of the agency, specifically, the NASA directorates and field centers. A discussion with a NASA human resources staff member indicated that it is "highly unlikely" that technology transfer is included as a performance measure for any Senior Executive Service member (outside of the IPP chain-of-command). As long as only IPP staff members are held accountable for technology transfer, performance will never be optimal. As the Panel's Phase I report said, "technology transfer should be everyone's job at NASA, not just IPP's." One way to ensure that it becomes "everyone's job" is to begin to include technology transfer objectives into the organizational and individual performance targets.

A recent study from NIST said that "most government research programs either target economic impact as the final outcome or as the means to achieve a social objective." Neither the economic impacts of NASA's commercialized technologies nor the benefits to the agency of technology infusion are routinely or systematically measured. Success stories and other vehicles tell of individual impacts and there are specific studies that look at particular areas, such as the 1998 study that examined NASA Life Science technology transfer.⁷¹ However, to make important policy decisions about technology transfer, it would be critical to have this bottom-line measure of success. The Panel believes that the push over the last several budget cycles to reduce or eliminate all aspects of IPP, except those explicitly required by law, is partly a result of the program's inability to demonstrate program impacts. Evaluating outcomes is no simple undertaking and there is little agreement as to the best methodologies for doing so. Ultimately, however, the ability to link technology transfer to economic welfare or NASA mission success is the only way of knowing if the IPP program is worth the money.

As discussed in Chapter 3, NASA's Operations Council has approved a transformation of the agency's technology transfer programs. Appendix A presents a side-by-side comparison of the Panel's recommendations and NASA's transformation plan, so that the reader has a clear understanding of the similarities and differences between the two approaches.

⁷⁰ Jake Barkdoll, "Balanced Scorecards in the Federal Government." *The Public Manager*, Fall 2000.

⁷¹ Henry R. Hertzfeld, "Measuring the Economic Returns from Successful NASA Life Sciences Technology Transfers." (Washington, DC: 2003).

COMPARISON OF CURRENT TECHNOLOGY TRANSFER
AT NASA VS. NAPA RECOMMENDATIONS

	<i>Current Program</i>	<i>Proposed Program</i>
ORGANIZATIONAL LOCATION	<ul style="list-style-type: none"> • Exploration Systems 	<ul style="list-style-type: none"> • Office of the Administrator
SPIN-IN RESPONSIBILITIES	<ul style="list-style-type: none"> • IPP is responsible. 	<ul style="list-style-type: none"> • Associate administrators for each mission directorate, center directors and program heads in the centers, are responsible for acquiring technology outside NASA—both through acquisition and through partnerships. • IPP would help identify potential partnership opportunities and develop partnership agreements.
SPIN-OUT RESPONSIBILITIES	<ul style="list-style-type: none"> • Headquarters IPP office shares responsibilities and funding with center technology transfer offices • Administrative work for spin-out handled by the center technology transfer office • Extensive marketing done through the IPP network 	<ul style="list-style-type: none"> • Center directors are responsible for the spin-out aspects of technology transfer. • The IPP office formulates policy and provides oversight of the center tech transfer offices carrying out the spin-out responsibilities. • Limited marketing of new innovations, relying more heavily on TechFinder website and related publications.
EXTERNAL NETWORK	<ul style="list-style-type: none"> • Center technology transfer offices and RTTCs report to Space Center officials • State affiliates report to the RTTCs • NTTC operates under a cooperative agreement with NASA • Private contractors provide computer support (NTTS) and market analysis support (RTI) 	<ul style="list-style-type: none"> • A single national contractor performs market research and serves as the primary link to private industry and universities. The contractor reports to IPP headquarters officials. • Contractor coordinates technology transfer efforts with state affiliates. • NTTC operates under a performance-based contract. • Technology transfer activities more automated with expanded access to data.

APPENDIX A

	<i>Current Program</i>	<i>Proposed Program</i>
WEBSITES	<ul style="list-style-type: none"> • Multiple and confusing websites pertaining to technology transfer • Different media used to report and track technology transfer activities 	<ul style="list-style-type: none"> • Consolidated and simplified website • NTTS used for reporting and information management
INTELLECTUAL PROPERTY	<ul style="list-style-type: none"> • Significant delays in processing Space Act Agreements, filing patents, licensing technologies, and completing partnership agreements. • Memorandum of Agreement between General Council and IPP to review technology transfer functions 	<ul style="list-style-type: none"> • Track specific elements of the processing cycles and set standards • Build standards into the Memorandum of Agreement
PERFORMANCE MEASURES	<ul style="list-style-type: none"> • Output measures only • Accountability limited to IPP officials. 	<ul style="list-style-type: none"> • Use a balanced scorecard system to measure outputs. • Measure economic impacts (jobs and wealth created from technology transfer) • Establish meaningful performance standards for accomplishing the agency's technology transfer mission for the associate administrators of each mission directorate, the center directors, and other senior managers within NASA

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APPENDIX C

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TECHNOLOGY TRANSFER REQUIREMENTS FOR NASA AND OTHER FEDERAL AGENCIES

The laws described here contribute to America's dominance in the world in R&D and the successful technology transfer of ideas and services. The seminal legislation that established the transfer requirement was the National Aeronautics and Space Act of 1958 (Space Act, 42 USC 2451 et Seq.). Section 102 of this law is the original mandate to transfer valuable technology to benefit U.S. industry. Section 305 authorizes the Administrator to patent inventions to which NASA has title. Section 203 requires the Administrator to provide the widest practicable and appropriate dissemination of information concerning NASA's activities and their results. NASA is required to protect the government's interests and the public's investment by monitoring and enforcing contractor compliance with requirements of the Space Act, Stevenson-Wydler, Bayh-Dole, and other legislation.

The Stevenson-Wydler Technology Innovation Act of 1980 (15 USC 3701 et seq.) governs the transfer of federally owned or originated technology to nonfederal parties. This Act establishes the full use of the results of the nation's federal investment in research and technology as the mission of each federal laboratory (15 USC 3710). It requires the agencies to strive, where appropriate, to transfer federally owned and originated technology to state and local governments and the private sector. It mandates that each federal agency operating or directing federal laboratories establish a formal technology transfer program and set aside a percentage of the laboratory budget specifically for transfer activities.

Additional agency requirements under the Stevenson-Wydler Act cover the establishment of an Office of Research and Technology Applications, with at least one or more full-time-equivalent employee to staff it. Each agency must make available sufficient funding, either as a separate line item or from the agency's R&D budget, to support the technology transfer functions. The Act further prescribes that agencies prepare application assessments for R&D projects that may have commercial applications and provide information on federally owned or originated products and services.

The Bayh-Dole Act of 1980 (PL96-517), as amended (35 U.S.C. 200 et seq.), governs patent and licensing issues. Agencies were directed to use the patent system to provide the transfer and public availability of inventions arising from federally supported R&D. The law further encourages maximum participation of industry in federally supported R&D efforts, ensuring that the government obtains sufficient rights in federally supported inventions. Under this Act, small businesses and universities and nonprofit organizations may elect to retain title to inventions developed under federal agreements. Bayh-Dole provides government-wide authority to license government-owned inventions. The requirements under the act apply to contracts, grants, and cooperative agreements with small businesses, universities, and nonprofit organizations. Agencies must monitor and enforce contractor compliance with provisions in the Act regarding the reporting, elections, and use of federally funded inventions. These rights include the government's ability to license and use these inventions when a contractor retains title. If the title is not retained, the government may obtain title, obtain patent protection and license these technologies. All rights must be documented and recorded in a government-wide database.

Federal Acquisition Regulations also has an important role in the maintenance of intellectual property. They not only require government agencies to monitor and enforce contractor reporting and use of technologies, but also require that the government ensure expeditious availability of these technologies to the public. To protect the government's interest and the public's investment, agencies are required to maintain appropriate follow-up procedures, ensure the inventions are identified and properly disclosed and, when appropriate, ensure that patent applications are filed establishing the government's rights therein.

NASA's Federal Acquisition Regulation (FAR) Supplement (NPD.1) governs the agency's contracts with large businesses, requiring prompt reporting of inventions, discoveries, and innovations. The regulations assist NASA by establishing procedures to provide the widest practicable and appropriate dissemination, early utilization, expeditious development, and continued availability of these technologies for the benefit of U.S. industry and the general public. All NASA contracts require that reports be directed to the NTR representative located in the technology partnership office. The supplement describes the procedures through which elections of title and requests for waivers are submitted to the Patent Counsel.

NPD 7500.2, a NASA policy directive, establishes the agency's technology commercialization policy and processes. According to the directive, technology commercialization is the development of NASA mission technology in commercial technology partnerships and the application of NASA technological assets in non-aerospace and aerospace markets, with the goal of improving the quality of life and the economy. It directs that all NASA activities whose planned or existing technology units will conduct research activities to effectively communicate the knowledge available at NASA and establish EDA goal of 10-20% of NASA's annual R&D budget be invested in these partnerships. This document specifies the roles and responsibilities of the technology transfer effort across the NASA organizational and management spectrum. NDP 7500.2 established Tech TracS as the agency wide commercialization information system.

Trademark Clarification Act of 1984⁷²

- Permits patent license decisions to be made at the laboratory level in GOCOs
- Permits contractors to receive patent royalties to support the R&D effort
- Permits private companies to obtain exclusive licenses

Federal Technology Transfer Act of 1986⁷³

- Requires all federal laboratory scientists and engineers to consider technology transfer an individual responsibility
- Authorizes GOCOs to enter into CRADAs

⁷² Public Law 97-219

⁷³ Public Law 99-502

- Authorizes GOCO laboratories to enter into licensing agreements for patented inventions made at the laboratories
- Authorizes GOCO laboratories to grant or waive rights to laboratory inventions and intellectual property
- Established the Federal Laboratory Consortium

Executive Order 12591, Facilitating Access to Science and Technology (1987)

- Requires government agency and government laboratory heads to identify and encourage exchange of technical knowledge among federal laboratories, universities, and the private sector
- Underscores government's commitment to technology transfer; urges GOCO laboratories to enter into cooperative agreements to the extent permitted by law
- Promotes commercialization of federally funded inventions by requiring laboratories to grant contractors title to patents developed in whole or in part with federal funds, provided government is given a royalty-free license

National Competitiveness Technology Transfer Act of 1989⁷⁴

- Extends to GOCO's similar ability to enter into CRADA's previously granted to GOCO laboratories
- Protects commercially sensitive information by denying disclosure of information and inventions that are the subject of CRADAs to third parties

National Technology Transfer and Advancement Act of 1995⁷⁵

- Provides assurances to U.S. companies that they will be granted sufficient intellectual property rights to justify prompt commercialization of inventions arising from a CRADA with a federal laboratory.
- Gives the collaborating party in a CRADA the right to choose an exclusive or nonexclusive license for a pre-negotiated field of use regarding an invention resulting from joint research under a CRADA.
- Enables a CRADA partner to retain title to an invention made solely by its employees in exchange for granting the government a license to use the invention.

⁷⁴ Public Law 101-189

⁷⁵ Public Law 104-113

Technology Transfer Commercialization Act of 2000⁷⁶

- Broadens CRADA licensing authority by permitting federal laboratories to grant a license for a federally owned invention that was created prior to signing a CRADA.
- Requires licensees to provide a plan for marketing of the invention and to make a commitment to achieve practical application of the invention within a reasonable time period.

MINIMUM FUNCTIONS REQUIRED OF NASA BY LAW

NASA, as an agency operating federal laboratories, is required to provide sufficient funding to support the technology transfer function. In addition, NASA is required to report annually to OMB on its technology transfer and licensing activities.

Each NASA laboratory with 200 or more system test and evaluation positions must provide one or more positions to staff an Office of Research and Technology Application to take responsibility for supporting technology transfer. These laboratories must also support the Federal Laboratory Consortium through representation and funding.

Inherently Governmental Functions

“Inherently governmental functions” are traditionally understood as functions the government must perform in order to preserve the public’s interest. These functions include making decisions, including budget decisions, that affect federal regulations and making government financial obligations and commitments.

When considering the relevant mix of civil service activity and the opportunity for outsourcing functions related to technology transfer, NASA must consider two critical matters outlined in the Federal Acquisition Regulation: (1) whether the services are personal and (2) whether they are advisory and assistance services.

Definition of Personal Services

The Federal Acquisition Regulation states, “a personal services contract is characterized by the employer-employee relationship it creates between the Government and the contractor’s personnel.” Contracting for personal services is restricted by the Civil Service Act (5 U.S.C. 3109). The following descriptions are used as a guide when assessing whether or not a proposed contract is for personal services:

- Services are performed on site.⁷⁷
- Principal tools and equipment are furnished by the government.

⁷⁶ Public Law 106-404.

⁷⁷ FAR Part 37.104.

- Services are applied directly to the integral effort of the agency or an organizational subpart in furtherance of assigned function or mission.
- Comparable services, meeting comparable needs, are performed in the same or similar agencies using civil service personnel.
- The need for the type of service provided can reasonably be expected to last beyond one year.
- The inherent nature of the service, or the manner in which it is provided, reasonably requires, directly or indirectly, government direction or supervision of contractor employees in order to:
 - adequately protect the government's interest,
 - retain control of the function involved,
 - retain full personal responsibility for the function supported in a duly authorized federal officer or employee.

Without special approvals, contracted services should be non-personal and therefore not captured in the descriptions above.

The personal services restriction is designed to ensure that contractor services are distinguished from work most appropriately performed by civil service personnel. As a general rule, contractor services should be work performed off-site, with equipment furnished by the contractor. In addition, the work performed should not duplicate civil service performance, and the contractor should be able to perform independently.

Advisory and Assistance Services

The acquisition of advisory and acquisition services is a legitimate way to improve government services and operations. Agencies such as NASA can acquire such services to do the following:⁷⁸

- Obtain outside points of view to avoid too limited judgment on critical issues
- Obtain advice regarding developments in industry, university, or foundation research
- Obtain the opinions, special knowledge, or skills of noted experts
- Enhance the understanding of, complex issues and develop alternative solutions to,
- Support and improve the operation of organizations

⁷⁸ FAR Part 37.203(b).

- Ensure the more efficient or effective operation of managerial or hardware systems.

Agencies may not use an advisory and assistance contract to do the following:⁷⁹

- Perform work of a policy, decision-making, or managerial nature, which is the direct responsibility of agency officials
- Bypass or undermine personnel ceilings, pay limitations, or competitive employment procedures
- Direct work on a preferential basis to former government employees
- Obtain aid in influencing or enacting legislation
- Obtain professional or technical advice readily available within the agency or another federal agency

Currently, NASA technology transfer is performed by a mix of civil service and contractor personnel. NASA civil servants perform the headquarters function and manage the technology transfer offices at each NASA center. Headquarters oversees the resourcing and policy decision making, while the civil servants in the centers manage the new technology reporting and the patent application process with the inventors.

Contractors perform services in partnership development and research on commercial market assessments of NASA inventions. Decisions committing government resources are made by NASA civil servants.

The mix of contractor and civil service responsibilities performed by NASA appears to be appropriate and consistent with “inherently governmental” regulations.

⁷⁹ FAR Part 37.203 (c).

PREVIOUS STUDIES

President’s Commission on Moon, Mars, and Beyond (The Aldridge Report)

President’s Commission on Implementation of United States Space Exploration Policy: A Journey to Inspire, Innovate, and Discover, June 2004 Aldridge report—E. C. Pete Aldridge, Jr., Chairman.

The administration wants to increase the NASA budget to \$16.2 billion. The Senate Budget Committee, while it supports the President’s vision for exploration and discovery, believes the current situation necessitates slower implementation. The committee is recommending \$15.6 billion; the current NASA budget is \$15.4 billion.

The long-term, ambitious space agenda advanced by the President for robotic and human exploration will significantly help the U.S. protect its technological leadership, economic vitality, and security. While this journey will be managed within available resources using a “go as you can pay” approach.... For the American people to maintain their support and ownership of these projects, our leaders must routinely explain and demonstrate value, affordability, and credibility of the program. Successful implementation will require significant cultural and organizational changes in NASA’s approach to managing this effort. Bold transformation initiatives must be undertaken.⁸⁰

Among the commission’s recommendations:

- NASA’s relationship to the private sector, its organizational structure, business culture, and management process—all largely inherited from the Apollo era—must be decisively transformed. To this end, the commission recommended NASA reorganize and implement a far larger presence of private industry in space operations with the specific goal of allowing private industry to assume the primary role of providing services to NASA. The preferred choice for operational activities must be competitively awarded contracts with private and nonprofit organizations, and NASA’s role must be limited to only those areas where there is irrefutable demonstration that only government can perform the proposed activity.
- NASA centers should be reconfigured as FFRDCs that would enable innovation, work effectively with the private sector, and stimulate economic growth.
- Creation of new NASA organizations:
 - Technical advisory board, which would give the administration independent and responsive advice on technology and risk mitigation plans.
 - Independent cost estimating organization

⁸⁰ President’s Commission on Implementation of United States Space Exploration Policy. *A Journey to Inspire, Innovate, and Discover*, June 2004 Aldridge report—E.C. Pete Aldridge, Jr., Chairman.

- Research and technology organization that sponsors high-risk/high-payoff technology advancement

Another major recommendation was for NASA to promote the successful development of identified enabling technologies. In addition, it recommended that NASA form special project teams to develop a road map that leads to mature technologies and plan for transition of appropriate technologies to the private sector.

In order to sustain long-term exploration of the solar system, the report also urged:

- NASA to aggressively use its contractual authority to reach broadly into the commercial and nonprofit communities to bring the best technologies and management tools to accomplish its goals
- Congress to increase the potential for commercial opportunities related to the national space exploration vision by providing incentives for entrepreneurial investment and or technology development by ensuring appropriate property rights for those who seek to develop space resource infrastructure.

NAPA Academy Panel Review

In 1997, another Academy Panel reviewed NASA's technology Transfer and SBIR programs at the request of NASA's Division of Commercial Technology.⁸¹ This review was focused on NASA's goal to extend the outcomes of its research and development efforts by transferring new technological processes, products, and practices into commercial markets. The study recognized that technology transfer and commercialization are often long-term propositions requiring specialized skills, such as knowledge of capital requirements, marketing, and patents, licenses and copyrights. These skills required a dedicated staff that could operate across functional lines. Because of the long-term perspective and strategic focus the Panel that led that review believed that it was difficult to measure the accomplishments of NASA's technology transfer and commercialization efforts. The study found that NASA's commercializing techniques compared favorably with those of other agencies. In fact, in a number of comparisons, NASA's methods and procedures were more evolutionary and generated better performance.

The Academy's overall assessment of NASA's technology transfer and commercialization was positive. It is interesting to note that the Academy's Panel's report highlighted weaknesses in the following areas: management, the technical assistance program, the roles of the RTTC, and the NTTC, metrics, capturing contractor-developed technologies, and staff training. Of the six major panel recommendations, five bear mentioning in this report, and several remain relevant today.

Recommendation #1—The Commercial Technology Division needs to develop a clear and coherent mission statement, establish specific goals, and formulate strategies to obtain them. The

⁸¹ National Academy of Public Administration Panel, *Review of the Commercial Technology Divisions Program*. (Washington, DC: 1997).

administrator should consider whether the Commercial Technology Division should report to his office.

Recommendation #2—The role of the RTTC’s as an outreach mechanism for dissemination of new technologies should be reaffirmed. The mission of the NTTC should be clarified by reaching agreement on the purpose that the NTTC serves.

Recommendation #3—NASA should focus on the development of key metrics that can be used to achieve accountability and improve program operations. The TechTracS database should be modified so that data available serves both the operational elements and the management of the commercialization program.

Recommendation #4—NASA should identify ways to provide contractors with positive incentives for reporting and screening innovation. NASA should develop a capability to evaluate and sort, value and market, its technological assets to industry.

Recommendation #5—With respect to SBIR, program criterion of commercial promise should be placed on an equal footing with the criterion of technological merit in the selection of SBIR projects. NASA should conduct case studies of SBIR firms; the studies should be aimed at discerning the factors that contribute to successful commercialization.

PCAST Report

This was a report⁸² by the President’s Council of Advisors on Science and Technology (PCAST) on two specific aspects of the government’s investment in research and development. The first part reviewed the federal government’s research portfolio and was issued in an October 2002 report entitled, *Assessing the U.S. R&D Investment*. The second review focused on the value of federal research in maintaining America’s economic leadership as it relates to the commercial use of technology developed with federal funding. The study found that the process of technology transfer is not simple; however, current laws improve our nation’s ability to facilitate the exchange of ideas from R&D to eventual commercialization. The report considered the transfer of publicly funded technology a critical mechanism to optimize the return on taxpayers’ substantial investment.

The report suggested 10 areas where improvement in the technology transfer process could be made.

Recommendations

1. Existing technology transfer legislation works and should not be altered.
2. Federal agencies, government laboratories, and the Department of Commerce need to formalize their oversight of and accountability for technology transfer.

⁸² The President’s Council of Advisors on Science and Technology, *Report on Technology Transfer of Federally Funded R&D*. (Washington, DC: May 15, 2003).

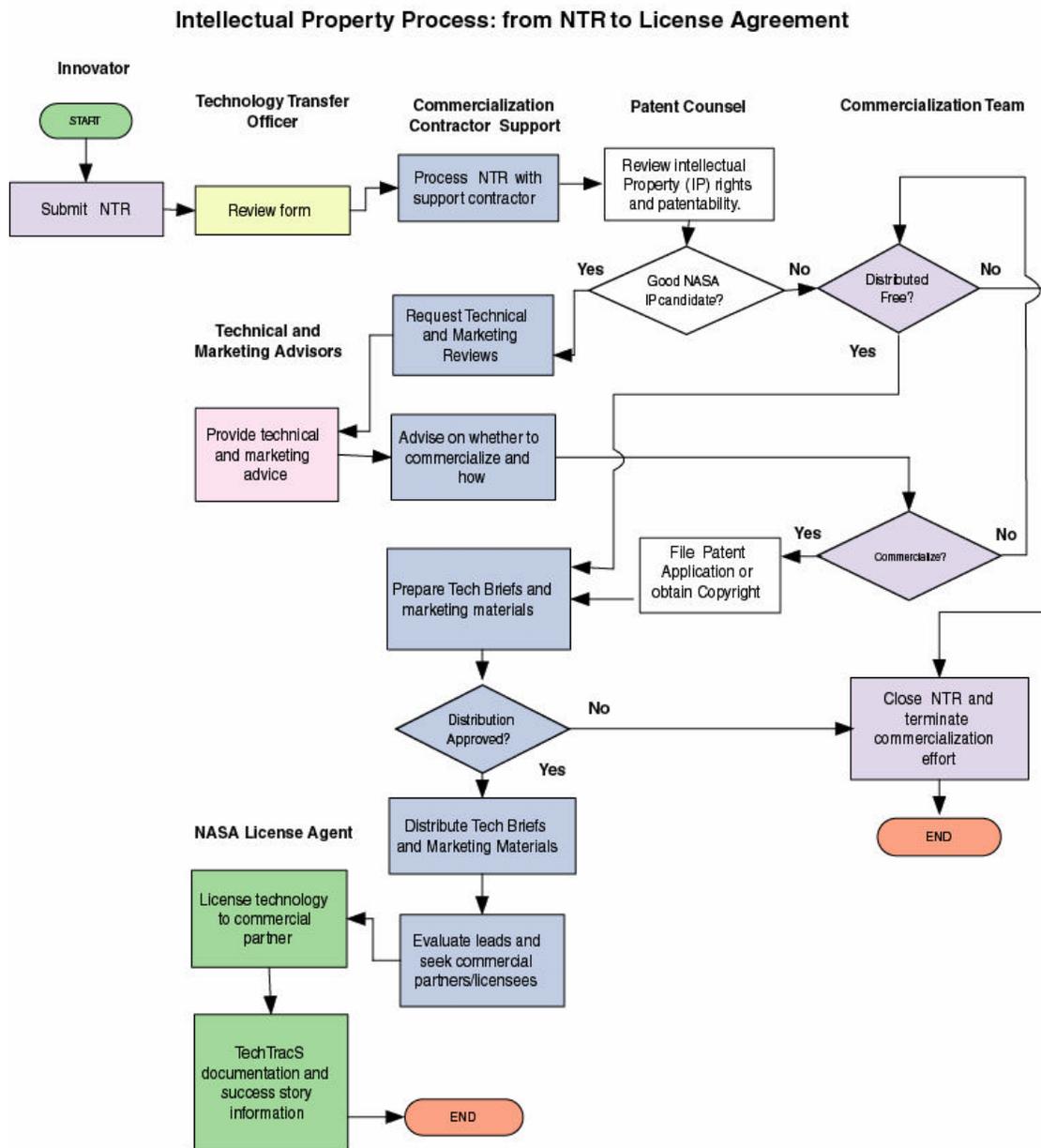
3. Industry differences need to be recognized and practiced by institutions licensing government-sponsored technology, but made consistent within individual disciplines.
4. The Department of Commerce should document “Best Practices” for technology transfer, as well as refine a set of metrics to better quantify practices and their effectiveness.
5. The Department of Commerce should include “education” as a part of its technology transfer mission and task the individual agencies to disseminate related materials specific to their R&D programs.
6. Individual agencies and government laboratories need to provide regular transaction “process reviews” to reduce the complexity of, and time required to complete, technology transfer transactions.
7. The Office of Science and Technology Policy should assist the new Department of Homeland Security in rapidly developing technology transfer policies and capabilities that meet the immediate and long-term agency needs.
8. The government should centralize information on technology transfer into a single accessible location.
9. The Department of Commerce should study and assess the implications for technology development and transfer in a global environment, as well as the possible effects of emerging technologies.
10. Recent discussions about the availability of research tools that result from federally-funded research need to be monitored to ensure that there is a balance in the protection of the commercial value of such inventions and assurance of access to these tools for further research and exploration.

The report mentioned two additional factors that need to be highlighted to put in proper context its 10 recommendations. The authors state that technology transfer mechanisms in America has been successful because strong technological and training programs have maintained a full pipeline of talent. The United States must continue to maintain this “pipeline” if it wishes to reap measurable economic benefit provided by the abundant talent in federally funded research programs. The report stated that the importance of metrics and documentation were worthy of specific mention. The ability to generate meaningful data to assess success of technology transfer is difficult. The process involves many steps and participants over extended time periods. The report cautioned against the sole use of anecdotal data and recommended continued development and study of technology transfer activities.

**INTELLECTUAL PROPERTY AND LICENSING PROCESSES:
AN ILLUSTRATIVE EXAMPLE FROM KENNEDY SPACE CENTER**

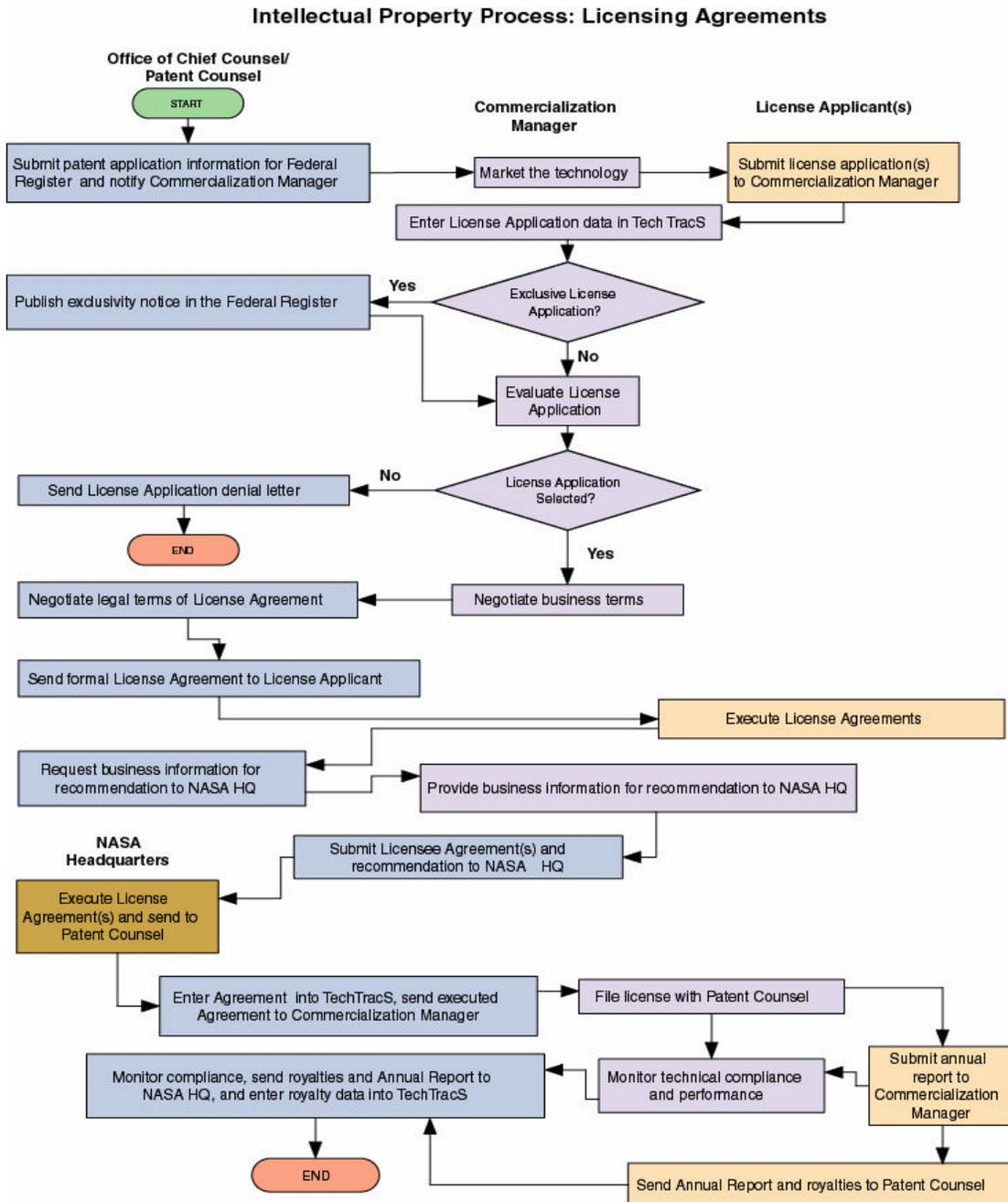
Figure F-1 maps Kennedy Space Center’s commercialization for a NASA technology from the time it is initially reported to the time, if applicable, it is patented by the agency and licensed to a company. Although each center’s process varies in some ways, Kennedy’s was identified as representative. As the figure shows, the overall commercialization process can involve as many as 18 major steps, with five key players: the innovator, the IPP office, a commercialization support contractor, the patent counsel, and a commercialization team.

Figure F-1. Technology Commercialization



Once a patent application has been filed, NASA can license the technology to a company. Figure F-2 maps Kennedy Space Center’s process for negotiating and signing licensing agreements; this is a subset of the overall commercialization process described in the previous figure (Figure F-1). Again, although each center’s process varies in some ways, Kennedy’s is representative. As Figure 2-1 shows, the licensing process can involve as many as 23 major steps, with five key players: the general counsel, the patent counsel, the commercialization manager, the license applicant or applicants, and other NASA headquarters officials.

Figure F-2. Process for Licensing Agreements



HOW NASA COULD USE A BALANCED SCORECARD TO MEASURE IPP OUTPUTS

The balanced scorecard approach to performance management is an attempt to translate an organization's strategic objectives into a set of performance measures. Scorecards have been used to evoke strategic thinking at multiple levels of the organization, increase self-assessment and management, demonstrate the contribution of support functions to the organization, and encourage and reward planning.⁸³

Scorecard measures traditionally look at a balance of measures in four primary areas:

- Learning and growth
- Internal business processes
- Customer focus and customer satisfaction
- Financial data

Undertaking a balanced scorecard approach involves a significant commitment of time and energy for any organization. Regarding the IPP, the Panel suggests a careful approach that builds on existing measures to the greatest extent possible while beginning to develop additional ones. IPP already has a number of measures that could be used to evaluate internal business processes and financial performance; it would still have to develop measures for evaluating customer perceptions or employee learning and growth. The total number of measures should be kept to a minimum both for administrative ease and user-friendliness.

The individual measures could be given assigned weights (importance to the IPP mission) to quantify and evaluate organizational performance. The process for agreeing on measures and assigning weights is one that should involve as many IPP staff members as practicable as well as staff from other organizations involved in technology transfer (legal counsel, scientists and engineers, and so on). Through such a process, the affected NASA officials should begin to understand this approach to performance measurement and feel a sense of ownership of the balanced scorecard itself.

Potential Balanced Scorecard

In conjunction with the IPP staff, the study team developed the sample balanced scorecard in Table G-1.

⁸³ Jake Barkdoll, "Balanced Scorecards in the Federal Government." *The Public Manager*, Fall 2000.

Table G-1. Potential Balanced Scorecard for NASA Technology Transfer Activities

<i>Measure</i>	<i>Weight</i>
Response Time	0.15
<i>Time to License</i>	
<i>Time to Execute Agreement</i>	
Leveraged Partnerships	0.40
Lead Generation	0.25
Success Stories	<u>0.20</u>
<i>Total</i>	1.00

Performance targets for organizational units involved in the technology transfer process could be based on such criteria, with performance targets for individuals then developed as subsets for each measure.

Partnerships, for example, could be evaluated both on total volume and the potential for a successful transfer of an important technology. “High potential” outcomes could be those where the expected commercial product line is likely to be used by one or more NASA mission directorates and/or private company. “Moderate potential” outcomes could be those likely to raise the Technology Readiness Level (TRL) from 2 to 3 levels and have high commercial interest. “Some potential” outcomes could be those likely to raise TRLs one level and have some commercial potential. “Unknown” outcomes could be those where no impact is expected or its too soon to evaluate.

Similarly, success stories might be evaluated based on their economic impacts:

- “Outstanding” would require a verifiable quantum improvement in quality of life—a more than 25% increase in market share or a more than 25% increase in sales or the size of firm, for example.
- “Very Good” might require a 10% - 25% increase in market share or a 10% - 25% increase in sales or the size of firm.
- “Good” might require up to a 10% increase in market share or up to 10% increase in sales or the size of firm.
- “Not Rated/Unknown” might mean that the impacts are under 10% or are unknown.

The balanced scorecard measures could be used to evaluate the IPP or any of its component parts. The weights can be adjusted up or down and measures can be added or deleted based on changing organizational needs. Potential scorecard measures could be the volumes and/or potential impacts of NTRs, patent applications and patent awards, licensing revenues, and royalties.

Accountability

In addition to providing a means for linking IPP performance to NASA strategic goals, the scorecard is also a means for establishing accountability for the outputs themselves. This is important not only for staff members in the IPP network, but also for those elements in NASA responsible for the technologies that are transferred into or out of the agency—specifically, the NASA directorates and field centers. One of NASA’s human resources staff said it was “highly unlikely” that technology transfer is included as a performance measure for any Senior Executive Service member (outside of the IPP chain-of-command). As long as the only people in NASA held accountable for technology transfer are the IPP staff, NASA will never be as successful as it otherwise could be. As the Panel concluded in the first phase of this study, “technology transfer should be everyone’s job at NASA, not just IPP’s.” One way for this to happen is to begin to include technology transfer objectives in both organizational and individual performance targets. The IPP staff would have much more access to researchers and technologists, for example, if their organizational units were evaluated on the outcomes of such transactions.

The Memorandum of Agreement recently signed by the Office of the General Counsel and the IPP is a good first step for linking the performance objectives of two organizations that each have roles in technology transfer. The agreement takes the positive step of delineating the roles and responsibilities of each organization for the various aspects of the IP process. A next step to consider is the establishment of performance metrics (expected timeframes for processing patents and so on) that each organization is to be held accountable for meeting.

Photographs Courtesy of the National Aeronautics and Space Administration

With origins reaching back to the early days of the Space Shuttle Program, Nextel Flame Stopping Dot Paper from 3M resists flame penetration for greater than 4 minutes at a temperature of 2,000 °F.

FIELDVIEW, a computational fluid dynamics post-processing code sprung from NASA software know-how, is used to design tactical aircraft systems, including F-16, F-22, and F-35 Joint Strike Fighters.

The Secure Ambulation Module creates a stable and secure environment for patients as they stand during ambulation therapy. The module's unique harness supports a patient's body weight and controls the pelvis without restricting hip movement.



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