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Information Infrastructure for Healthcare: An Evaluation of a Government-Industry Technology Development Initiative

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Abstract

This paper illustrates a "bottom-up" model of a civilian technology policy program by recounting the story of the "genesis" of the ATP IIH focused program beginning with the initial exchange of ideas between members of the private and public sector (industry's submission of "white papers"; workshops conducted by the ATP; meetings held between individuals from both groups) in which those technologies necessary for the development of a national information infrastructure in healthcare were identified. Included is a discussion of the ATP "white paper" process in which noted differences existed between what the ATP hoped to gain through this method and how the private sector responded. The ATP review and selection process and the experience of firms, small, medium and large, with ATP projects is also discussed.

Key search words: Advanced Technology Program, healthcare, information technology, R&D consortia, technology policy.

1. Introduction

This paper illustrates how a “bottom-up” model of a civilian technology policy program works by recounting the story of the “genesis” of the Advanced Technology Program’s (ATP)[2] Information Infrastructure for Healthcare (IIH) focused program. This program began with an initial exchange of ideas among members of the private and public sectors (industry’s submission of “white papers”; workshops conducted by the ATP; meetings held between individuals from both groups) to identify those technologies necessary for the development of a national information infrastructure in healthcare. A discussion of the ATP “white paper” process[3] notes differences that existed between what the ATP had hoped to gain through this method and how the private sector responded. The ATP review and selection process and the experience of firms, small, medium and large, with ATP projects is also discussed. Key findings include the development of a comprehensive national program from piecemeal ideas of individual companies and individuals; the role of “double life” individuals, whether medical doctors or computer scientists, who embody both areas of expertise, in smoothing the translation process between the disciplines in complex interdisciplinary projects; and the notion of “balanced firms” whereby the ATP provided the means to allow a firm to operate somewhere in a spectrum consisting of “market” and “research” oriented firms at either end.

[1] We thank Rosalie Ruegg and Maryellen Kelley both of the ATP Economic Assessment Office for their thoughtful comments.

[2] The ATP statute originated in the Omnibus Trade and Competitiveness Act of 1988 (Pub. L. 100-418, 15 U.S.C. 278n) and was amended by the American Technology Preeminence Act of 1991 (Pub. L. 102-245)

[3] It should be noted that there is a difference between the individual white papers submitted by industry members, citizens, university professors, etc., and the comprehensive white papers created by ATP program managers from the individual papers. A program manager would synthesize the information supplied by the various submitters of individual generated white papers into a comprehensive white paper prepared for submission to the ATP Director for consideration of the development of a focused program.

The Advanced Technology Program at the National Institute of Standards and Technology (NIST) is a cost-sharing program designed to partner the federal government with the private sector to further both the development and dissemination of "high-risk"[4] technologies which offer the potential for significant, broad-based economic benefits for the nation. In this program, industry proposes research projects to the ATP to be judged in competitions for funding based upon both the technical and economic/business merits of the proposal. From 1990 through 1998, the ATP held "General" competitions each year open to all technologies. From 1994 through 1998, the ATP awarded most of its funding through "focused-program" competitions in which a suite of projects were funded to mobilize technology to address a particular problem. Thirty focused program competitions were held, each with a unifying set of project goals.[5]

> "Focused programs are defined as multi-year efforts aimed at specific, well-defined technology and business goals. These programs, which involve the parallel development of a suite of interlocking R&D projects, tackle major technology problems with high payoff potential which cannot be solved by an occasional project coming through the general competition. By managing groups of projects that complement and reinforce each other, the ATP can have the greatest possible impact on the economy."[6]

This paper discusses one particular focused program, the Information Infrastructure for Healthcare (IIH) focused program, initiated in 1994 amid a nationwide discussion of the rising costs of healthcare and the quality of care offered.

The ATP IIH focused program encompassed several objectives, some official and some unofficial, some explicit and some intuitive. It encouraged the introduction of new modalities into IIH, such as speech recognition, even as the enhanced capabilities, in part deriving from research conducted with IIH funding, found their way into a general commercial speech recognition software product. ATP awards for research made possible new technological capabilities in firms, allowing them to introduce advanced functionalities into their existing IIH products. These awards allowed the smallest firms to extend their limited resources and gave them additional ability to overcome research barriers impeding the attraction of private venture capital funding.

2. The Role of Medical Information Science In Healthcare Productivity

There are incentives for the creation of the field of healthcare information science, from within the medical profession to improve diagnosis and treatment, and from government and industry to reduce costs, although all spheres share each of these motivations to some

[4] High risk technologies are defined as...."technical challenges which display significant recognized uncertainty of success; where success will dramatically change the future direction of technology and its market impact. Risk may be high in developing single innovations, integrating technologies, or both." *ATP Proposal Preparation Kit*, U.S. Department of Commerce, NIST, November 1998, p. 25.

[5] Beginning with fiscal year 1999, ATP shifted to a hybrid form of competition—an "Open Competition"—in which ATP performs its outreach with industry much as it did under focused program competitions, with a single competition open to all, but organized by technology focus. This change was made primarily because the industry demand for focused programs outstripped ATP's budgetary ability to respond. Selected projects for award are then grouped and managed as "virtual" focused programs.

[6] See the ATP web page http://www.atp.nist

degree. Nevertheless, medicine is widely perceived to lag other areas in the degree to which computer hardware and software have been applied to these tasks.[7] Initially the field was "tool-driven" in that people saw specific problems that computers could solve, such as managing patient data. Many saw the limitations of human performance (human error in decision making, error in the interpretation of x-rays), and this provided an incentive for their work in informatics. Some others came to the field from an examination of the information required in medicine and how it was learned and managed. And still others were introduced to medical informatics from an interest in technology—the medical field being one of many areas to which computer technology could be applied.

The past several years have witnessed a paradigm shift in the way this country delivers healthcare to its people; managed care, legislation, and consolidation have worked to redefine the relationship between patient and physician. Managed care has provided the impetus to seek ways to increase the quality of results, to be accountable for outcomes, to provide accurate measures of success, and to accomplish all of these with lower costs.[8] As the interface of medicine, science, and technology, medical informatics de-emphasizes the computer and places more emphasis on the nature of the field to which computations are applied, for example, record-keeping; the study of the nature of medical information itself; and the storage, retrieval, and optimal use of biomedical information, data, and knowledge for problem-solving and decision making.[9]

In response to changing economic conditions, which have created conditions in which technology could serve as a strong agent for change in how healthcare is delivered, there has been a consolidation of healthcare facilities. The report of a special committee under the Domestic Policy Council[10] identified an opportunity for computer technologies to make a significant impact in the healthcare sector of the economy which had lagged behind other sectors in adoption rates, and identified an opportunity for a public/private initiative to make a difference. The Clinton Healthcare Reform initiative contributed to a heightened awareness of the issues involved. The level of public awareness generated helped shape the context within which industry and ATP developed the IIH focused program.

3. White Papers

As a first step in establishing a structured dialogue with industry, ATP issued a call for "white papers," a mechanism by which industry conceptualizes the problems it is having difficulty addressing, including the kinds of technological barriers that must be overcome. Of course, "industry" is not monolithic. In fact, white papers are submitted by companies, individuals with companies, associations of companies, university professors, members of other organizations, and private citizens without organizational affiliation.

[7] "Health Security: The President's Report to the American People." The White House Domestic Policy Council, 1993. P. 12.

[8] "Advanced Technology Program: Information Infrastructure for Healthcare (95-10)." U.S. Department of Commerce, NIST, 1995, p. 1.

[9] Greenes, MD, PhD, Robert A., and Edward H. Shortliffe, MD, Ph.D. "Medical Informatics: An Emerging Academic Discipline and Institutional Priority." JAMA 263 (8, Feb. 23, 1990):1115.

[10] "Health Security: The President's Report to the American People." The White House Domestic Policy Council, 1993,. p. iii.

The white paper process as well as the notion of focused programs were introduced to the ATP from the Advanced Research Project Agency (ARPA). Between the end of 1993 and the beginning of 1994, 920 white papers covering a range of technologies were submitted and sorted by a technology taxonomy. Of this total, 22 white papers addressing healthcare issues were received, providing both scope and technical detail. These offered a comprehensive roadmap for the ATP in developing a partnership with industry. The white paper process provided a place for people to go with their ideas and an opportunity for the ATP to more clearly define the goals of the focused program.

3.1 Industry's Response

The healthcare white papers varied significantly in scale, scope, and level of detail, as well as in their strategies and underlying assumptions about innovation. Some of the documents fit the traditional definition of a white paper as "an authoritative and detailed report; "others were brief, informal communications, more like memoranda in their format and style. Ranging from 14-page, single-spaced, in-depth analyses to single-page overviews, the IIH white papers can be categorized according to the perspectives of the formative, summative and "real time" evaluation models. The formative approach views outcomes from the perspective of goals set in advance; the summative approach looks back at the impetuses to action from a later point in time; the "real time" approach views the situation as a series of concurrent interactions.

Formative themes included impetuses to action such as healthcare reform, defense conversion and foreign competition. The publicity about healthcare reform highlighted the significance of informatics to the program and thus focused the attention of companies with relevant expertise on a potential business opportunity. For example, one company mentioned the expectation of the imminent restructuring of federal health laws as a driver to technology development in this field. Defense-related companies also recognized the extensive market for medical technology as they sought alternatives to a shrinking defense sector. One paper, drawing upon ARPA-supported target recognition research, analogized surgery to the mission of a fighter pilot: to gather intelligence and to seek and destroy. foreign competition such as the European AIM Program (Advanced Informatics in Medicine) was cited as an incentive for the ATP to focus on its approach. The case was often made in the form of the warning that "Asia is taking a hard look" at the possibilities offered by health informatics.

Summative themes, relating to the projected effects of the projects, include such topics as time acceleration, cost savings and spillovers. Several papers argued that the length of time needed for commercialization was too long for individual companies and too costly for even a group of companies. Thus, a catalyst of government funding is said to be necessary to get an industrial group to cohere and increase the length of its time perspective. A common theme is that advanced technology can drive costs lower. For example, one contributor argues that its technology will make possible earlier diagnosis, leading to cost savings through earlier treatment. While some proposals envisioned a close relationship among different projects, "spillovers" into other areas were expected to occur. Thus, medical imaging technology was said to be "highly transferable between industries," as imaging technology is also useful for inspection of tires and luggage.

"Real time" themes were apparent in a number of proposals which emphasized the feedback aspect of new technical ideas from IIH and the particular medical application area itself and how it related to computer science. For example, the sensing and signal processing technologies to be developed in one project were claimed to be relevant to emerging medical companies with very specific products. Knowledge transfer is expected not only from the medical specialist to the general physician, but also from the doctor to the patient. Thus, one paper proposed technology to assist primary care physicians, allowing them to take over problems previously left to specialists, while another suggested technology that will allow transfer of monitoring skills from doctor to patient.

3.2 ATP's Response

Upon receipt of the first batch of white papers and their grouping by taxonomy, the ATP Director assigned program managers[11] to form a series of focused programs and charged each with additional development of the scope of the proposed programs, as well as furthering the relationship already established with industry. The program manager for the IIH focused program organized a public workshop in which 400 representatives from industry, as well as the non-profit and academic communities, attended. It was structured in a series of breakout sessions addressing the more relevant technological sub-domains identified in the white papers, e.g., information technologies, telemedicine and technology imaging.[12] At the conclusion of the workshop, a representative from each session reported the group's findings to the entire body. From the resulting general discussion, a consensus was formed identifying information technologies as offering the best means to achieve a significant reduction in healthcare costs without sacrificing quality of care, two objectives accepted by the members of the workshop as constituting the primary reason for the establishment of a focused program in this particular area. Information technologies for healthcare also offered one of the most clearly defined areas of technological development requiring the public/private partnership offered by the ATP. The role of the ATP was thus defined as one of fostering cooperation and communication and as the catalyst needed to bring together the members of the information technology and medical communities to achieve the objectives.

The dialogue begun at the workshop between the program manager and healthcare industry consultants, representatives from non-profit healthcare organizations, medical doctors, and software development companies was sustained through the solicitation of additional white papers.[13] The 11 new white papers complemented the discussions held at the workshop, identifying the increased demands placed upon the U.S. healthcare industry to raise the quality of service, to extend consistent quality between rural and urban areas, to provide accurate measures of success, and to accomplish all of these with lower costs in a timely fashion while establishing national standards for the electronic transfer of patient records and related medical documents. This information, offering

[11] For the first year of the focused programs eight program managers were tasked with developing focused programs. The number was influenced by the count, scope and expected potential impact of the white papers received in any one technology category. ATP published and followed a set of criteria in selecting focused programs for further development and funding.

[12] Advanced Technology Program, "Information Infrastructure for Healthcare (94-04)", U.S. Department of Commerce, NIST, 1994, p. 15.

[13] Additional white papers were received from workshop attendees as well as from those who responded to a solicitation for additional white papers posted by the program manager in the Commerce Business Daily (CBD) website.

quite different notions of technological innovation in this area, fell into three distinct categories: a systems approach to an entire technological field; identification of a technological area that is purported to offer special promise for significant economic spillovers if "bottlenecks" are addressed; and, specific technical ideas that will, if supported, result in particular products.

Specific technologies identified in the IIH white papers included development of:

- Information tools to automate, validate and distribute clinical practice guidelines for mass use. These could include clinical practice guidelines that capture the current "best practices" for an array of medical situations. Their use by physicians and other healthcare professionals could potentially improve overall healthcare by reducing variations in treatment and the use of inappropriate procedures and treatments.
- The tools to enable healthcare providers and quality/cost monitors to browse and to extract data automatically from a multitude of scattered clinical and administrative databases, without requiring changes to the existing databases. This technology would enable the use of potentially valuable healthcare information which is often inaccessible due to the fact that most databases are isolated "pockets" of information, separated by diverse access programs and incompatible file and data formats.
- Tools that facilitate the production of clinical notes and, as a byproduct, gather the codified clinical data and store it in a database system. This technology will develop an automated coding system to support healthcare professionals in generating clinical notes of the patient's condition, treatment, and outcome, which could then be codified and stored in a database system for later retrieval and analysis.
- An open-systems architecture to serve as an interface between independent healthcare information systems. This technology will address a central problem faced by many healthcare organizations created by the need to work with a wide variety of existing healthcare and health management information systems, generally incompatible with each other, which have been created independently to serve the needs of various healthcare domains.

Upon completion of the fact finding phase of the development of an ATP focused program, each of the program managers was tasked with making a presentation before a selection board comprised of the Director and Associate Director of NIST and members of the ATP management team. ATP programs were selected based on four criteria: potential for U.S. economic benefit; good technical ideas; strong industry commitment; and, the opportunity for ATP funds to make a significant difference.[14] In 1994, ATP announced funding in five focused programs, including the IIH Focused Program.

4. Information Infrastructure for Healthcare Focused Program

The *ATP Information InfraStructure for Healthcare Focused Program* solicitation kit identified the program's objectives as:

> "Infrastructural development focusing upon 'tools' and prototype systems to enhance the flow of information between existing 'legacy' systems in the healthcare enterprise while being scalable from a single provider's office to a fully integrated healthcare system. Infrastructural development is intended to enable enterprise-wide integration

[14] *Program Idea Guide*, Advanced Technology Program, U.S. Department of Commerce, NIST, May 1997, p. 3.

of information among all sectors of the healthcare industry and is expected to encompass the following:

- the integration, synthesis, and definition of any information which needs to be shared across the enterprise; and,
- the means by which to transport, store, and access that information in a way that enhances the productivity of the end-user."[15]

The white paper process was instrumental in the development of a model of the program, which resulted in a portfolio of technologies. The model is presented in figure 1 in the form of a "pyramid" consisting of three categories from bottom to top: (1) Infrastructure Development Technologies (e.g., tools for enterprise integration, business process modeling); (2) User Interface and Efficiency-Enhanced Technologies (e.g., hypermedia human interfaces, natural language processing, data retrieval & advanced search mechanisms); and (3) Healthcare-Specific Technologies (e.g., clinical decision support systems, consumer health information and education systems).[16] Each level is presented as being quite distinct from the next with the thought at the time being that development of those technologies in the lower levels should precede development of those above, resulting in a "bottom-up" approach. This logic influenced the announcement of the first and second solicitations whereby only those technologies "fitting" into the respective levels were to be funded. This reasoning was modified for the announcement of the third solicitation when it was recognized that technological R&D in this industry requires simultaneous development of "infrastructural" technologies along with that of applications, resulting in a "cycling" of technologies among the multiple levels of the pyramid. This cycling from the bottom levels, through the middle, to the top and back down again in the development process for information technologies was evident at the time of the third solicitation in 1997 when it was determined that funding of those technologies located in the lower level would "cycle-up" through the levels above. The third solicitation sought proposals that focused on the lower two levels of the pyramid but addressed all technologies listed.

5. Focused Program Project Selection Process

5.1 Source Evaluation Board (SEB)

The ATP forms Source Evaluation Boards (SEBs) to review project proposals and make recommendations for funding. SEB membership is comprised solely of federal employees possessing technical and business expertise. In focused program competitions, proposals were first screened to determine if they were "within scope"[17] and contained all of the necessary documentation, then those remaining received detailed technical and business reviews. For the focused programs operated during this time, the SEB was generally comprised of 8-10 people. SEB reviews of proposals are supplemented by additional reviews from non-SEB members.[18]

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[15] Advanced Technology Program, "Information Infrastructure for Healthcare (94-04)", U.S. Department of Commerce, NIST, 1994.

[16] Ibid, p. 4.

[17] The concept of being "within scope" applies only to those proposals received through the focused programs. In the instance of the IIH focused program "within scope" carried an additional requirement of fitting into the portfolio of technologies specified in the solicitation kit.

[18] Non-SEB technical reviewers are primarily scientists employed in federal labs chosen for their expertise in the selected technical area. Non-SEB business reviewers are business professionals who in some cases are retired executives whose careers were spent in the selected technical area, economists, venture capitalists, and business academics. All sign non-disclosure and conflict of interest forms.

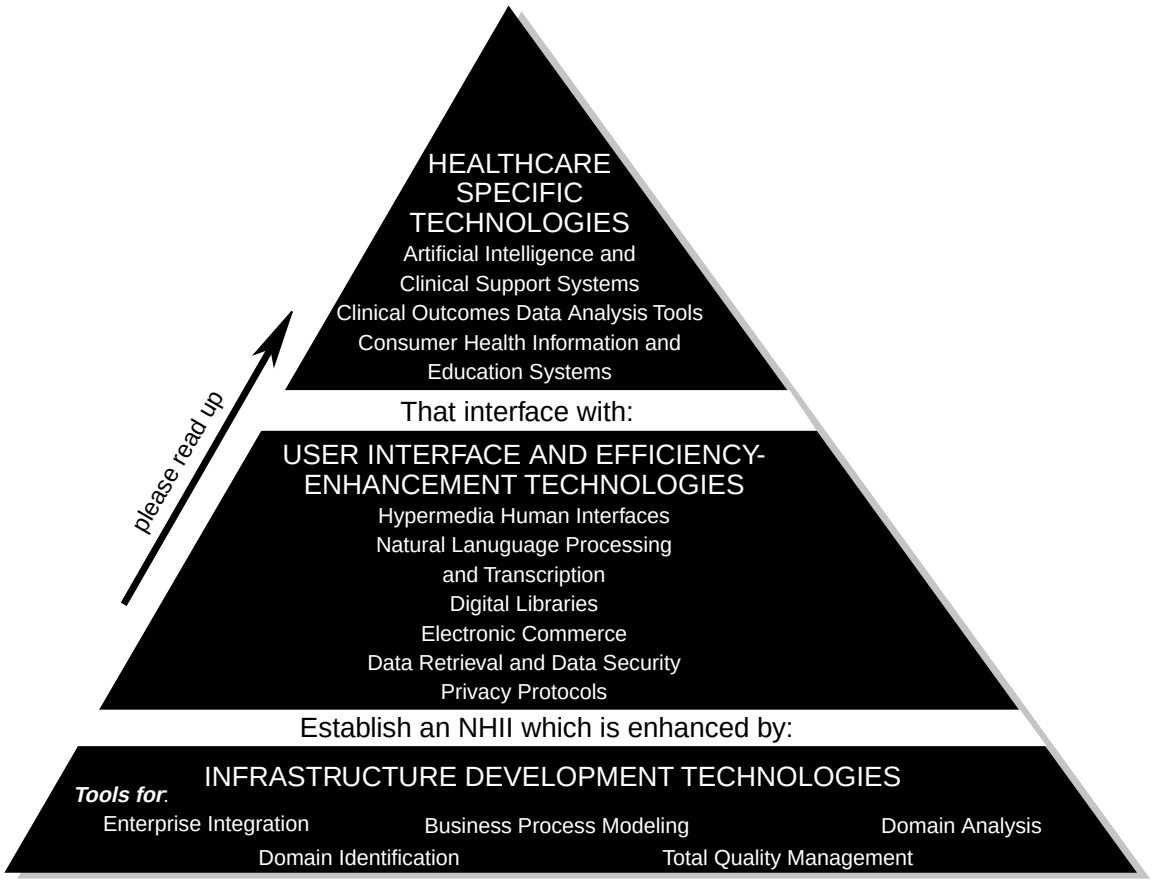

Figure 1 - Pyramid

With the full membership in attendance, or a pre-determined quorum, the members of the SEB discuss each proposal with attention to its conformance with both the technical and business criteria outlined in the *ATP Application Kit*.[19] Those proposals determined to be "within scope" and possessing high technical and business merit against the criteria are placed in a semi-finalist category.

5.2 How ATP Communicates with Proposal Writers

The ATP offers several means of communication with proposal writers. Pre-proposals of one to four pages in length allow potential applicants an opportunity to submit a scaled-down version of what might become a more lengthy and expensive to prepare, full proposal.[20] The pre-proposal could be used to determine if the ATP is the correct place to go to with one's idea and also to determine if the proposed work is within the scope of the intended focused program.[21] Companies are also free to submit full proposals whether or not they had submitted a pre-proposal. All proposals are reviewed, and semi-finalists are invited by the SEB to attend an oral review in which they are asked to respond to a

[19] *ATP Proposal Preparation Kit*, U.S. Department of Commerce, NIST, November 1994. pp. 12-27. The ATP is an evolving program and changes have been made that alter the conditions and practices that were in place for the IIH Focused Program.

[20] Proposals submitted by single applicants at the time of the first IIH Focused Program had a maximum page count of forty pages, those submitted by Joint Ventures had a maximum page count of fifty pages.

[21] The use of the pre-proposal was left to the discretion of the focused program manager in previous years and has been used only sparingly. (Pre-proposals were an option for the 1994 IIH focused program solicitation). For the fiscal year 1999 "Open Competition" pre-proposals were welcomed in all technology areas.

series of technical and business questions that address specific issues. Technical questions commonly focus on the "high technical risk" component of the proposal, while business questions are often centered on applications of the technology, or the need for ATP funding as opposed to private sector funding, commercialization plans, and budgetary matters. For those proposals not selected as semi-finalists, a telephone debriefing is offered upon request.[22] [23] Semi-finalists who are not selected as finalists may also request a telephone debriefing. The debriefing is usually performed by both the technical and business "sponsors"[24] of a particular proposal.

Debriefings offer an opportunity for proposers to receive feedback from the ATP that could be useful in rewriting a proposal for re-submittal. The debriefing might also be useful in formulating an entirely new proposal to ATP, or in preparing a proposal for venture capitalists or other alternative sources of financing.

5.3 Funding Decision

Upon completion of the oral reviews, the SEB presents a ranking of proposals to a Selecting Official who is charged with making recommendations of funding to the ATP Director. At this point the Selecting Official may request clarification from the SEB regarding the final ranking. The ATP Director makes the ultimate funding decision.

6. IIH Focused Program Awardees[25]

Table 1 below provides summary statistical data from the three IIH solicitations held between 1994 and 1997, in which 221 proposals were received and 32 awards were made to 79 participants. R&D funding totaled $295 million, representing a commitment of $146 million from the government and $149 million from the private sector.

The number of awards are listed by Single Applicant (SA) or Joint Venture (JV), number of participants, and type and size of organization. The first competition, held in 1994, resulted in awards to 10 SA's and 6 JV's encompassing a diverse collection of for-profit and non-profit companies. This pattern was repeated when the second competition was held in 1995, but there was a downturn in the number of awards. The third competition, held in 1997, resulted in awards to small for-profit companies. The decline in the number of awards in 1995, and more noticeably in 1997, is mainly attributable to the decline in the total dollar amounts that were available despite an increase in the number of proposals submitted.[26] The lack of awards to joint ventures in 1997 is likely explained by the high degree of uncertainty that surrounded the debate over the federal budget and the relatively short solicitation announcement time that followed.[27]

[22] Proposals not classified in the semi-finalist category may also include those screened out due to deficiencies in proper documentation and/or failure to fit within the technical scope of a particular focused program.

[23] Requests for debriefings can only be made during a limited period following notification from the ATP. ATP has followed the practice of providing one debriefing per proposal by telephone.

[24] "Sponsors" are SEB members who are assigned responsibility to see that each proposal receives an impartial hearing. Each proposal is assigned to two SEB "sponsors."

[25] The statistical data included in Table 1 is from the "Awards Database" of the Economic Assessment Office (EAO) of the ATP.

[26] The amount of funding available for the first competition was up to $30M, with up to $20M available for the second competition and up to $15M for third. (All amounts listed were fully committed for the respective first year of funding).

[27] When the budget issue for fiscal year 1997 was resolved there was a relatively short period of time in which to announce the 97-10 competition and establish a project proposal submission deadline. Joint Ventures are rather complex organizations which require a significant period of time to arrange.

Table 1: IIH Focused Program Participation

	1994	1995	1997
Total Number of **Proposals** Submitted*	59	68	94
Total Number of **Projects** Funded	16	10	6
Type of Award **Participant** Single Applicant Joint Venture	 10 6	 7 3	 6
Total Number of **Participants****	43	32	6
Type/Size of Organization*** PS (For-Profit Small Company) PM (For-Profit Medium Company) PL (For-Profit Large Company) NP (Non-Profit) U (University)	 17 6 6 7 4	 12 4 5 8 3	 6

*The *ATP Program Proposal Preparation Kit* specifies the rules covering submission.[28]
**The number of participants presented here is not inclusive of Sub-contractors.
*** "Small" companies are defined as having fewer than 500 employees. "Large" companies are defined as belonging to the Fortune 500 or equivalent. "Medium" companies are defined as all others.

What remains relatively constant across the three solicitations is the dominant role of small for-profit companies (PS). These companies participated both as SA's and as members of JV's. Single applicant award recipients included start-ups as well as research organizations in medium and large size companies. The JV's consisted of several types of organizations of varying size, and scale, and with different orientations to technology development, including a diverse group of large and small companies, non-profit organizations, and universities, including, in some instances, competitors joining to overcome rather complex technical issues.

6.1 Small Firm Participation in the IIH Focused Program

The concept of "firm" covers a diverse range of companies. Two strikingly different types of small firms were involved in the ATP IIH projects: "front end" firms oriented to the market and "back end" firms oriented to the research frontier. There was a movement in both directions toward a middle ground, with research oriented firms attempting to

[28] "A single for-profit company may apply, as well as a joint venture with at least two separately owned for-profit companies, both of which are substantially involved in the R&D and both contributing towards the matching-fund requirement. The joint venture need not be a legally constituted entity. Most ATP joint ventures consist of companies who simply agree to collaborate on the R&D and divide the tasks. Single company recipients can receive ATP funds for R&D activities for up to 3 years, with ATP funding not to exceed $2 million for direct costs. Single-company recipients are responsible for funding all of their overhead/indirect costs. Small, medium and large size companies applying as single company proposers are not required to provide cost-sharing of direct costs. Beginning with the 1998 competitions large companies applying as single company proposers must cost-share at least 60 percent of the total project costs (direct plus indirect costs) for each quarter in each year of the award. Joint ventures, however, "can receive ATP funds for R&D activities for up to 5 years, with ATP funding a minority share of the total project costs. Joint ventures must cost-share (matching funds) more than 50 percent of the total project costs (direct plus indirect costs) for each quarter that the ATP funds the project." *Advanced Technology Program Proposal Preparation Kit*, November 1998, p. 1.

position themselves to produce products, and market oriented firms pursuing more advanced research as an outcome of their participation in ATP projects.

6.1.1 Research Oriented Firms

Companies are commonly thought of as being market oriented. However, some firms have little connection to broader markets beyond a single customer, for example, a particular agency of the government or an individual large firm. Indeed, there is a tradition of companies that produce research results and technology to order, as government contractors. Such firms operate as research shops, producing reports, papers, patents and "tools" that others can use in product development. Not surprisingly, some of these companies tend to view the ATP as merely another mission agency contracting for technology development. Although legally companies, they have very little notion of how to go about selling a product. To qualify as a finalist for ATP funding, with emphasis upon both business merit as well as technical merit, they may need to recruit a business manager, obtain advice from business consultants, or ally with other companies who have business capability. Without strengthening their business capability, their main hope for eventual utilization may continue to be their habitual route, that is, dissemination through papers and patents. The ATP seeks to add to the knowledge dissemination path a direct commercialization path.

6.1.2 Market-Oriented Firms

At the other end of the spectrum are market oriented firms that may view the ATP award as a centerpiece of their strategy to move their technologies into the marketplace. Market-oriented companies are typically populated with collaborating practitioners with similar technical expertise, such as doctors with software coding skills, and marketing and sales experts. These firms typically have an extremely short time horizon for product development and do not usually engage in advanced research. Although such firms are "high tech," in that they utilize state-of-the-art technology to develop high-tech products, they usually do not do early-stage research in the traditional sense of investigation that is not directly tied to immediate product development.

Market-oriented firms are typically restricted from mounting a research program by stringent finances, strategic orientation, and/or lack of appropriate personnel. These firms tend to operate with an incremental perspective toward product development, utilizing new combinations of existing technologies to solve a problem or provide a service. They consider doing research only when they can envisage that it will allow them to make a significant competitive leap forward in sales by adding a new capability or functionality to their product line. Given the concentration of available resources on short-term product development and the pressures of cash flow balancing, they seek to find an external source of funding so that their existing efforts in product development will not be financially drained. Another requirement is that management attention should not be excessively diverted from the firm's primary goal of current product development.

6.2 The Encouragement of Balanced Firms

An ATP award can allow a firm at either end of the market-research spectrum to broaden its focus and operate in the middle ground, thus bridging the gap between product

development and R&D from whichever side it has opened up. For example, a research-oriented firm may seek an alliance with a market-oriented firm to commercialize its technology. Conversely, a market-oriented firm may establish a research unit. Thus, an ATP award can broaden the focus of firms to include advanced capabilities in its products when it would otherwise not have had the needed resources. This phenomenon was observed among the IIH companies. Originally oriented toward supplying individual doctors' offices, one market-oriented firm's founders realized that the extended capabilities to its product line made possible by the ATP project would make its products attractive to larger vendors. Indeed, the very medical units where the firm was testing its ATP-enhanced product were now seen as potential customers. Thus, by allowing the firm to extend the capabilities of its product, the ATP project will have opened up a new market opportunity.

Similarly, research-oriented firms have extended their focus into new topics as a result of their ATP work. Several defense contractors in the IIH set became involved in healthcare informatics, at least in part due to learning about the ATP program directly from ATP workshops or being invited by other companies to participate in joint projects or consortia. Of course, the expectation for the growth of medical informatics since the health sector is a significant portion of the economy, in contrast to expected contractions in defense research, was also a factor influencing their entry into the field. Nevertheless, the ATP program was often at least a precipitating cause speeding up their entry into the field advancing the application of advanced software skills to healthcare informatics.

Even if the ATP is initially viewed as "simply another route to a government contract," an ATP award can become the first step by a research-oriented firm stretching sufficiently to eventually take a product to market. Much of this market preparation can be accomplished by addressing the business criteria specified in the application kit. Although, in at least one case observed, the ATP project did not take the "research shop" awardee as far as it hoped toward this goal in part due to difficulties with partners who had differing medical perceptions of software technical requirements, a process of transformation was initiated. Even though ATP funding ended before the technology development was completed, the medically-oriented firm hired its own programmers, including one from the former software collaborator, in order to bring the project to completion and then to market. To accomplish this end, the formerly research-oriented firm entered into negotiations to raise private funding.

7. IIH as a Catalyst for Collaborations

One objective of the ATP is to assist in the formation of collaborative joint ventures, especially in the case of the IIH focused program where almost by definition the infrastructural nature of the program calls for rather large coordinated initiatives. In several instances the white papers submitted by some of the larger JV's explicitly encouraged the participation of the ATP in the creation of collaborations among computer and medical professionals and organizations to enhance the development of these technologies, and to, "... help the healthcare industry avoid 'fragmentation'."

ATP collaborative projects comprise both formal joint ventures and informal collaborations within single-company projects. Anecdotal evidence points towards the following reasons given for such informal collaborations—prevalent among small- and mid-sized single-company awardees-- including: (1) meeting ATP requirements that single applicants for awards be firms in the cases where ideas were generated by universities or other non-profits, (2) a belief that despite official inclusion of small firms and startups that large company involvement might increase the chance of satisfying the criteria and getting an award, and (3) a need for complementary technical expertise to carry out a project. The formal joint venture collaborations typically comprised the R&D units of large corporations, small firms, universities, hospitals, and other non-profit organizations, including specialists in consortia organization and management.

Behind the official awardee was sometimes a much smaller firm that initiated the interest in ATP, then persuaded the larger firm to apply. In this arrangement, the smaller firm typically became a subcontractor to the awardee. This strategy, seemed in part to arise from a perception of some firms that "ATP is for large companies." Some very small firms felt that they could not successfully apply alone. Yet, the ATP has awarded many awards to small, start-up companies and, as of the end of 1998, more than half of the ATP projects were led by small companies.

Sub-contractors appeared important for extending the technical reach of firms into areas in which they have little background. Thus, subcontracting roles allowed software firms to gain access to medical expertise and vice-versa. Indeed, it is difficult to see that many of the projects could have been carried out by individual firms acting alone, given the complex requirements for successfully performing the projects. Small firms are typically concentrated in narrow areas. In lieu of a costly expansion into other areas, most companies find it more feasible to form a coalition with another firm or an academic research group as the path to acquiring distinctly different capabilities.

Indeed, some of the firms were introduced to ATP by organizations, such as universities, that are not eligible to apply themselves. Since the formal requirements of the ATP mandate that the primary applicant be a company, interested academics have to identify a company to undertake a project in which they are interested. A respondent from an academic background said, "So when we saw the ad, it was almost exactly what we wanted, but it was not to universities. The ATP program had to go to industry, so that left us searching for an industry partner."

In some cases, the initial step toward forming a formal joint venture was participation of different companies in a voluntary group focusing on the IIH problem area. A voluntary group found that it could undertake limited trials based on existing technology but not undertake technology development itself. As a respondent said, "Volunteer work will only get you so far." Nevertheless, previous relations among the volunteer group proved important later. When the ATP opportunity came along there was an existing pool of trust deriving from previous experiences in working together that could be drawn upon in getting a new project underway more smoothly. Consortia specialists, who devote considerable effort to consensus building, engaging in extensive meetings and interaction,

helped pull the joint venture together. Decisions were made collectively, based upon extensive discussions among relative equals, who were primarily the representatives of large companies.

Despite the clear notice that ATP projects are relatively long term, some joint venture members expected quick results and dropped out when these unrealistic expectations were not met. Thus, as one respondent noted, "Some communications companies dropped out [of one joint venture when]..… they didn't see them[selves] getting from here to there in the approach they were taking, in the time frame they were willing, with the investment they were making." For firms that are unwilling to extend their time perspective, even the funding by the ATP may not be sufficient to keep their participation once they learn that the technology they are working on is not as close to commercialization as they had hoped.

Although small firms differed greatly in their strategy and focal point, by virtue of their constraint of scale they were able to concentrate their effort and attention. A joint venture whose members were primarily small-scale firms was more likely to be focused on the project, since it represents a significant involvement for the member firms. These member firms were more likely to have assigned a senior person to give a relatively large proportion of time to the project to manage internal difficulties and negotiate external problems.

As would be expected, there was a recognizable division of labor among the partners involved in the ATP-funded IIH joint ventures, e.g., one group was more responsible for the business side, the other more for the technical one; or the work was divided into the healthcare part on the one hand and the informatics (e.g., voice recognition) on the other. The division of labor typically began in the proposal writing stage when each participant took responsibility for a particular domain. Thus, as a respondent explained the reasoning behind partnering, "So the two things/capabilities that they've got that we don't have are they have good connections with the local hospitals and the local medical community. And it's easier for them to do the field trials. And certainly for marketing." Beyond technological expertise is the issue of organizational capacities. Thus, the special significance of a successful joint venture lies with the capabilities to integrate diverse elements into a coherent package.

8. Interdisciplinary Collaboration or “Double Life” Individuals

Difficulties in translation from one discipline to another in IIH projects are reduced by persons on each side who have significant knowledge of the other. Thus, the presence of medical persons with significant computer knowledge facilitated projects; absence of a computer expert with medical knowledge slowed them down. Persons who combine two fields in new ways are a key to innovation in fields such as healthcare informatics that are in the early stages of development. By maintaining a "double life" these individuals are able to translate between both spheres of interest, in this case computer science and medicine. By retaining their interest in the old role even as they move into a new one, a cross-disciplinary bridge for their colleagues is created.

Crossover was observed in the IIH projects in both directions: from computer science to medicine and from medicine to computer science. A business founder described his partner, a medical doctor with a computer background: "His vision is great because he sees what happens in everyday practice and can take that to help us develop products. He can say, 'You know, it would really help physicians if this could happen.' And that's a major contribution because the other companies don't have their finger into that." There are more medical persons with significant computer knowledge then computer scientists with medical knowledge, although a computer scientist with a personal interest in medical issues was often an important impetus to involvement in a project.

A lack of these shared understandings could cause differences of interpretation of job tasks due to different expectations of task requirements in medicine and computer science. For example, transcription of the spoken word involved an entirely different degree of specificity, and cost, to linguistic experts than to medical practitioners. As expressed by a software developer, "the upside is when you get a lot more people together, you get a lot more skills. The downside is there is no central control. You know, we get in a feud about the speech data and we just sort of cut them off." A potential role for translators and brokers in the collaboration formation process might obviate the misunderstandings that arise in unsupervised courtship between potential partners from different cultures.

9. Conclusions

The ATP IIH focused program has contributed significantly to accelerating the development of infrastructural tools. It has encouraged their development from the "bottom up" rather than imposing them in a "top down" fashion, which could have resulted in restrictions on the types of technologies developed. This bottom-up approach has contributed to an environment where a more "natural" evolution of technologies has taken place from many piece-meal ideas that reflected formative, summative, and "real time" perspectives of a coherent program (in parallel with the development of standards).

The IIH focused program has also acted as a catalyst in establishing collaborations. It has brought together diverse firms and other organizations and provided them the opportunity to pursue cross-disciplinary projects. Healthcare providers, computer scientists, and information technology specialists have all participated in collaborative efforts. In several cases the collaborations that were formed included companies that never had nor, under ordinary circumstances, likely never would have worked together.

Although the ATP focuses on pre-competitive research and emphasizes broad spillover benefits, small market-oriented firms tend to view their participation in ATP projects strictly in terms of competitiveness. They typically structure their projects to satisfy research requirements, on the one hand, and the firm's product development goals on the other. Thus, a "field deployment" to assess research results also serves as an alpha test site for an emergent product. Small research-oriented firms, on the other hand, tend to need nudging to remember the longer run goals of product development. In both cases, the ATP experience tends to balance research and business goals. The experience of firms in combining the research and business objectives suggests that while distinctions

between pre-competitive and competitive, and between research and product development may be becoming less clear cut, this may be a positive development for both the competitiveness of U.S. companies and achieving ATP's broader goals.

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About the Advanced Technology Program

The Advanced Technology Program (ATP) is a partnership between government and private industry to conduct high-risk research to develop enabling technologies that promise significant commercial payoffs and widespread benefits for the economy. The ATP provides a mechanism for industry to extend its technological reach and push the envelope beyond what it otherwise would attempt.

Promising future technologies are the domain of the ATP:

- Enabling technologies that are essential to the development of future new and substantially improved projects, processes, and services across diverse application areas;
- Technologies for which there are challenging technical issues standing in the way of success;
- Technologies whose development often involves complex systems problems requiring a collaborative effort by multiple organizations;
- Technologies which will go undeveloped and/or proceed too slowly to be competitive in global markets without the ATP.

The ATP funds technical research, but it does not fund product development. That is the domain of the company partners. The ATP is industry driven, and that keeps it grounded in real-world needs. For-profit companies conceive, propose, co-fund, and execute all of the projects cost-shared by the ATP.

Smaller companies working on single-firm projects pay a minimum of all the indirect costs associated with the project. Large, Fortune-500 companies participating as a single firm pay at least 60 percent of total project costs. Joint ventures pay at least half of total project costs. Single-firm projects can last up to three years; joint ventures can last as long as five years. Companies of all sizes participate in ATP-funded projects. To date, more than half of the ATP awards have gone to individual small businesses or to joint ventures led by a small business.

Each project has specific goals, funding allocations, and completion dates established at the outset. Projects are monitored and can be terminated for cause before completion. All projects are selected in rigorous competitions which use peer-review to identify those that score highest against technical and economic criteria.

Contact the ATP for more information:

- On the World Wide Web: http://www.atp.nist.gov;
- By e-mail: atp@nist.gov;
- By phone: 1-800-ATP-Fund (1-800-287-3863);
- By writing: Advanced Technology Program, National Institute of Standards and Technology, 100 Bureau Drive, Stop 4701, Gaithersburg, MD 20899-4701.

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