ADVANCED TECHNOLOGY PROGRAM
INFORMATION INFRASTRUCTURE FOR HEALTHCARE:
Case Studies from a Focused Program

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ABSTRACT

This study investigates the organization and management of large research partnerships that form around risky, early-stage, complex technologies. It uses the cases of four such ventures that were selected for funding during the first two competitions of the ATP's Information Infrastructure for Healthcare (IIH) focused program in the mid-1990s. The main objective of the study was to indicate opportunities and problems in such partnerships and to identify operational procedures conducive to partnership success. The results of the study thus have direct implications for organizations participating in such ventures. In addition, it was an explicit goal of the researchers to provide intelligence to the Advanced Technology Program, and perhaps to other research and development funding agencies, for improving future project selection and monitoring procedures. While it is certainly impossible to guarantee the success of research projects ex ante, it can be strongly argued that efficient selection and monitoring procedures would raise the chances of success.

EXECUTIVE SUMMARY

This study focuses on the organization and management of large research partnerships that form around risky, early-stage, complex technologies. The main objective of the study was to indicate opportunities and problems in such partnerships and to identify operational procedures conducive to partnership success. The results were intended to provide intelligence to the Advanced Technology Program (ATP), and perhaps to other research and development (R&D) funding government agencies, for improving future project selection and monitoring procedures.

We chose the case study method to achieve these objectives. More specifically, we searched for "coupled pairs," that is, ventures that are as close as possible in terms of every dimension but the dimension(s) the study focuses on (organization, management). The coupled pairs chosen for this study consisted of two sets of research partnerships selected for funding during the first two competitions of the ATP Information Infrastructure for Healthcare (IIH) focused program: the SCRA research partnerships and the KOOP research partnerships (our terminology).[1]

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The SCRA research partnerships are made up of two ventures organized with the initiative of the Healthcare Open Systems and Trials consortium (HOST):

- the Healthcare Information Infrastructure Technology venture (HIIT), a winner in the 1994 IIH competition, and
- the Healthcare Information Technology Enabling Community Care" venture (HITECC), a winner in the IIH competition of 1995.

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The KOOP research partnerships comprised two ventures organized with the initiative of the C. Everett Koop Institute, later renamed Koop Foundation Inc. (KOOP):

- the Health Informatics Initiative venture (HII), a winner in the 1994 IIH competition, and
- the Health Object Library On-Line venture (HOLON), an IIH competition winner in 1995.

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The SCRA research partnerships and the KOOP research partnerships shared many common features:

- *Composition*. Each set comprises a pair of 3-year research partnerships, both motivated by the same nonprofit organization.
- *Technology*. The research partnerships in both sets aimed at developing appropriate information technology infrastructure for the healthcare community, including providers and users of healthcare.
- *Continuity*. The research objectives of the two research partnerships in each set were related. In both cases, research objectives were clearly influenced by the debates on the National Information Infrastructure and healthcare reform in the United States in 1994 and 1995.
- *Timing*. The two ventures in each set were funded in the focused competitions of 1994 and 1995, respectively.

[1] The South Carolina Research Authority later changed its name to the Advanced Technology Institute.

- *Membership*. Both sets of research partnerships were inclusive, involving all kinds of stakeholders, including large and small firms and universities, product suppliers, and prospective users/validators.
- *Budgets*. The ATP funding of the ventures in each set and the cost-sharing levels of the partners were fairly similar.

However, the SCRA ventures and the KOOP ventures started out with very dissimilar organization and management procedures. The SCRA research partnerships used a classic hub-and-spoke organizational structure, but the KOOP research partnerships were set up on a model of a weak organizational center surrounded by concentric circles of research partnership members and subcontractors.

The investigated ventures featured "model" characteristics for government-sponsored cooperative R&D: (a) they addressed an area of perceived market failure due to the nature of the required research, best described as uncertain, broad, and infrastructural; (b) they focused on resolving technology problems of generic interest to large numbers of partners (collective infrastructure solutions, "middleware switch"); and (c) firms unable to justify heavy investments in the fluid, high-risk, high-potential technological area of information infrastructure for healthcare joined the partnerships to explore the field and create options for possible future investment.

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In both cases, the interviewees strongly indicated that their organizations benefited substantially from the commercialization of specific technologies developed in or accelerated by the R&D undertaken in the examined research partnerships. However, neither the SCRA nor the KOOP ventures managed to produce the collective infrastructure solutions that partners had sought from the start—the middleware (the "interface technology switch," that would open the wonderful world of vast, shared healthcare information to prospective users. There are currently no signs that the private sector will reach that goal anytime soon.

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The ATP Role

Specifically regarding the role of the ATP in the examined research partnerships, the comments of the interviewees were generally th positive, reflecting several observations:

- The ATP served as a catalyst to bring partners together.
- The ATP's presence during the early parts of the projects assisted the research partnership management teams in maintaining their development schedules.
- ATP administrators did not micromanage, thus avoiding biasing the research results.
- ATP funds provided the incentive for potential competitors to work together.
- ATP funds tended to encourage large, risk-averse companies to pursue long-term, risky, ambitious technologies. When this happens, the market takes notice. The leverage of expended funds is considerable.
- ATP participation assisted smaller research partners in thinking strategically and becoming involved in research activities well beyond their means.
- The ATP's decision to focus a program on a broad technology area such as healthcare informatics was instrumental in focusing industry's attention. Many of the core issues in the focused program remain relevant, especially issues of security and data compatibility.

- A major impact of the ATP in emerging sectors such as healthcare informatics reflects the contribution to clarifying expert expectations of technology evolution as early as possible. Firms join research partnerships in emerging sectors to use them as mechanisms to place their technological bets and open up options to new technologies. The public and private sectors can coalesce to create points of leverage for the basic building of such a sector.
- The ATP's role is valuable in technology areas that are still in their infancy.

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1. INTRODUCTION

The Advanced Technology Program (ATP) at the National Institute of Standards and Technology (NIST) supports the development and application of high-risk, enabling technologies with strong potential for broad-based U.S. economic benefit. The ATP is a cost-sharing program designed to partner the federal government with the private sector. Since its initiation in 1990, the program has supported research undertaken by both individual firms and research partnerships.[2] Industry proposes research projects to the ATP, and the proposals are judged in competitions for funding based on both the technical and the economic/business merits of the proposal.

During 1990–2001, the ATP held open competitions each year for all technologies. From 1994 to 1998, however, the ATP awarded most of its funding through focused-program competitions in which a suite of projects was funded to mobilize enabling technology to address a particular issue. The ATP defined focused programs as follows: "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."[3]

The focus technology area was determined through an elaborate process involving the submission of large numbers of white papers followed by a long iterative process between the agency and all stakeholders.[4] This bottom-up procedure aimed at developing consensus regarding a perceived market failure in the provision of research and development (R&D) funds. Thirty focused-program competitions were held during 1994–98, each with a unifying set of project goals. One of these programs was the Information Infrastructure for Healthcare focused program (IIH), which conducted proposal solicitations in 1994, 1995, and 1997. Initiated amidst a nationwide discussion of the rising costs of healthcare and the quality of care offered, the IIH focused-program purpose was to develop the information infrastructure technologies needed to decrease the amount spent on paperwork, thus improving the quality and flexible delivery of care by faster broad access to better information and complementing the activities surrounding the development of the National Information Infrastructure (NII)[5] (Lide and Spivack 2000). In the United States, more than $1 trillion is spent on healthcare. Approximately 20 percent of that is spent on paperwork (U.S. Department of Commerce, 1996)

[2] In this paper the terms Ventures, Joint Ventures, Consortia, and Partnerships are used interchangeably.

[3] From the ATP's inception in 1990 through the final competition of 2000, the "General Competition" format of collecting all proposals under one annual solicitation (and then subdividing them by a technology taxonomy) was in effect. This was replaced in 2002 by the "Gated Process" of proposal solicitation by which proposals are solicited several times in one fiscal year.

[4] Papers were submitted by companies, business associations, university professors, members of think tanks and other organizations, and private citizens.

[5] The NII requires building foundations for living in the Information Age and making these technological advances useful to the public, business, libraries, and other nongovernmental entities. The NII is more than just the physical facilities used to transmit, store, process, and display voice, data, and images. It encompasses a wide and ever-expanding range of equipment—including cameras, scanners, keyboards, telephones, fax machines, computers, switches, compact disks, video and audio tape, cable, wire, satellites, optical-fiber transmission lines, microwave nets, television, monitors, printers, and much more.

For ATP's purposes, information infrastructure development was defined to include (a) the integration, synthesis, and definition of any information that needs to be shared across the enterprise; and (b) the means by which to transport, store, and access that information in a way that enhances, rather than impedes, user productivity (U.S. Department of Commerce, 1994)

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This study focuses on the organization and management of large research partnerships (consortia) that form around risky, early-stage, complex technologies. The main objective of the study was to indicate opportunities and problems in such partnerships and to identify operational procedures conducive to partnership success. The results were intended to provide useful intelligence to the Advanced Technology Program (ATP), and perhaps to other research and development (R&D) funding government agencies, for improving future project selection and monitoring procedures. The willingness of representatives from several participating organizations interviewed for this purpose has assisted tremendously in deepening our understanding of these important, yet elusive, issues in what makes a cooperative R&D effort successful.

We chose the case study method to achieve these objectives. More specifically, we searched for "coupled pairs," that is, ventures that are as close as possible in terms of every dimension but the dimension(s) the study focuses on (the organizational and management aspects of large ventures). We investigated four large research partnerships selected for support by the IIH. Two of these research partnerships were conceived by the Healthcare Open Systems and Trials consortium (HOST) and led by the South Carolina Research Authority (SCRA),[5] one each for the periods 1994–97 and 1995–98. Likewise, two research partnerships were led by the Koop Foundation, Inc., one each for the periods 1994–97 and 1995–98.[6] For convenience, we will refer to the former two as the SCRA ventures and the latter two as the KOOP ventures. The SCRA and KOOP research partnerships worked in parallel (but independently) on the development of information infrastructure for health enterprises and emergent community health systems as well as the appropriate tools to support such infrastructure. However, they pursued their objectives through strikingly different organizational structures. The KOOP research partnerships started with a broader and more flexible concept of the process of technological advance in the healthcare information field and, accordingly, a looser organizational scheme than the SCRA research partnerships. Based on extensive review of the available documents and several personal interviews, this paper recounts the incentives to create the SCRA and KOOP research partnerships, the way they operated and perceived success and failure factors, and the role of the ATP in setting up the partnerships and maintaining momentum.

The rest of the paper consists of four sections. Section 2 summarizes the technical and business goals of the ATP's focused program in IIH. Section 3 describes the research objectives and approach. In the fourth section, the SCRA and KOOP research partnerships are analyzed in some detail. Finally, a summary and lessons learned are provided in the fifth section.

2. THE IIH PROGRAM[7]

The ATP Information Infrastructure for Healthcare (IIH) focused program, which held the first of three solicitations beginning in 1994,[6,7] was directed towards the development of "tools" and prototype systems that facilitate requirements analysis, demonstrate interoperability and scalability, and enhance the flow of information in the healthcare enterprise. Technologies proposed under the first solicitation in this program were directed towards the capture and organization of user requirements as well as development of varying forms of user information repositories. Any tools, prototypes and demonstrations developed under this solicitation should therefore have satisfied the criterion that they optimize and accelerate infrastructural development. They should be tailored to acquiring and organizing knowledge from healthcare providers, but should be reusable for building other infrastructures in other domains.[8] They should also be useful both for designing the infrastructure and for modifying it as a result of lessons learned from actual use.

The *ATP Information Infrastructure for Healthcare Focused Program* solicitation kit (U.S. Department of Commerce, 1994) identified the program's goals as follows:

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Technical goals. To establish the technologies for

- reliable storage and retrieval of complex medical information for varied applications;
- real-time, data-driven medical decisions;
- real-time data entry by mobile medical personnel;
- real-time global transport of complex medical records with accuracy, speed, and security; and
- computer-based medical training, diagnostic, and reference tools.

Business goals. To advance the capability to develop products that will:

- reduce unit healthcare costs,
- improve quality of healthcare (higher treatment success rates, avoidance of complications),
- capture global market share of new and improved products and services, and
- undertake infrastructural development focusing on tools and prototype systems to enhance information flow among existing "legacy" systems in healthcare, ranging from a single provider's office to a fully integrated healthcare system.

Table 2.1 provides summary statistics from the three IIH solicitations between 1994 and 1997. R&D funding totaled $295 million, representing a commitment of $146 million from the ATP and $149 million from the private sector. The four research partnerships covered in the case studies below represented a major part of this funding. Together, they received approximately

[6] This program was initially scheduled for three solicitations with each competition addressing a different level of the infrastructural needs necessary to accomplish the goals as spelled out in the initial solicitation kit. Due to a variety of factors including program budgeting, as well as significant paradigm shifts in the information industry, this program has now completed three competitions in four years addressing the first two levels solely. The prospect of a fourth competition in which the third level will be addressed in the future remains a possibility.

[7] In response to the three solicitations held, 28 awards have been made to 76 participants representing a commitment of $146.5M from the government and $149.2M from the private sector.

[8] One of the ATP requirements is that any funded technologies should be able to find use in more than one industrial sector...this is believed to contribute to a greater economic growth potential of the US economy.

$34 million of distributed ATP funds in 1994 (47 percent of the total for IIH) and approximately $30 million in 1995 (48 percent of the IIH total). To this, they added $37 million of private R&D funds in 1994 and $30 million in 1995.

TABLE 2.1. *IIH Focused Program participation, 1994, 1995, 1997*

	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	10	7	6
Joint venture	6	3	
Total number of participants	40	32	6
Type and size of organization			
For-profit small company	17	12	6
For-profit medium-size company	6	4	
For-profit large company	6	5	
Nonprofit	7	8	
University	4	3	

3. RESEARCH METHODOLOGY

It is well established in the literature that large, diverse research consortia do not typically lend themselves to the development of specific products. Rather, multiparty partnerships are appropriate for combining the diverse resources and capabilities required to advance the state of the art in early-stage technologies and create standards, thus decreasing the uncertainty among individual agents (Hagedoorn et al, 2000; Vonortas. 1997). Moreover, the literature has emphasized several important characteristics of cooperative R&D:[9]

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- Early-stage research partnerships can often be viewed as technology search engines: firms unable to justify heavy investments in fluid, high-risk, high-potential technological areas may join one (or more) research partnerships to explore the field and create options to invest more in the future.
- For many firms, research partnerships provide a vehicle to leverage internal funds and gain access to complementary resources of their partners. Public support may particularly assist small firms in their initial attempt to join a research partnership by substituting for their lack of experience and reputation.
- Government agency missions (aside from national defense) typically provide incentives for concentrating public funding of collaborative research of a more generic and infrastructural nature.

[9] For extensive literature reviews see Caloghirou et al. (2003), Contractor and Lorange (1988), Dodgson (1993), Hemphill and Vonortas (2003), Link and Bauer (1989), Nooteboom (1999).

The combination paints a picture of publicly-supported research partnerships to encourage experimentation with early-stage infrastructrural technologies. This is reflected in the objectives of ATP's IIH program.

This study concentrated on the organization and management of large research partnerships that form around risky, early-stage, complex technologies. The main objective was to indicate opportunities and problems in such partnerships and to identify operational procedures conducive to partnership success. We chose the case study method to achieve these objectives. More specifically, we searched for "coupled pairs," that is, ventures that are as close as possible in terms of every dimension but the dimension(s) the study focuses on (organization, management). Screening of the research partnerships supported by the IIH focused program and completed by the year 2000, and taking advantage of the domain knowledge of one of the authors, singled out four of them as the best candidates. These ventures had been selected for funding during the first two competitions of the ATP's IIH focused program. Two of these research partnerships were led by the SCRA: the Healthcare Information Infrastructure Technology venture (HIIT) was a winner in the 1994 IIH competition, and the Healthcare Information Technology Enabling Community Care venture (HITECC) was a winner in 1995. The other two research partnerships studied were organized with the initiative of KOOP (the C. Everett Koop Institute, later renamed the Koop Foundation Inc.): the Health Informatics Initiative venture (HII) was a winner in the 1994 IIH competition, and the Health Object Library On-Line venture (HOLON) was a winner in 1995.

The SCRA and KOOP research partnerships shared many common features (which make them a "coupled pair"):

- *Composition*. Each set comprises a pair of 3-year research partnerships, both motivated by the same nonprofit organization.
- *Technology*. The research partnerships in both sets aimed at developing appropriate information technology (IT) infrastructure for the healthcare community, including providers and users of healthcare.
- *Continuity*. The research objectives of the two research partnerships in each set were related. In both cases, research objectives were clearly influenced by the debates on the NII and healthcare reform in the United States in 1994 and 1995.
- *Timing*. The two ventures in each set were funded in the focused competitions of 1994 and 1995, respectively.
- *Membership*. Both sets of research partnerships were inclusive, involving all kinds of stakeholders, including large and small firms and universities, product suppliers, and prospective users/validators.
- *Budgets*. The ATP funding of the ventures in each set and the cost-sharing levels of the partners were fairly similar.

The major differences between the two sets of ventures related to organization: even though the KOOP and SCRA joint ventures operated in the same technological area, they started out with diametrically different organizational approaches. The SCRA research partnerships used a classic hub-and-spoke organizational structure, featuring a strong administrative core that undertook all managerial, reporting, and communication tasks and several semi-independent technology spokes, each led by a company retaining responsibility over technological advance and commercialization of the results. The KOOP research partnerships were set up on a model

of a weak organizational center surrounded by concentric circles of research partnership participants and their subcontractors. This organizational structure promoted the innovation potential of smaller, dynamic companies while depending on larger participants for commercialization. It also allowed for frequent redefinition of the organizational structure and the alliances among research partnership members as they confronted "waves of cascading innovation" (a term favored by the project champion).

The study is based on three sources of information:

1. the proposals of the four research partnerships that won the two competitions,
2. periodic progress reports from the partners, and
3. interviews conducted with key individuals from seven participating organizations, including core representatives of the SCRA and KOOP. The interviews were carried out during the fall of 2000 and spring of 2001.)

Table 3.1 lists the core members of the four research partnerships as shown in their original research proposals. Membership changed somewhat during the lifetime of the projects, and this is discussed later in this paper. In addition, other organizations got involved in some research components as subcontractors.

TABLE 3.1**.** *Research partnership membership (as proposed to the ATP)*

KOOP(HII), 1994	KOOP(HOLON), 1995	South Carolina Research Associates	South Carolina Research Associates

		(HIIT), 1994	(HITECC), 1995
C. Everett Koop Institute	Oracle Corporation	SCRA	SCRA
Analytic Services, Inc. (ANSER)	Southern New England Telecommunications Corp. (SNET)	GE Research (formerly General Electric Corporate R&D)	Shared Medical Systems Corp. (SMS)
Oracle Corporation	Beth Israel Deaconess Medical Center–Harvard Medical School	Microelectronics & Computer Technology Corp.	GE Research (formerly General Electric Corporate R&D)
Logicon Inc. Strategic & Info Systems	Norwalk (CT) Hospital	Windom Health	Technology 2020
D. Appleton Co., Inc. (DACOM)	Meta Software Corporation (META)	TransQuick, Inc.	University of Florida, Dept. of Anesthesiology
Science Applications International Corp. (SAIC)	Lumina Decision Systems	Coleman Research Corp. (CRC)	Charleston Area Medical Center, Inc.
Wizdom Systems, Inc.	Rice University, the Forefront Group		University of Maryland, Baltimore
Corporation for Studies and Analysis (CSA)	Wizdom Systems, Inc.		Connecticut Healthcare Research and Education Foundation, Inc. (CHREF)
AT&T	Talisman Dynamics, Inc.		Bellsouth Telecommunications
META	IntelliTek, Inc.– George Washington University Medical Center		Advanced Radiology
Ogden Government Services			
Systems Research and Applications Corp. (SRA)			
Booz-Allen & Hamilton, Inc.			

4. CASE STUDIES OF IIH-SPONSORED RESEARCH PARTNERSHIPS

In the early 1990s, healthcare IT was a mix of vendor-supplied and home-grown customized software. The healthcare community was facing a major challenge: how to evolve its existing, fragmented information systems into a unified, effective system while continuing to provide quality care. The American Hospital Association advocated the establishment of a National Health Information Infrastructure (NHII), which was considered imperative for realizing the fullest benefit from health information. Failure to address this need would perpetuate the insular approach to building local and community health information networks. The lack of an integrated computerized system of healthcare provision was becoming increasingly costly (American Hospital Association 1992).

Even though there was already a trend toward cooperation among health providers to offer a seamless continuum of care, this required sharing of medical information and communication across different sites, which in turn required revamping and retooling the existing electronic infrastructure. Integrated information systems would be critical for the community care networks of the future. Such integration would also require appropriate business process changes to support it.

A realignment of the industry's ongoing business was a necessary, but insufficient, means for changing its existing information environment into one that supports the emerging virtual healthcare enterprises. Major barriers included deficiencies in a coherent methodology to employ a new system, a systematic way to represent medical knowledge, consistent and widely accepted semantics to represent functions and relationships, and strong market incentives for healthcare application providers to operate in an open environment.

The inadequacy of the tools and technologies available at the time for providing the required integration and the lack of market incentives led many to advocate seting up cooperative efforts involving industry, academia, and government to tackle the problem. The ATP's IIH program presented at that time a conduit for organizing such broad-ranging cooperation and leveraging scarce public sector resources with the resources of the private sector. Attracted by the opportunity, the private sector moved to organize large research consortia to tackle the problem.

4.1. Case Study I: SCRA Research Partnerships

4.1.1. HIIT

Rationale

The Healthcare Open Systems and Trials consortium (HOST) was created as the healthcare arm of the Microelectronics and Computer Technology Corporation ((MCC), itself a research consortium formed in 1982 to address international competitiveness problems facing American companies in this sector. In early 1994, the MCC and the Computer-Based Patient Record Institute (CPRI) collaborated in the founding of HOST to address these problems, influenced by the healthcare reform proposals that were being widely discussed at the time. The consortium was activated to assist communications among the different parts of the healthcare industry by creating the necessary IT infrastructure and tools to deliver its services more effectively and

decrease costs. HOST aimed at addressing the industry's problems by accelerating the development and adoption of open, integrated healthcare systems, focusing especially on the computerized patient record.

ATP's focused program in IT tools for health care was initiated around that time to operate as a catalyst, an external force focusing the public's attention on the coming changes in the industry and the perceived technology gaps. HOST decided to enter the first focused-program competition in 1994 with a cooperative research proposal that included several of its members as partners. The result was the HIIT research partnership. The HIIT's objective was to develop the infrastructure tools to accelerate the adoption of open systems, enabling the emergence of the virtual health care enterprise.HIIT partners pledged to contribute more than $22 million in matching funds for the duration of the program (3 years). The total request for ATP funds was approximately $20 million. ATP funding was considered critical by our interviewees as an incentive to bring the partners together: No single healthcare organization or IT supplier could, it was argued, afford to integrate the many elements of the healthcare environment. Without the ATP's support, system development would have been fragmented and slower, according to our interviewees, leaving the healthcare system riddled with inefficiencies, service duplication, and high administrative paperwork costs.

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Joint venture participants included large, medium, and small businesses, telecommunications companies, inner-city hospitals, government alliances, universities, and prestigious medical centers. HOST participants from the program's 35 member organizations included healthcare providers, telecommunications executives suppliers, vendors, hardware and software developers, and researchers.

Organization

The SCRA, a seasoned company in consortium management, became the HIIT's overall program manager and facilitator. The SCRA joined the effort while the proposal to the ATP was being formulated. They took over the responsibility for the administrative and the strategic planning parts of the program, thus becoming the central node of the network—organizing the parts of the consortium, arranging budgets, setting up business meetings, completing paper work, and reporting.

The research strategy of the HIIT evolved from the successful interaction among three major components in a hub-and-spoke organizational model:

- A central *hub* with HOST's Open Systems Laboratory (OSL) to provide common services and validate interoperability during the R&D phase and a vehicle to spur commercialization later on.
- *Spokes* consisting of teams of partners combined under infrastructure technology projects:
  - General Electric (GE) teamed with the Statewide Health Information Network (SHINE) and Liberty Medical Group to form Healthcare Electronic Commerce Services. The purpose of the project was to create automated workflow and electronic commerce services (ECS) tools for healthcare enterprises. The targeted market was the small private practice and its basic connectivity to hospitals, health

maintenance organizations (HMOs), and indemnity insurers. The goal was to ensure that the right clinical, administrative, insurance/financial, and statistical/analytical data would get to the right person or automated application at the right time.

- Coleman Research Corporation (CRC) teamed with Bellsouth, the New Jersey Institute of Technology, and the Medical University of South Carolina to form Enabling Distributed Rural and Remote Diagnostics. The purpose of this project was to create tools for remote and distributed clinical database access and associated tools such as object-oriented vocabulary server tools. The primary thrust for tool development was "one door data access," that is, one-workstation access for heterogeneous multiple database linkages, data organization, and data employment.
- MCC teamed with the University of Georgia, and the Connecticut Healthcare Research and Education Foundation (CHREF) to form Healthcare Enterprise Information Modeling (HEIM). This project was targeted at creating tools for business process, information, and workflow modeling. The goal was to address the many business processes that have been automated, but in an ad hoc manner, without standards, and with much duplication of function and effort among geographically distributed healthcare providers.
- Windom Health teamed with the Western Consortium for Public Health, Systems Enterprise, Inc., Drew University of Medicine, and a number of small businesses to form Health Interoperations Prototype Systems. This project was targeted toward community health promotion and disease prevention through development of a set of tools that would enable representation of reusable knowledge about component behaviors within the public health environment. The technologies would address diverse age groups and special populations that require customized programming for effective results, as well as sectors that affect the population's health status and are involved in activities to improve it.[8]
- TransQuick, Inc. teamed with the University of Florida, the Medic Alert Foundation, and the Johns Hopkins Medical Center to form Medical Specialty Knowledge Bases and Medical Data Capture. The purpose of this project was to overcome barriers to the development of a computerized patient record by advancing a cost-effective mechanism for capturing necessary clinical information on-line. Recognizing the existence of multiple technologies that assist in data capture (e.g., voice recognition, personal digital assistants, hand-held devices), this project would develop multiple, flexible user interfaces to meet the diverse and specialized needs, requirements, and environments of healthcare providers.

- A *Technical Review Council* to ensure the overall quality of the projects and tight teaming among spoke team members: Members of the council included senior technical members of the research partnership and experts from the ATP, healthcare, universities, and industry.

Spoke leaders (all HOST members) assumed responsibility for their respective technical projects and implementation of the major components of the commercialization plans. The overall program facilitator, the SCRA, was responsible for the management of the dispersed partnership and communication with the ATP. The Technical Review Council was set to meet quarterly to review technical quality, provide recommendations, and file status reports.

Partners were fully aware that the protection of intellectual property was necessary to ensure appropriate incentives. They established four general rules for protection of intellectual property rights (IPR):

- Those who pay for the development of intellectual property would have basic control over it.
- Background technology is controlled by the owners. Foreground technology is controlled by the developer to the extent allowed under ATP rules.[9]
- Each team developing intellectual property would do so under a contractual binding agreement. Intellectual property developed in the program would be available to other members at preferential licensing fees within 3 years from development.
- Nonconfidential information on a technology developed in a program (i.e., what was developed and why, but not how it was developed) should be available to all members of the research partnership.

4.1.2. HITECC

Rationale

HITECC was conceived by HOST to develop and demonstrate the information mechanisms needed to turn fragmented, paper-based healthcare data into a community-wide, computerized information resource that provides secure and simple access to integrated, multimedia information across local and wide-area networks. In other words, HITECC aimed at user-friendly access to geographically distributed, multimedia healthcare information with multiple owners.

HITECC partners pledged to contribute approximately $20 million in matching investments. They requested an equivalent contribution from the ATP for the duration of the program (3 years). According to our interviewees, progress toward the professed goals would have been markedly slower without ATP support. Moreover, it was argued, proprietary interests would have been expected to fragment development and inhibit rapid deployment of open systems. Open system development was encouraged by the ATP as a means of enhancing the economic benefits of the technology.

Organization

HITTEC focused on the development and demonstration of technology to interface with existing healthcare information systems and provide community-wide, secure sharing of multimedia information across local and wide-area networks. It concentrated its efforts on three technology areas:

1. *Integrated multimedia functionality* for providing efficient, user-friendly capture, use, and management of integrated multimedia, including (a) a fully automated voice-to-report capability that eliminates the need for manual transcription, (b) multimedia visualization, and (c) multimedia information management (storage, retrieval, archiving, data compression, system interoperability);

2. *Community-wide, secure information sharing* aimed at providing the mechanisms for an effective balance between protection and user-friendly, efficient access of healthcare information; and
3. *Collaborative computing* aimed at providing reliable and cost-effective techniques to support the transmission of high-resolution imagery across communication lines, enabling medical specialists' access to provide real-time consultation from a distant location.

HITECC was an industry-led research partnership, incorporating healthcare providers, suppliers, vendors, hardware and software developers, and researchers. Its core strength was the assembly of industry leaders in technology solutions development and implementation and healthcare providers, many of whom had collaborated previously—most notably in the related HIIT consortium. Technical leadership rested on GE Research, Lockheed Martin, and Bellsouth. They were responsible for each technical project and the implementation of the major components of commercialization plans. According to the initial plan of the venture, Lockheed Martin acted as the overall technical director. As with the HIIT, the coordination and administrative activities were facilitated by the SCRA.

HITECC called for iterative cycles of development, trials, and refinement of the technologies and products between producers and users (healthcare providers). Users were included in the work teams to define requirements and test the resulting technologies, thus accelerating prototyping and technology acceptance. In addition, HITECC members resolved to market products through well-established sales and distribution networks and via alliances with both vendors and communications companies. Commercialization of technology among team members would include direct sales, licensing, and site licensing.

HITECC adopted IPR protection mechanisms similar to those of the HIIT. In addition, it was determined that HITECC and the HIIT would form a joint Technical Review Council, with similar composition to that for HIIT, to review technical progress and provide feedback. The joint council would meet quarterly. HITECC's System Integration Group, composed of the focus-area project leaders and the overall HITECC manager, convened quarterly to review integration and interoperability issues across the three research projects.

4.1.3. The Process of Cooperation in SCRA Research Partnerships

HOST served as the proposal inspiration and strong advocate of the thematic concentration of both the HIIT and HITECC. It also engaged in some brokering to bring partners in and set them up. However, HOST's research role in the consortia turned out to be fairly small. The SCRA primarily operated as facilitator and implementer—a professional manager, but it also possessed strengths specific to the research domain of the two research partnerships. The SCRA eventually replaced HOST as the core administrative organization mediating the dialogue with the ATP and dispensing ATP funds to consortia members.

The relationship between the core administrative organization in the two research partnerships and the core technical partners had positive and negative features. Early in the life of the ventures, the technologists at the different participating organizations were largely relieved

because the SCRA took responsibility for all organizational and reporting matters, leaving them with more desirable technical work. According to the interviewees, everyone also seemed to recognize that strong leadership was necessary in administration. The SCRA successfully completed reports and managed meetings and schedules.

The meetings of both research partnerships led by the SCRA were held simultaneously at the same location, bringing together many organizations and researchers. This facilitated knowledge spillovers not only within a research partnership but also across ventures. Meetings focused on the technical aspects of the projects. At the height of the activity, such meetings created a lot of excitement, bringing together about 100 very qualified researchers and doctoral students.

As time went on, however, the SCRA's management style reportedly caused dissatisfaction among partners who felt left out of important business decision-making. There was a feeling that the SCRA was too secretive. Some participants from small companies operated under the impression that the SCRA was the contractor and all others were simply subcontractors. Large, core partners seemed to pull the technical strings with little input from others, while claiming that "every one at the table had an equal vote [and that] decision making on the technology side was absolutely egalitarian."[10]

Commercialization plans for HIIT and HITECC outputs depended on several features of the partnerships:

- In each technology project, developers were paired with healthcare sites to provide rapid feedback and points of market entry, instant market, and immediate feedback.
- The diversity of healthcare sites would ensure the production of broadly targeted technologies with widespread applicability.
- HOST was expected to provide high visibility to industry because it represented—together with the CPRI—a significant share of the healthcare market.
- Each spoke and project leader had specific plans to support commercialization activities. Technology leaders used a variety of approaches to commercialize technologies, including direct product sales and licenses.

Interviewees expressed strong opinions that, by and large, the subject matter and output of both research partnerships were important to the participating organizations. Several of the ventures' technologies were reported to be at different stages of commercialization at the time of the interviews. They include a voice recognition system for radiologists that allow for dictation of reports on the spot, instead of transcribing them; systems for picture archiving and recognition; technology enabling night radiology (i.e., collecting several hospitals' radiology readings at a single location and processing them overnight); solutions to finding a trading match in the network (i.e., helping trading partners find each other); interactive voice systems to enroll in a service and check the status of claims electronically on the Internet, and so forth.[11]

Interviewees, however, also stressed that most research partnership benefits have been different from what was expected and difficult to quantify. The research undertaken by the two research partnerships was primarily process oriented (the individual organizations preferred keeping the supply of critical equipment proprietary), making it difficult to point out individual new

products that can be directly and exclusively attributed to the specific cooperative R&D effort. Benefits were argued to be primarily intangible, particularly in terms of contributing to strategic decision making within the firm. With better understanding of the technological trends, participating firms could more efficiently gauge the future, thus making fewer strategic mistakes and allocating resources better. An example is the heightened interest of GE Research in healthcare informatics, which raised the company's willingness to invest more of its own resources in the field. This resulted in the development of the company's management consulting business in medical informatics.

Moreover, collaborative work in the HIIT and HITECC established the understanding that interoperability is not exclusively a technical problem in the narrow sense but hinges on cultural and linguistic factors, including syntax and language differences among the different medical specialties. Finally, business process reengineering was a big part of the work of the two research partnerships, reportedly providing important benefits to the participants' operations.

In the past few years, the Internet has vastly increased the ability to share data. Still, the core concern of the HIIT and HITECC with technical interoperability remains a major factor in the healthcare industry.

4.2. Case Study II: KOOP Research Partnerships

4.2.1. Health Informatics Initiative (HII)

Rationale

The HII consortium aimed at establishing a cooperative effort among industrial, academic, and government partners committed to the development of a comprehensive architecture that would both accommodate state-of-the-art information technologies and enable the advance of future infrastructure development technologies. The purpose of the venture was to enable the development of an information infrastructure for health enterprises by engaging in

- *health domain analysis* for identification and analysis of various subsystem components of the healthcare field;
- *business process reengineering (BPR)*, aiming at the definition of an enhanced BPR life-cycle methodology tailored to the needs of the health industry and capable of producing systems that exploit emerging NHII services;
- *knowledge base development* to define and prototype a health enterprise metamodel and a health information infrastructure knowledge base (The metamodel would provide a standard, object-oriented, open model to integrate data, process, organization, and functional control capabilities for BPR.); and
- *integrated BPR toolset development*, aiming at the definition and prototyping of an integrated set of tools that supports the full life cycle of enterprise planning, business process improvement, generation of information support capabilities, and deployment of NHII services.

The HII was selected for funding by the ATP during the focused competition of 1994. HII partners pledged to contribute approximately $15 million in matching investments. They requested close to $14 million from ATP for the duration of the program (3 years). ATP funding was considered the necessary catalyst for industry to produce an integrated toolset to perform business reengineering in healthcare. The lack of ATP funding would have resulted in the continuation of independent efforts producing a limited range of integrated tools. Without ATP support, the scope of the project would diminish because participants would direct their R&D dollars toward development of tools to optimize the individual companies' markets.

Organization

KOOP conceived the initiative and mastered strong corporate support for the HII. Several kinds of organizations were part of the consortium, including both large and small firms and universities. Many participating companies were among the leaders in their respective fields. The organizational structure of the HII combined the technical strengths of BPR methods and tool developers, informatics developers (telecommunications, software), and healthcare providers and validators. (See table 3.1 for a list of core participants.) A number of academic institutions also participated as subcontractors.

With an allocation of 10 percent of HII funds, KOOP was tasked with administration, project management, and technical oversight. Initially, a not-for-profit company, ANSER, was assigned to work with industry participants and KOOP to establish the administrative support structure for the consortium. ANSER would assist KOOP and the HII team in the definition phase of the project, as well as provide such services as project management, coordination between the ATP and the participants, and administrative support, including legal, accounting, and contracts. However, ANSER did not participate in the project, and instead their stated functions were assumed by KOOP.

Three specific project research tasks were undertaken by groups of intercompany technical teams, each led by an industrial member with special expertise. The SRA championed the requirements and specifications task, and DACOM championed the technology development task. AT&T was responsible for the validation and linkages task.

A steering committee, made up of the senior technical representatives and the project manager, was the primary management group of the joint venture, integrating the overall technical and administrative management.

A Comprehensive Industry Review Board was planned to convene at the end of each year of the project. This board served as a key deployment mechanism for technologies to U.S. suppliers and in reported nonproprietary project results.

Finally, KOOP would serve as the archive and clearinghouse for all new technology developed by HII partners. This function was said to help protect the partners from the leakage of proprietary information among competitors and avoid disseminating newly developed intellectual property outside the United States. For security purposes, technology developers were required to work with KOOP in submitting reports, specifications, and designs.

4.2.2. HOLON

Rationale

HOLON's research focused on developing an essential middleware framework for the health care information systems infrastructure. This included the general architecture that specifies necessary organization, functions, and interfaces for secure collaborative access, as well as a reusable, object-class library (HOLON) to support companies in developing healthcare applications. The venture aimed at providing "… the glue for creating a three-way team among consumers, providers and the larger healthcare system."

The core objective was to integrate several of the emerging knowledge systems; intelligent, object-based communication schemata and healthcare processes; and component tools with an innovative infrastructure that would support interoperability, and "anywhere, anytime, any form" access to information and intelligent decision support.

HOLON was selected for funding by the ATP in the focused competition of 1995. HOLON partners pledged to contribute approximately $10 million in matching funds. They requested almost $10 million from the ATP for the duration of the program (3 years). ATP support was argued to be necessary for augmenting the financial resources of existing firms and bringing them together to exploit technical synergies, thus enabling the development and marketing of the next generation of healthcare IT. Government intermediation was considered essential to sensitize the private sector to the need for this kind of R&D and overcome high technical risk. The private sector reportedly lacked the appropriate incentives to proceed on their own. The lack of ATP funding would have resulted in diminishing the scope of the activity because participants would direct their R&D dollars toward development of tools to optimize the individual companies' markets.

Organization

KOOP conceived the HOLON initiative and led the consortium. Various kinds of organizations were part of the consortium, including both large and small firms and universities. (See table 3.1 for a list of core participants.)

The original HOLON management plan identified KOOP as the convener and administrator of the venture, which involved financial and general administrative responsibilities. The plan called for the establishment of an executive committee, the Project Steering Committee, with voting representatives from all partners and a nonvoting seat for KOOP. The Project Steering Committee would be the highest body of the consortium.

The Project Operations Committee, operating under the Project Steering Committee, was responsible for continuously overseeing progress in the technology tasks. This committee was made up of representatives from two large corporate partners (Oracle and SNET) plus a representative from the Center for Clinical Computing at Harvard with domain expertise on doctors' and hospitals' needs.

The technology tasks were to be performed by groups of interpartner technical teams. Three such tasks were determined:

1. *Design and integration*. This task was led by the participating healthcare group (Beth Israel Deaconess Medical Center and the Center for Clinical Computing, Norwalk Hospital, and Windom Health) Time Warner, SNET, and Oracle. With knowledge of the health and transmission domains, this group was expected to define the technology needs for the project and put together the resulting technology pieces from the research.
2. *Technology development*. This task was led by SNET, Oracle, and the healthcare group. All partners were expected to contribute in this core task.
3. *Test and evaluation*. This task was led by SNET, with the healthcare group providing tests and validators for HOLON products.

IPR protection arrangements were identical to those of the HII and were based on a similar rationale. The partners agreed to publish directories of archived technologies at KOOP for the benefit of healthcare industry members and others working in the field.

4.2.3 The Process of Cooperation in KOOP Research Partnerships

The project "champion" described the organizational approach of the KOOP ventures as a relatively weak center surrounded by concentric circles of research partnership members and their subcontractors. This organizational structure placed a lot of faith in smaller, dynamic companies for spearheading innovation in this rapidly changing field and depended heavily on larger participants for commercialization. It also allowed for frequent redefinition of the organizational structure of the research partnership and of the smaller-scale alliances anticipated to be formed among venture members as they confronted cascading waves of innovation.

Several factors made such a setup attractive to the lead organization. Two were key:

- First, the champion behind both KOOP research partnerships conceived an environment of cascading waves of innovation in healthcare information infrastructure. Rapid rates of technological advance were understood to require frequent organizational changes for success, that is, flexible joint venture architecture. A command and control style of organization was considered to be incompatible with cascading innovation.
- Second, KOOP tried to avoid liability through this setup. Individual research partnership members were supposed to fill out the paperwork and submit it to the ATP through KOOP. Although KOOP reviewed everything, it did not have liability for mishaps. The role of the facilitator with limited powers placed responsibility for contract compliance with individual players.

Additional reasons for this organizational structure reportedly included altruistic behavior on the part of KOOP management and considerations of a democratic arrangement: each research partnership member had the same vote, irrespective of the company's size. Considerations of prospective gaming among partners were also influential: a strong center surrounded by strong members could have invited attempts by individual members to influence the center and tilt the research partnership to their benefit. Finally, the very public nature of the leading organization—founded by the retired U.S. Surgeon General, Dr. C. Everett Koop—was an

important concern. Instant name recognition provided visibility to the HII and HOLON research partnerships and their respective research undertakings, and being in the public eye made the foundation cautious about becoming involved in potential squabbling among partners.

A "soft" management approach, leaving ample room for maneuvering and presumably conducive to radical innovation, prevailed in the early years of the KOOP research partnerships (throughout the HII and during the first year of HOLON). The Project Steering Committee could discipline partners and stop or divert the money flow in cases of insufficient performance. KOOP, however, tried to avoid imposing its views on members. "Democratic" management was extended to partner meetings, where the project champion from KOOP presided with a low profile, basically serving as discussion facilitator.[12] The champion was reportedly very much focused on the management of the interdependencies that existed in the research partnership and acted as a benign referee. He assisted in redirecting resources within the research partnership to meet the needs of developing interdependencies.

The goal of the KOOP research partnerships was to mix various kinds of stakeholders, including big and small industry players, universities, and technology producers and users. Small firms were expected to play a leading role in radical innovation, and large companies were expected to use their business muscle and diversified operations to spread the technology widely and market the research outputs. Ii was important that the project champion did not anticipate the research partnerships to come out with a conventional collective product that partners would try to market together. Rather, research partnerships of such large size were considered best for investigating the more generic and infrastructural aspects of the technology. The vision was that extensive experimentation would assist in ultimately creating a "middleware switch": a user could plug into it and gain access to all kinds of healthcare information domains that communicate with each other.

Intellectual property was not collectively owned. Individual partners owned what they had created and could walk away with it.

The lack of strong central command, combined with the early stage of technological evolution and rapid rates of advance (inside and outside the research partnership), meant that interdependencies between small sets of research partnership partners did change frequently. Some strengthened, some weakened, and new ones were created. It is estimated that the HII and HOLON experienced no fewer than six architecture iterations as technology kept changing and partners better understood the requirements and the complementarities among them. Although this agreed with expectations, such ongoing reconfiguration introduced obvious administrative costs and a certain amount of confusion. A few partners took the initiative to drive the process. Such practice intensified dissatisfaction among others who questioned the viability of the initially agreed management philosophy. Several partners (especially those that felt relatively disadvantaged in influencing the process) grew unhappy as the first year of the second research partnership (HOLON) rolled on. Concern was also expressed about the perceived lack of an adequately strong central mechanism in the early years of the KOOP research partnerships to discipline under performing partners.

In the wake of rising discontent, there was a move for change as the first KOOP research venture drew to a close. Although difficult to accomplish—because each member had an equal

vote and three-quarters of the vote were needed to modify the agreement—change did come. Several actions were taken in an effort to strengthen central command and create more direction overall. The overseeing organization hired a full-time technical manager for the project. The project champion left KOOP in 1997, three years into the first research partnership and little more than one year into the second.[13] He was replaced with a retired military officer who proved more effective in providing overall operations leadership, managing politically, and resolving grievances among members.

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The Project Steering Committee also became more involved with monitoring technical progress. They developed an extensive schedule of deliverables and an elaborate system of green, yellow, and red signals to evaluate partner performance. Green indicated deliverables and reports turned in on time, yellow flagged caution, and red indicated missed deadlines. Partners whose work resulted in a yellow signal were asked about plans to get to the green zone. Partners in red were questioned and, if not responsive, disciplined. Discipline meant fund reallocation and, ultimately, replacement. There was a sense among those interviewed for this study that strengthening of the management of the project proved beneficial to the research partnerships.

These changes seemed right for combating the perceived problems of frequent change, coordination, discipline (particularly with the larger companies that made substantial resource contributions), and enforcement. On the basis of our interviews, it is difficult to judge their effectiveness with another factor: the apparent lack of a common vision among partners regarding the ultimate objectives of the research partnerships. Common vision is naturally difficult to find in early-stage infrastructural research, but disagreements in this case may also reflect the project champion's relatively amorphous vision of cascading waves of innovation to create a common IT infrastructure for healthcare. This may have complicated the creation of collective products. Various projects apparently succeeded in bringing products to the market (see below), but they did not include the much sought-after, plug-in IT middleware for healthcare.

The HII's commercialization plan was for the technology to migrate from subject, methods, tools, knowledge base, and testing to future healthcare information infrastructure. Partners were expected to leverage parallel projects to create products related to domain objects (reusable software), business process reengineering methods and toolset, as well as develop an object-based data repository allowing easy user access. The use of several pilot sites or test beds for the validation of scale, function, and technology refinement was expected to provide launch points for commercial deployment. It was anticipated that the principal elements of technology transfer and commercialization for the NHII would be arranged around the emergent strategic partnerships within the research partnership. Such partnerships were considered very important for mitigating the high risk of the technologies and respective markets.

As originally proposed, the commercialization plan for HOLON had four components:

1. software: the actual, object-oriented software developed by the research partnership that makes up its large collection (library);

2. content-based services: The HOLON software library as the foundation for providing content-based services;
3. consumer-, provider-, and network-based products: the necessary products that would be created by HOLON partners (or others) on the basis of the enabling technologies developed by the venture (e.g., voice recognition technology); and
4. content tools to locate, query, retrieve, and store health information.

Technologies from the two research partnerships have found their way to the market. Examples include the Baby Care link and Care Web, which interviewees reported are in use at Harvard-affiliated hospitals. Other examples of new or significantly improved technologies reported by HII and HOLON participants at different stages of development can be found in the quarterly performance reports to the ATP. However, no healthcare IT "tool package" has been developed. One interviewee attributed the inability to come up in the end with a common product suite to weak central coordination. Another stressed the failure to communicate the ventures' "vision." For example, although "HOLON" had apparently become a widely recognizable term in the medical information community at the time, few clearly understood its research focus (the middleware switch).

5. ANALYSIS

The cases in this study confirm that large research consortia with diverse membership do not typically lend themselves to the development of specific products, Rather, multiparty partnerships like those investigated here are more appropriate for combining the diverse resources and capabilities required to advance the state of the art in early-stage technologies with broad applications and create standards, thus decreasing the uncertainty among individual agents. A narrowly defined appraisal of the expected benefits in terms of specific products would tend to miss most of the knowledge and network spillovers and the benefits from exposure to new concepts that the interviewed companies claimed as beneficial. To the extent that the collaboration increases experimentation with early-stage, risky, infrastructural technologies, as our interviewees claimed to be the case, the investigated partnerships could have created significant social benefits.

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Interviewees offered important suggestions for the future organization of cooperative R&D. They include:

- Egalitarian organization, where consortium members have equal votes and clear majorities are required for important decisions (e.g., for removing a partner), can become detrimental by raising management costs and weakening the enforcement abilities of the partnership. More structured, yet not very rigid, organizational structures facilitate decision-making.
- The funding agency can play a substantial role in assisting awardees in making the transition from early research to specific product/process development and commercialization—for example, by making explicit budget allocations for proof of concept activities.
- Research partnership contracts must be flexible enough to accommodate changes in the use of funds as they become appropriate during the undertaking.

- The funding agency can be a more active arbitrator to (a) inform smaller partners about what to typically expect in a research partnership and (b) assist small firms in avoiding the danger of being treated unfairly by larger partners.
- Research partnerships should not be considered a panacea. Strong internal R&D should accompany collaborative research agreements.
- Cost sharing may decrease the power of research partnership management to discipline partners who share costs often but underperform. (Presumably, these would be the larger participants). Such partners are difficult to replace. In other words, resource-poor firms are easier to discipline than resource-rich firms in research partnerships.
- Monitoring quality control is very important. Initial documents tend to specify deliverables and time of delivery, but they are usually less informative in cases where the deliverable comes on time but is of poor quality. Aggressive and knowledgeable management is needed to solve the quality problem. The overseeing body must be firm and have knowledge of the technology domain.
- Contracting agencies should try to eliminate significant gaps in terms of partner experience with government financing rules.

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Handling of confidential information in research partnerships is very important and requires special attention from the venture managers.

5.1 The ATP's Role

Specifically regarding the role of the ATP in the examined research partnerships, the comments of the interviewees were generally positive, reflecting several observations:

- The ATP served as a catalyst to bring partners together.
- The ATP's presence during the respective project life cycles assisted the research partnership management teams in maintaining their development schedules.
- Administrators from the ATP did not attempt to micromanage, thus avoiding bias in the research results.
- Funds from the ATP provided the necessary incentive for potential competitors to work together.
- ATP funds tended to induce large, risk-averse companies to pursue long-term, risky, ambitious technologies. When this happens, the market takes notice. The leverage of expended funds is significant.
- Participation by the ATP assisted smaller research partnership partners to think strategically and to become involved in research activities well beyond their means.
- ATP's decision to focus a program on a broad technology area such as healthcare informatics was instrumental in focusing industry's attention. Some interviewees emphasized that even today, the ATP could play a role in providing a sense of coherence in healthcare industry changes. Many of the issues surrounding the focused program in 1994 remain relevant today—most specifically, issues of security and data compatibility.
- A major impact of the ATP in an emerging sector such as healthcare informatics reflects the contribution to clarifying as early as possible expert expectations of technology evolution. Firms join research partnerships in emerging sectors to use them as mechanisms to place their technological bets and open up options to new technologies. The public and private sectors can coalesce to create points of leverage for providing the basic building blocks of such a sector.

The ATP's role is reportedly important in technology areas that are still in their infancy. One example from HITECC involved the SMS collaboration with General Electric Medical Systems (GEMS) to develop integrated multimedia functionality. SMS had been doing some research in this area before the formation of the research partnership—they were at the initial stages of placing software on the Windows platform to move images and other medical information. This made their work complementary with that of GEMS, which also had interests in this field but primarily on the hardware side. The two companies shared a long-term vision: First, create the technology that would enable GEMS, SMS, and other Joint Ventures partners to work together; second, try to actually work together in creating integrated products to fulfill the perceived need for fast, reliable, and efficient electronic transmission of medical images and information over great distances.

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The targeted area was still in its infancy. No company was willing to take the requisite risks. However, according to the interviewees, buyers of health care information systems want to see the products before committing to them. At the time, this was creating a chicken-and-egg problem. The ATP came in at a critical juncture to facilitate resolving this gridlock through its interest in this commercially promising, yet very risky, technology. ATP funding allowed producers to justify the risks and move faster toward commercialization.

GEMS and SMS collaborated in the research but the relationship came under stress when it was time to approach potential users. Both companies were very protective of their clientele. In terms of the two steps described above, the first succeeded, but the second failed for competitive reasons beyond the ATP's reach.

6. CONCLUSION

This study examined four research partnerships chosen in the mid-1990s for support by the ATP's focused program, Information Infrastructure for Healthcare. The first two research partnerships were led by the SCRA, the second two were championed by KOOP. The SCRA and KOOP research partnerships shared many features relating to technological focus, motivating factors, membership composition, and timing. They also had significant differences in terms of organization: the SCRA and KOOP joint ventures started out with different organizational approaches, featuring a classic hub-and-spoke organizational structure versus a model of weak organizational center surrounded by concentric circles of research partnership members and their subcontractors. The KOOP research partnerships converged later on by considerably strengthening their core administrative bodies and intensifying the role of the main organ of monitoring and control while probably paying less attention to the original concept of cascading waves of innovation.

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All research partnerships investigated herein featured "model" characteristics for government-sponsored cooperative R&D: (a) they addressed an area of perceived market failure due to the nature of the required research, best described as uncertain, broad, and infrastructural; (b) they focused on resolving technology problems of generic interest to large numbers of partners (collective infrastructure solutions, "middleware switch"); and (c) firms unable to justify heavy investments in the fluid, high-risk, high-potential technological area of information infrastructure

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for healthcare joined the partnerships to explore the field and create options for possible future investment.

The interviewees indicated that participating organizations benefited considerably from the commercialization of specific technologies developed in and accelerated by the R&D undertaken in the examined research partnerships. However, the research partnerships did not manage to produce the collective infrastructure solutions that partners had sought from the start—the middleware switch that would open the vast world of shared healthcare information to prospective users. There are currently no signs that the private sector will reach that goal anytime soon.

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Hence, the study confirmed that large research consortia with diverse membership do not typically lend themselves to the development of specific products ready for the market. Rather, multiparty partnerships like those investigated here are more appropriate for combining the diverse resources and capabilities required to advance the state of the art in early-stage technologies with broad applications and create standards, thus decreasing the uncertainty among individual agents. A narrowly defined appraisal of the expected benefits in terms of specific products would tend to miss most of the knowledge and network spillovers and the benefits from exposure to new concepts that the interviewed companies claimed as beneficial. To the extent that the collaboration increases experimentation with early-stage, risky, infrastructural technologies, as our interviewees claimed to be the case, the investigated partnerships could have created significant social benefits.

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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 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 that will go undeveloped and/or proceed too slowly to be competitive in global markets without 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 ATP.

Smaller firms working on single-company projects pay a minimum of all the indirect costs associated with the project. Large, "Fortune 500" companies participating as a single company pay at least 60 percent of total project costs. Joint ventures pay at least half of total project costs. Single-company 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 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.

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Richard Spivack has been with the Advanced Technology Program since 1994, where he is an economist in the ATP's Economic Assessment Office. Dr. Spivack, who received his Ph.D. in economics from the University of Connecticut, undertakes research into and publications on the ATP's long-term impacts on the U.S. economy and serves as both the business chair and the project manager in the Information Infrastructure for Healthcare focused program. He was previously a professor of economics at Bryant College in Smithfield, Rhode Island.