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Managing large research partnerships: Examples from the Advanced Technology Program's Information Infrastructure for Healthcare 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. Rather than developing specific products ready for the market, large research partnerships with diverse memebership are more appropriate for combining the diverse resources and capabilities required to advance the state of the art in early stage technologies and to create standards, thus decreasing the uncertainty of subsequent research. Some form of effective central authority is desirable in order to galvanize a common vision for the partnership, to establish clear milestones, and to take the burden of day-to-day negotiation and decision-making. Too much or too little management concentration brings similar detrimental results: members feeling left out of the decision-making process and a perception of unfair distribution of power to influence the process and the vision of the partnership.

Keywords: Public-private partnerships; Alliances; Risky research; Information technology; Healthcare

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 US 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.[1] 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.

The ATP has held open competitions each year for all technologies. During 1994–1998, however, most funding was awarded through 30 focused-program competitions in which a suite of projects was funded to mobilize enabling technology to address a particular issue. 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 purported to develop the information infrastructure

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[1]In this paper, the terms ventures, joint ventures, consortia, and partnerships are used interchangeably.

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technologies needed to improve the quality and flexible delivery of care by faster broad access to better information (Lide and Spivack, 2000). In the United States, more than $1 trillion was spent per year on healthcare in the mid-1990s. Approximately 20 percent of that was spent on paperwork which IIH purported to limit (US Department of Commerce, 1996).

Four research consortia selected for support by the ATP IIH focused program have been selected in this study to illustrate important aspects of the organization and management of large research partnerships that form around risky, early stage, complex technologies. The paper identifies opportunities and problems in such partnerships to discern operational procedures conducive to partnership success. In addition to private sector strategists, then, the results can provide useful guidance to research and development (R&D) funding agencies like the ATP for improving future project selection and monitoring procedures. Representatives from several participating organizations were interviewed at length for this study and have been instrumental in deepening the understanding of what makes a cooperative R&D effort successful.

The research partnerships in question were chosen by the ATP on the basis of promising technology outcomes, high expected social return, and perceived market failure: extensive research with infrastructural characteristics addressing technology problems of generic interest to large numbers of stakeholders none of which could justify the requisite heavy investments in the fluid, high-risk, high-potential technological area of information infrastructure for healthcare. In addition, the specific four partnerships discussed in this paper were chosen on the basis of "coupled pairs" criteria. Two of the selected research partnerships were conceived by the Healthcare Open Systems and Trials consortium (HOST) and led by the South Carolina Research Authority (SCRA), 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. The SCRA and KOOP research partnerships worked in parallel (but independently) following strikingly different organizational structures.

The rest of the paper consists of four sections. Section 2 describes the research objectives and approach. In Section 3, the SCRA and KOOP research partnerships are described in some detail. Section 4 presents the analysis. Section 5 offers a summary and lessons learned.

2. 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:[2]

- Early stage research partnerships can often be viewed as technology search engines.
- For many firms, research partnerships provide a vehicle to leverage internal funds and gain access to complementary resources of their partners.
- Government agency missions (aside from national defense) typically provide incentives for concentrating public funding of collaborative research of a more generic and infrastructural nature.

The notion of publicly supported research partnerships to encourage experimentation was reflected in the objectives of ATP's IIH focused program as spelled out in the initial solicitation.[3]

To facilitate the investigation of intangible aspects of research partnering, we chose the "coupled pairs" approach. That is to say, we focused on partnerships that are as close as possible in terms of every dimension but the dimensions the study focuses on (organization, management). These partnerships were selected for funding during the first two competitions of the ATP's IIH focused program.[4] Two of these research partnerships were led by the SCRA: the Healthcare Information Infrastructure Technology venture (HIIT) was an awardee in the 1994 IIH competition, and the Healthcare Information Technology Enabling Community Care venture (HITECC) was an awardee 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 an awardee in the 1994 IIH competition, and the Health Object Library On-Line venture (HOLON) was an awardee in 1995.

The SCRA and KOOP research partnerships shared many common characteristics:

- *Composition*: Each set comprises a pair of 3-year research partnerships, with member of the pair 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,

[2]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).

[3]"Advanced Technology Program: Information Infrastructure for Healthcare (95-10)." US Department of Commerce, NIST, 1995.

[4]In response to the three IIH 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.

research objectives were clearly influenced by the debates on the National Information Infrastructure (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 was considered appropriate for promoting 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).

Table 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.

3. 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

Table 1
Research partnership membership (as proposed to the ATP)

Koop (HII), 1994	Koop (HOLON), 1995	SCRA (HIIT), 1994	SCRA (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.			

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, lack of a systematic way to represent medical knowledge, in consistent and the absence of widely accepted semantics to represent functions and relationships, and strong market incentives that prevented healthcare application providers from operating 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 setting 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.

3.1. Case I: SCRA research partnerships

3.1.1. HIIT

3.1.1.1. Rationale. The 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 founding HOST, influenced by the healthcare reform proposals that were 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 accelerating the development and adoption of open, integrated healthcare systems, focusing especially on computerized patient records.

HIIT participants represented healthcare providers, communications suppliers, hardware and software developers. They included large, medium and small businesses, communications companies, inner-city hospitals, universities, and prestigious medical centers.

3.1.1.2. Organization. SCRA, a seasoned company in consortium management, became HIIT's overall program manager and facilitator. 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 HIIT evolved from the successful interaction among two 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.

A *Technical Review Council* was created to ensure the overall quality of the projects and ensure tight teaming among members of the same spoke. Members of the review 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, 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 established four general rules for protection of Intellectual Property Rights (IPR) in their effort to ensure appropriate incentives:

- 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.[5]

[5]Pursuant to the ATP statutory and regulatory authorities, title to any inventions arising from an ATP-funded project must be held by a for-

- 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.

3.1.2. HITECC

3.1.2.1. 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.

3.1.2.2. 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.

HITECC was an industry-led research partnership, incorporating healthcare providers, suppliers, hardware and software developers, and individual researchers like its predecessor. 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 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 HIIT. In addition, it was determined that HITECC and 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.

3.1.3. The process of cooperation in SCRA research partnerships

HOST served as the proposal inspiration and strong advocate of the thematic concentration of both 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. 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. 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 both ventures, technologists at the different participating organizations were pleased to have SCRA take responsibility for all organizational and reporting matters, leaving them with more desirable technical work. Also, there was a mutual recognition that strong leadership was necessary in administration. The SCRA was successful in completing reports, and managing meetings and schedules in a timely fashion.

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 the two 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 one hundred very qualified researchers and doctoral students.

With time, however, SCRA's "centralized" management style reportedly started causing dissatisfaction among partners who felt left out of important business decision-making. There was a feeling that SCRA was too secretive. Some participants from small companies operated under the impression that SCRA was the contractor and all

(*footnote continued*)
profit company or companies incorporated or organized in the United States. A university, governmental laboratory, or independent research organization cannot retain title to patents, although such organizations can receive mutually agreeable payments from the company or companies holding title to the patent. A for-profit corporation organized by a university may be considered a for-profit company for the purpose of retaining title to patents arising from an ATP award (see ATP, 2000, p. 9).

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".[6]

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.

3.2. Case II: KOOP research partnerships

3.2.1. HII

3.2.1.1. 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;
- *knowledge base development* to define and prototype a health enterprise metamodel and a health information infrastructure knowledge base; and
- *integrated BPR toolset development*, aiming at the definition and prototyping of an integrated set of tools to support the full life cycle of enterprise planning, business process improvement, generation of information support capabilities, and deployment of NHII services.

3.2.1.2. Organization. KOOP conceived the initiative and garnered 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. A number of academic institutions also participated as subcontractors.

KOOP was tasked with administration, project management, and technical oversight. KOOP and the HII team participated in the definition phase of the project and also provided such services as project management, coordination between the ATP and the participants, and administrative support, including legal, accounting, and contracts.

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 US suppliers and in reported nonproprietary project results.

Finally, KOOP was tasked to 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.

3.2.2. HOLON

3.2.2.1. 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.

3.2.2.2. 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.

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

[6]From a teleconference with consortium members.

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.

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.

3.2.3. The process of cooperation in KOOP research partnerships

Both KOOP projects adopted a weak center model surrounded by concentric circles made up 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 asume 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 included a desire for a more democratic management style: each research partnership member had the same vote, irrespective of the company's size. Considerations of prospective gaming among partners were also important: 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 US 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. The Project Steering Committee could discipline partners and stop or divert the money flow in cases of insufficient performance. KOOP attempted to avoid imposing its views on members. Instead the project "champion" chose to serve as a benign referee assisting in the redirection of 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. It 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. Concern was 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 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.

Technologies from the two research partnerships have found their way to the market. Examples include the Baby Care link and Care Web, which are in use at Harvard-affiliated hospitals.[7] 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'' was developed. This may be attributed to the inability to come up in the end with a common product suite due to weak central coordination. Another explanation could be attributed to 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).

4. Discussion

While all four projects were similar in size and scope the organization and management procedures adopted by each management team were dissimilar. The two projects led by SCRA were organized around a hierarchical format focusing on a strong central authority. The two projects led by KOOP were coordinated around a decentralized central authority allowing for ''waves of cascading innovation''. Both sets of projects had successes as well as setbacks.

Participants in both SCRA-led projects were initially pleased with an organizational framework that relieved them of administrative burdens while allowing them to focus on the technical aspects of their respective projects. SCRA held joint meetings for members of both projects thus facilitating knowledge spillovers within and between projects. Resources were shared among participants in a true cooperative spirit. With time, though, this particular management style led to dissatisfaction as many participants felt left out of the decision-making process. A sense that larger companies appeared to dominate management decisions at the expense of smaller companies and subcontractors was pervasive.

Participants in both KOOP-led projects faced an organizational model in which smaller companies were relied upon for innovation while the larger companies offered their commercialization expertise. The expected benefits of this model included the ability to make rapid changes amongst small sets of research partners, essential in early stage technological development. Also, there was a feeling early on that each participant had an equal say in decision-making matters regardless of company size. The lack of a strong central authority did lead, though, to several management architectural changes contributing to a feeling of uncertainty. This, in turn, created an environment in which a few partners exercised greater influence over the process causing a sense of dissatisfaction amongst those seeking more discipline in developing a common vision.

In the end two diametrically different management philosophies ended up creating similar anxieties among members, of unequal distribution of power and influence over the process and the vision of the partnerships. In both cases, allegations that a few important partners dominated the decision-making process were prevalent. In the KOOP ventures this led to a change in management and management style to one that was more authoritarian.

5. Conclusion

All research partnerships investigated in this study addressed a field of perceived market failure that provided the justification of government support of large research consortia aiming at bringing technology producers and users together to explore and create options for possible future investment in a fluid, high-risk, high-potential technological area with significant social benefits.

[7]Examples of other new or significantly improved technologies reported by HIIT and HITECC participants at different stages of development can be found in the quarterly performance reports to ATP.

While a number of specific technologies have been commercialized, the research partnerships did not manage to produce the collective infrastructure solutions sought from the start—the middleware switch that would open the vast world of shared healthcare information to prospective users. Participating organizations benefited primarily in intangible ways by getting exposed to the problems and getting access to ideas and capabilities. In other words, 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.[8] Rather, multiparty partnerships 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. To the extent that the collaboration increases experimentation with early stage, risky, infrastructural technologies the investigated partnerships did contribute to significant societal benefits.

Regarding the management of such partnerships, it emerged that some form of effective central authority is desirable in order to galvanize a common vision for the partnership, to establish the milestones and make certain that the partnership adheres to them, and to take the burden of day-to-day negotiation and decision-making. This role can be accomplished by a professional management organization. A strong preference for balance —an equilibrium of sorts—was pointed out. Too much or too little management concentration brings *similar* detrimental results: members feeling left out of the decision-making process and a perception of unfair distribution of power to influence the process and the vision of the partnership.

The examined cases offer several important observations/lessons for the organization and management of large research partnerships:

- Egalitarian (flat) organization, where consortium members have equal votes and clear majorities are required for important decisions (e.g., for removing a partner), can raise management costs and weaken the enforcement abilities of the partnership. More structured, yet not very rigid, organizational structures facilitate decision-making.
- Research partnership contracts must be flexible enough to accommodate changes in the use of funds as they become appropriate during the undertaking.
- Monitoring quality control within the partnership is very important. Aggressive management is needed to maintain quality. The overseeing body must also have knowledge of the technology domain.
- Handling of confidential information in research partnerships is very important and requires special attention from the venture managers.

[8] Hagedoorn et al. (2000).

- There are also important lessons for public support programs for such partnerships:
- The typical cost sharing principle of public programs has obvious advantages in terms of incentives but also a serious disadvantage in terms of management: it may decrease the power of the management body of the research partnership to discipline partners who cost share a lot but underperform as they are difficult to replace.
- The funding agency can play a substantial role in assisting awardees to transition from early research to specific product/process development and commercialization—for example, by making explicit budget allocations for proof of concept activities.
- The funding agency can be an 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.
- Contracting agencies should try to eliminate significant gaps in terms of partner experience with government financing rules as they create dependencies within the partnership.

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