Research Collaboration Network for Managing Collaborative Research Centers
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Project Summary:

An increasing portion of scientific research is performed by distributed, collaborative scientific research centers. These collaborative centers are growing in size, diversifying in scope, and are foundational to an increasing portion of the contemporary scientific endeavor. Although many centers do operate effectively and innovate consistently, there is a dearth of systematic exploration into the management practices that enable this success. Further, there is relatively little in terms of practical support for center directors to turn to for benchmarking, best practices, guidance, and education on managerial issues associated with running centers. Where can center directors go to share what works and to get ideas for managing their centers more effectively? Currently their choices are limited and ad-hoc.

To address this need, the proposed Research Collaboration Network will begin building a community around the management of collaborative scientific centers. Such a community is important for two reasons. First, center managers often receive their training within particular scientific disciplines and gain experience managing projects only within those disciplines. However, the management of smaller-scale disciplinary projects is fundamentally different from the management of cross-disciplinary, distributed organizations (Berente 2010), and center managers may not be well-prepared to effectively handle the latter. Second, even if center managers were well-versed in organizational scholarship, it is as yet unclear which elements of management research apply to contemporary scientific centers. Such centers are different than other organizations (Atkins et al 2003) and are subject to a variety of unique pressures, including those associated with infrastructural innovation (Bowker et al 2010), distributed software development (Howison & Herbsleb 2011); and virtual organizing (Borgman et al 2009), among others.

Through a series of workshops, the proposed Research Collaboration Network will bring together diverse stakeholders from a variety of disciplinary traditions, including center directors, scholars from science and engineering "domain" disciplines, cyberinfrastructure specialists, and researchers from organizational science, software engineering, information systems, and social studies of science. These disciplines rarely interact, and when they do it is in a small scale, ad-hoc manner. The Research Collaboration Network will provide the groundwork for a persistent network devoted to systematically bringing these communities together through a series of workshops. The goal of any contemporary collaborative research center involves enabling and advancing scientific discovery and innovation. This Research Collaboration Network will begin building a community that fosters research and training specifically suited to the management of such centers. Such a network can enable center directors to share their best practices and to benchmark their performance against similar centers, and will help to equip center directors with what they need to advance science more effectively.

Statement of Objectives

The proposed Research Collaboration Network will begin building a cross-disciplinary community of scholars and practitioners interested in studying and improving the management of contemporary collaborative scientific research centers. Through a series of workshops, we will investigate which elements of organizational scholarship might apply to the management of such centers and in what way; in turn organizational scholars will learn and explore their understandings in the context of scientific research. Further, we will look to determine how to best disseminate relevant training, best practices, benchmarking, and actionable research associated with the management of such centers. Finally, we will explore how such a community might be sustained over time.

Intellectual merit

This research collaboration network will begin building a community around managing contemporary scientific research centers, and will investigate the issues that are important to this community. Outcomes will therefore extend the research programs associated with supporting the design and management of research centers (Berente 2010) as well as scientific software development (Herbsleb & Howison 2009) that is increasingly important to contemporary science. Further, this project will both draw upon and inform the broader managerial and social streams of research into large scale research environments, collaborations, and cyberinfrastructure (e.g., Cummings and Kiesler, 2005; Olson et al 2008; Edwards et al 2009).

Broader impacts

Center managers and their teams could benefit from a collaborative network targeting the specific the issues that enable them to succeed: improved center performance (and the related science impacts) should improve as a result. Further, scholars across a variety of disciplines that study issues important to the management of such centers will have a highly focused community with a stake in their research. These various disciplines include social studies of science, organizational science, information systems, and software engineering research.

Project Description:

Research Collaboration Network for Managing Collaborative Research Centers

"…the same power of science which has so amazingly increased the productive capacity of mankind during the past century will be applied again, and the prizes of industrial and commercial leadership will fall to the nation which organizes its scientific forces most effectively."- Elihu Root, 1918

Elihu Root's famous address to the National Research Council[1] was a call to draw upon lessons from industrial management to marshal scientific knowledge for World War I. Although the context has changed, in many ways the fundamental insight still applies today: so much of a nation's competitiveness depends on its ability to marshal scientific knowledge for innovation and discovery. Lessons from industrial management – now the mature field of organization science – can contribute to this effort.

One way that the National Science Foundation coordinates the scientific endeavor is by funding collaborative research centers. These are intended to "exploit opportunities in science, engineering, and technology in which the complexity of the research problem or the resources needed to solve the problem require the advantages of scope, scale, duration, equipment, facilities, and students."[2] The realization of successful scientific research across such centers requires effective distributed collaboration made possible by advancements in computing technologies. However, success is not simply a matter of placing enabling technologies. These technologies are important, of course, but it is the human and organizational elements of the collaboration that are the "hardest part" of such collaborations (David 2006). Much of today's most innovative and impactful research takes place across distributed, collaborative research centers (NAS 2005). On one level, the organization of these centers can be conceived of in terms of distributed team collaboration – and such team collaboration can be a complex management endeavor in its own right (Boh et al 2007). However, scholars have suggested that distributed research centers represent more than just team collaboration. Such centers are complex hybrids of traditional and novel organizational structures, nested social networks, transitory roles, and ever-changing, "drifting" arrangements (Lee et al 2006). Thus it should be no surprise that those center managers that can more effectively manage such collaborative centers have an advantage - the appropriate coordination of these complex arrangements is often the key enabler of collaborative research center success (Cummings & Keisler 2007).

Collaborative research centers are growing in size, scope, and importance to the scientific community, and are critical for the innovations that address central concerns in contemporary society (e.g., Teasley & Wolinsky 2001; NAS 2005). Although this form of organizing is so important, what is in place to pass down the knowledge on how to successfully run such centers? What are the methods through which we can aid the development of up-and-coming center managers? More specifically, how can we capture and disseminate the managerial knowledge on what works and what does not when it comes to managing contemporary collaborative centers? As it stands, there is no consistent community around benchmarking center activities, sharing best practices, and building the particular managerial competencies that such centers increasingly require. There are pieces available – such as ad-hoc networking between center directors at major conferences and formal project management training. But informal networking does not equate to the capturing and diffusion of best practices; and project management is but one of the many forms of management required for center success (others include strategic management, resource management, team governance and leadership, software engineering management and, no doubt, others which the proposed Research Collaboration Network will discover).

[1] May 29, 1918 meeting of the Advisory Committee on Industrial Research of the National Research Council, as reported in *Science*, Vol. XLVIII, No. 1248.

[2] NSF FY2009 budget, p.5: http://www.nsf.gov/about/budget/fy2009/pdf/37_fy2009.pdf

Further, although there are a number of researchers who study the management of such centers from a variety of disciplinary perspectives, including organization science (e.g., Cummings and Kiesler, 2005), information systems (e.g. Ribes & Finholt 2009), software engineering (e.g., Howison & Herbsleb 2011), and social studies of science (Bowker et al 2010), and a number of these researchers do collaborate, there is no community for coordinating these efforts and disseminating their findings back to the community. For example, although NSF's Virtual Organizations as Sociotechnical Systems (VOSS) program has funded dozens of exemplary research projects that might directly inform the practices of such centers, there is no community in place to systematically diffuse these findings across center directors in a way that can be readily applied.

Through the proposed Research Collaboration Network we plan to rectify this situation by building a community around the management of collaborative research centers. This community will gain knowledge about successful center management and look to disseminate this knowledge in ways that are useful to the community. Next we will address the ways that the network might gain knowledge, followed by a brief discussion of knowledge dissemination and our activity plan.

Knowledge about Managing Centers

Management knowledge – particularly knowing how to manage in an innovative context – is an elusive construct. Despite the self-interested promises of "management gurus", only portions of knowledge used for managerial action can be codified and made explicit, whereas much remains tacit (Nonaka 1994). The application of managerial knowledge is highly context-sensitive and that knowledge which can be made explicit and transferred in a simple fashion may sum up to "rookie" knowledge, and not the knowledge of experienced managers (Flyvbjeg 2003). Managerial knowledge cannot be reduced to a recipe or "one-size-fits-all" set of prescriptions. Instead, managers must adapt to situations – in part sensitized by normative models of action – but also by reflecting on a variety of experiences that are built up over time (Schön 1983). Therefore, to build an actionable body of knowledge based with a goal toward practice, any strategies should involve interpersonal exchanges of experience on as wide a variety of descriptive cases as possible that deal with managerial problems *in situ* (Flyvbjerg 2003).

There are three sources of such rich descriptions relevant to collaborative research centers: (1) experiences of center managers; (2) organizational research in general; and (3) research into these forms of centers in particular. The three sources are complementary, and all can contribute to the reflective practice of center managers. It is the role of the proposed research collaboration network to bring the three together and to leverage them with the goal of informing practice and preparing center managers to help each other tackle the complex problems they face. Next we will address each in turn.

Center Manager Experiences: Best Practice & Benchmarking

Experienced center managers have abundant stories to tell, experiences to share, and perspectives about what works and what does not. These stories can lead to what is often described as the "best practices" associated with a given center activity. Organizational research and practice have a rich tradition of using best practices as patterns for action (not one-size-fits-all solutions) to guide managers in designing the processes that are critical to organizational performance (Szulanski 1996; Malone et al 1999). The experiences of center managers might inform best practices in key processes giving other center managers a place to start when reflectively dealing with similar processes. Although best practices are certainly useful, it is important to note that the transfer of best practice is no trivial thing. There are problems with moving working practices from one context to another because contexts can be fundamentally different and the existing practices might be resistant to change, "sticky" (Szulanski 1996), or may involve diverse communities who do not readily adopt common practices (Wagner & Newell 2004). Nevertheless, the

identification of certain modes of activity that a community deems to be best practice has been found to be quite useful in organizational practice.

Further, even if everything managers do is not entirely replicable across contexts, center managers generally understand what constitutes good outcomes and bad outcomes associated with the performance of the center. To determine whether a given center is running effectively, it may make sense to benchmark performance against other centers. Managers often refer to the "key performance indicators" or "KPIs" that are vital to making organizations run. Keeping a knowledge base of KPIs would help center managers understand where they are with respect to industry standard benchmarks. Also, exploration into the appropriate KPIs for different outcomes would be in order.

Of course, the main problem with focusing primarily on existing center management practice is that it emphasizes the way things are currently done or have been done in the past. These practices may not take full account of the decades of research in a variety of organizational science traditions. These traditions can be a source for insight beyond current

Organizational Research: Theories & Prescriptions

For over half a century, a legion of scholars has studied organizational design and management. While organizational management is a complex task with no clear set of standard best practices, there are a variety of well-established trade-offs, tensions, and guidelines associated with organizational design decisions and management practices. Although organizational researchers have not addressed the particular needs of collaborative scientific organizations (with some exceptions, see Cummings & Keisler 2007 and Ribes & Finholt 2009), many of the key ideas from this body of literature might be adapted to the collaborative research context in some way.

In the domain of organizational design, for example, many of the canonical prescriptions that address the traditional ways that managers should structure organizations offer timeless lessons for managers (e.g., Galbraith 1977, Mintzberg 1979). More contemporary work on business models (e.g., Osterwalder et al 2005) may help center managers navigate the way they are bringing resources to bear on their organizational strategies. Beyond this, there is the work that addresses specific challenges such as interorganizational governance (e.g., Dyer & Singh 1998; Helper et al 2000), collaborative, network forms of organizations (Moller & Halinan 1999; Yoo et al 2006), and distributed team collaboration (Boh et al 2007). There are specialized prescriptions for managerial activities based on different types of organizations, as well, including high reliability organizations (Weick & Sutcliffe 2001), organizations focusing on different forms of product innovations (Baldwin & Clark 2000), research & development organizations (Thamhain 2003), and organizations looking to capitalize on "open" innovation (von Hippel & Von Krogh 2003).

Many collaborative research centers contribute to the development of infrastructural artifacts like infrastructural software, domain-specific software, supercomputing technologies, or technological standards. Indeed many collaborations not originally conceived as being software-heavy find themselves managing software development. Research into infrastructural innovation has found that organizations that generate elements of infrastructure act as complex adaptive systems, and those that establish the processes for continually changing the way they do things ("routines") will be better equipped for adequately dealing with unpredictable, emergent activity (Hanseth & Lyytinen 2010). Thus, to handle emergence simultaneously with delivering value real-time, organizations need to develop robust routines and at the same time intentionally develop routines for changing and adapting these routines. Organizational science refers to the routines that adapt and change existing routines as "metaroutines" (e.g., Feldman & Pentland 2003; Eisenhardt & Martin 2000; Adler et al 1999). Understanding

metaroutines as they apply to collaborative centers would be critical for effectively "growing" infrastructural artifacts.

A similar body of scholarship can be found across a variety of other organizational domains, including leadership (Miner 2005), business process management (Grover & Markus 2007), change management (Burnes 1996), and virtual teams (Martins et al 2004). Beyond such specific domain-oriented research, organizational scholarship also provides practicing managers a vocabulary which enables them to make sense of complex organizational phenomena (Astley & Zammuto 1992). Popular examples of such sensitizing devices include March's (1991) distinction between exploratory and exploitative learning; Christensen's (1997) characterization of the "innovator's dilemma"; Weick & Roberts (1995) description of mindfulness; and Boland & Tenkasi's (1995) perspective making and taking between different communities.

In addition to this general work on organizational practices, there is a great deal of work that address different elements of software-related activities in organizations, including analysis of various software risk management practices (Lyytinen et al 1998), requirements elicitation techniques (Hansen et al 2008), IT project management (Mahring 2002), distributed software development (Herbsleb & Mockus, 2003), and software development methodologies in general (Hirscheim et al 1995; Berente & Lyytinen 2007). Software development as a domain has a rich and varied history that is addressed by multiple disciplines in different ways, including the information systems, software engineering, and computer science disciplines, and each tradition has its own strengths and weaknesses, but each has an focus on actionable practices.

It is important to reiterate that collaborative research centers embody novel ways of organizing, whereas most organizational research focuses on industrial corporations. Therefore, we must be cautious applying the lessons of this research directly. It is important to draw upon the emerging body of work that studies collaborative research centers to identify which elements of organization research can be adapted to this context, and which practices might offer the most leverage. Next we will touch upon some of this work on collaborative research centers.

Research into Collaborative Research Centers: Description & Theory in Practice

Of the managerial research that does exist, it is unclear to what degree these findings can inform the specific context of scientific research centers. Thus there is a growing body of research exploring the unique challenges of such centers (Ribes & Finholt 2009), the way such centers are organized (Lee et al 2006), different types of centers (Bos et al 2007), and issues important to these centers. In particular, there is a body of research that is directly focused on understanding the management of collaborative research centers funded by NSF's Virtual Organizations as Sociotechnical Systems (VOSS) program. A number of recent awards focus explicitly on the management of distributed, collaborative research centers. These projects include, for example, evaluating best practices for such centers (Knobel & Bowker 2011); understanding the design and management of centers (Berente 2010); the drivers of project success within such centers (Wilkins-Diehr 2009); and the development of center leadership talent (Finholt 2009). Further, there are occasional studies of the management of collaborative research centers in the organization literature (e.g., Ribes & Finholt 2009; Cummings & Keisler 2007). As research continues to accumulate in this area, the proposed Research Collaboration Network will facilitate the diffusion of findings throughout the center management community.

However, a number of other VOSS awards continue in the tradition of looking to understand collaborative centers (e.g., Binz-Scharf 2009; Edwards 2009), and thus join the rich tradition of largely descriptive

scholarship into the way collaborative science takes place. Next we will briefly touch upon two well-established streams of research: (1) social studies of cyberinfrastructure; and (2) scientific software development.

1. Social Studies of Collaborative Centers

Social studies of collaborative research centers can be generally aggregated into two tightly related domains: research into "collaboratories," and research into "cyberinfrastructure." Collaboratories are "centers without walls" (Wulf 1993) in that they are comprise of geographically distributed scientists working together. Advancements in computing have enabled collaboratories to emerge as a growing form of research center (Wulf 1993; Finholt 2003), and the computational infrastructure that enables these collaboratories and other forms of collaborative science is often referred to as "cyberinfrastructure" (Atkins et al 2003). Next we will briefly touch upon each body of work.

Research into Collaboratories – At its most fundamental level, research into collaboratories finds that such virtual, distributed centers are different than more traditional centers. Established scientific practices implicitly assume a shared space, and therefore collaboratories require new organizational routines that necessitate new roles to coordinate the distributed activity (Finholt 2003). Nevertheless, computing technologies that enable broad scientific collaboration are cannot completely substitute for collocation (Olson et al 2008), and scientists involved with large-scale collaborative centers must work harder than those in other forms of cooperative work to maintain the center (Boh et al 2009). The result is not a distributed version of a traditional center, but instead, becomes something qualitatively different. Thus researchers have questioned the definition of collaboratories as "centers without walls" and instead conceptualize them as new and unique forms of organization (Finholt 2003) and researchers are only recently beginning to conceptualize these organizations in their own right (Boh et al 2009). Social theorists have identified how the management of such centers are critical to their success and have begun crafting general theories of collaboration (Olson et al 2008) and lifecycle models of collaborative research centers (Sonnenwald 2007). The literature is still emerging about the social aspects of these new collaboratory organizational forms, but is in wide agreement that collaboratories are enabled by computing infrastructures. The long-term vision for and integrated set of information and communication technologies that undergird contemporary distributed science has been described as an integrated science "grid" (Berman et al 2002). The reality of scientific computing infrastructures, however, is rife with human, organizational, and institutional issues. A stream of social research into cyberinfrastructure has emerged to address the sociotechnical challenges associated with distributed, collaborative science.

Research into Cyberinfrastructure – Collaborative research centers organize around technological artifacts and standards and inevitably contribute to the emergence of cyberinfrastructures (either intentionally or unintentionally). This generation of cyberinfrastructure results in what will one day be the infrastructural environments that are embedded in the practice of science (NSF 2007). It is important to keep in mind, however, that these infrastructural environments are only partly technical, they are also social and political. Star and Ruhleder (1996) referred to technical issues as the level 1 contexts of infrastructure, which can be quite complex in their own right. They further indicate that social and political elements of infrastructural design organization comprise level 2 and 3 contexts of infrastructure, which can be significantly more unpredictable, discontinuous, and complex. As authentic infrastructure, then, the outcome is not entirely technical. Rather, the social and organizational aspects of the future infrastructure comprise just as important a component as the technical hardware and software infrastructure (Lee et al 2006). Perhaps more important, since the software and hardware components can often be readily changed but the social elements of the future infrastructure will be institutionalized prior to being embedded, and therefore resist change (Ribes & Finholt 2009; Bietz et al 2010). Thus it is imperative that center managers look at collaborative research center activity not only in terms of building

the technical foundation for the future, but also building the path dependent organizational forms and institutionalized routines of the infrastructure.

Further, the need for long-term perspectives associated with infrastructural projects is the source of a significant tension in cyberinfrastructure research (Ribes & Finholt 2009; Karasti et al 2010). As center managers focus on delivering on project outcomes, they may inadvertently ignore or deemphasize the organizational arrangements that result from their efforts. There is no certainty that center managers will be funded beyond the current project, and attention and resources are scarce. Therefore, while it is critically important that the long-term view pervades efforts to design and grow the nation's future cyberinfrastructure, the natural way that projects are organized directly contradict this long-term perspective.

An important point is that hardware and software technologies are constantly changing in unpredictable ways and thus any long-term standards or architecture-based approach will necessarily be a complicated endeavor. Collaborative research centers compound this complexity because they are distributed geographically and across-disciplines (Edwards et al 2007) and distributed collaboration is necessarily a challenging task under any circumstances, but especially under conditions of groundbreaking science (Olson et al 2008). Traditional project management practices generally assume some sort of discrete technical goal as the outcome of the project. While social and organizational aspects of the project are sometimes considered, they are considered in the service of the technical goal which is the main goal of the project. Similarly, scientific software is often generated in the service of particular projects, and this software becomes sedimented upon over time – eventually become part of the infrastructure – but often the software element of collaborative research centers is taken for granted in big science projects. We hold that the conscious, reflective development of scientific software is critical to both short and long-term collaborative research outcomes and that this is also an underexplored domain in the management of collaborative research centers. Next we will address this critical software element of collaborative research centers.

2. Scientific Software Development

Software is the "relational web" upon which distributed collaborative scientific research operates (Spencer et al 2011) and research centers produce a variety of software artifacts and other standards, the impact of which extends far beyond the project at hand (Spencer et al 2006). While successful management of software development is a challenge in all kinds of organizations, software development in scientific research centers combines some of the hardest challenges of other environments and adds some unique challenges of its own.

The design of software is challenging because it involves bringing together knowledge of the needs of potential users and the technical skills needed to build the software. The implementation of software requires drawing together contributions from many participants in a synchronized and coordinated manner. These challenges are compounded in distributed environments (e.g., Herbsleb & Mockus, 2003) where lack of consistent face-to-face contact undermines the coordinating flow of informal communication between developers that seems unavoidably fundamental to the successful development of software. Scientific research centers, particularly those operating in a virtual mode, face these challenges. Further, once built, scientific software must be sustained; scientific research centers face four particular challenges here. First, science-funding cycles have traditionally been focused on discovery, rather than sustainability. Second, much software development work in science is undertaken by relatively junior participants (graduate students and post-docs) who are incentivized to move away from software work if they are to advance as scientists (Howison and Herbsleb, 2010). Third, many scientific software contributions are written for specific analyses, facing publication deadlines. Such code is quite different from that designed for infrastructural reuse and converting it to be so is difficult (Howison and

Herbsleb, 2010). Fourth, the scientific reputation economy does not deal well with rewarding software contributions, despite their importance for scientific progress (Howison and Herbsleb, 2011). As a result of all of these challenges, software has been found to be a consistent point of weakness associated with collaborative research centers, including in crucial areas such as climate models (Merali, 2010; Stodden et al, 2010). Software errors, often in including tools shared by others, and have caused retractions of major research results (Merali, 2010). In part this stems from the complexity of the software infrastructure, which is composed of many layers written by many different people for many different purposes (Edwards, 2010; Jackson et al, 2007).

The initial enthusiasm for combining computer science researchers with domain specific research projects has dampened in recent years because the need for developing sustainable software environments requires organizational and process capabilities in addition to the technical capabilities typically offered by computer science (Olson et al., 2008, p. 81). The disciplines of software engineering and information systems both look for processes and methods associated with bringing the technology and the domain together. Software engineering tends to emphasize the "requirements analysis" portion of this combination (Hansen et al 2009), whereas information systems literature tends to emphasize the "alignment" or "fit" between the organization and the information technology (Henderson & Venkatraman 1993; Goodhue & Thompson 1995). There is potential to adapt these literatures, with the understanding however that the challenges in the scientific domain are perhaps even more complex given the very dense knowledge required for scientific applications and the exploratory, unfolding nature of research (Segal and Morris, 2008).

While writing new software is important, building any non-trivial software system means relying on software written outside the control of any individual organization. Thus managing software development requires making judgments about the reliability not only of external software but those who write it. This is addressed in literature on the procurement of software and software development services (e.g., Hirschheim et al 2008) and, increasingly, in the management of relationships with heterogeneous open source software development projects (e.g, Agerfalk et al, 2008; Crowston and Howison, 2006). Scientific research centers face a particular challenge here because their needs can be very specialized, but their budgets relatively limited. More than one large scientific research project has found itself unable to get timely support from commercial suppliers focused on more profitable customers, or unable to convince sometimes ornery open source developers to accept very specialized patches (Howison and Herbsleb, 2010).

Thus far we have focused on the ways that the Research Collaboration Network can begin bringing together manager experience, organizational research, and research into collaborative science to help center managers and to begin building a body of knowledge for the management of collaborative research centers. Next we will describe the proposed plan for forming this network.

Research Collaboration Network on Managing Collaborative Research Centers

To address the management of collaborative research centers, we propose to create a Research Collaboration Network on Managing Collaborative Research Centers. The Research Collaboration Network will be established with four goals in mind. These goals are (1) to begin building a cross-disciplinary community; (2) to identify elements of existing research that apply to the management of such centers; (3) to explore dissemination of this research; and (4) determine how the community might be sustained over time.

Next we will describe each of these goals, followed by the tactics for realizing those goals and the means by which we plan to assess success in realizing these goals over the course of the project.

1. Building a Cross-Disciplinary Community

- *Tactic 1a:* As indicated in the previous section, a number of researchers have begun exploring the management of collaborative research centers and related topics across a variety of traditions. The fundamental goal of this effort will be to bring these researchers together with practitioners (center managers) through a series of workshops. In addition to senior faculty, we will actively seek to include talented junior faculty, postdoctoral researchers, and PhD students to encourage them to pursue research in this field and to begin building their networks with each other and with the senior scholars and practitioners.
- *Tactic 1b:* An important part of interdisciplinary work involves aligning the incentives for such work (NAS 2005; David 2006), and many of the incentives in faculty careers involve research publication. Beyond the networking portion of the community-building workshops we will also use workshop time to plan for creating effective outlets for such work. Such outlets might include proposing paper tracks and panels at prestigious academic conferences or special issues at top journals.
- *Tactic 1c:* As a continuing artifact of the workshops, the University of Georgia will develop and host a community website, integrated with a blog accessible by the community and run by the PI and Co-PI, and the blog will link to updates on an appropriate social networking group (i.e., academia.edu or LinkedIN) where workshop participates will be encouraged to join the group. Community members will be able to contribute to both the blog and the LinkedIN community, and will be able to upload research and presentations to the website.

- *Outcomes:* This networking activity should have the result of encouraging senior researchers to engage more fully with research into the management of collaborative research centers, and to entice junior faculty to become interested in this research domain. Further, through networking with practitioners, these networks should allow researchers to gain better access to data in this domain. Finally, center managers will be exposed to a community of scholars of diverse backgrounds who they could look to for collaboration in managerial issues.
- *Success Assessment*: Success in the area of community building will be assessed using metrics associated with workshop and web-based participation, but also by an annual workshop impact survey. We will specifically seek to assess the network based on the following criteria:
    - Active participation in the workshops measured by number of attendees and contributions of position statements and presentations.
    - New research collaborations made possible by the workshop measured through annual post-workshop survey assessing the impact of the workshops.
    - Qualitative comments and perspectives of network members (from survey).
    - Successful proposal and acceptance of at least one track and one panel at major conferences and at least one special issue of a top journal.
    - Enrollment in the on-line network and participation in community correspondence.

2. Identify Relevant Knowledge

- *Tactic 2a:* During workshops there will be three forms of presentations, based on the three sources of knowledge identified above: (1) experiences of center managers (best practice and benchmarking); (2) organizational research in general; and (2) research into these forms of centers in particular. These will be discussed in terms of relevance and actionability in the workshops and the workshop participants will report out from minigroups at the end of each workshop. Minigroup reports will focus on relevance of experiences and research presented, and suggestions for follow-up research and curriculum development. The workshop committee will summarize these reports and make the report available to NSF and the network participants.

- *Outcomes:* During the workshops researchers and center managers will be exposed to the most current thinking on the management of collaborative research centers, and some of this thinking will be captured by the minigroup reports, presentations, papers, and center manager transcripts. Further, workshop participants will help identify what sorts of research are required and what knowledge should be disseminated.
- *Success Assessment*: Successful identification of relevant knowledge will be assessed using the following criteria:
    - Surveys at the end of each workshop crafted to address the relevance of the workshop content to research and practice.
    - Reports from each workshop identifying (1) relevant knowledge presented, (2) ideas for dissemination, and (3) suggestions for future research.

3. Explore Dissemination of Knowledge

- *Tactic 3a:* Transcriptions of center manager presentations, and also papers associated with organizational and center management research, will be made available to network participants through the website.
- *Tactic 3b:* The website will host a knowledge base of papers, presentations, and links to published work associated with the management of collaborative research centers. A PhD student will be partially funded to aggregate relevant research before and after each workshop to be sure the content is refreshed at least twice annually.
- *Tactic 3c:* During workshops participants will explore the best ways for disseminating the knowledge and adjust the tactics as necessary.
- *Tactic 4c*: A key outcome from each workshop will involve suggestions for curriculum development around disseminating relevant knowledge

- *Outcomes:* By storing workshop-related documents in one location, researchers will have a place to go to easily find related work from the network, but also a place to list their own work and make it easy for other members of the community.
- *Success Assessment*: Making knowledge available is only one part of dissemination – network members must also view and/or download this knowledge. The primary measure for dissemination will involve web analytics:
    - Through the website we will capture and report page views and downloads of community content.

4. Determine Community Sustainability

- *Tactic 4a:* The first element of sustainability will be interest. Each workshop will devote time to collectively assessing the value of the community and eliciting ways to make the community more valuable.

- *Tactic 4b:* A key theme in each workshop will involve discussion around value and sustainability of the community. Any tactics identified will be acted upon to the degree possible.
- *Tactic 4c:* If tactics are identified that require additional funding, the workshop committee will set up a plan to attain this funding.

- *Outcomes:* A sustainable community must remain relevant and valuable to its participants over time, and the focus on sustainability during each workshop will increase the likelihood that the proposed research collaboration network remains relevant and valuable to the scientific community over time.
- *Success Assessment*: It is difficult to determine in advance what a sustainable community may eventually look like. To assess whether sustainability determination was successful, each workshop committee will do the following:
    - Develop a report to NSF reporting on the current state of the network and making recommendations for sustainability, followed by recommended actions to realize this sustainability.
    - Ultimately, success will be evident if the community persists after the project has been completed.

It is important to note that while the overall objectives will be consistent throughout the project, other elements of the project may change. In such situations where the standing committee believes that there should be a change to the plan, justification of this change will be discussed with the appropriate NSF program manager who will determine whether the change is reasonable and whether this justification needs to be made in writing. Any such changes will also be documented in each year's annual report. Keeping in mind that the above four objectives will remain constant throughout the project, following is a summary of the workshop activities and a proposed plan.

Workshop Activities Plan

The primary method for bringing the proposed Research Collaboration Network together involves annual workshops (two in the first year) for a total of six, each followed by committee reports of the content of each workshop and annual reports to NSF about the project. In addition to the workshops, the steering committee will look to identify academic conferences where related cross-disciplinary panels and tracks would be appropriate, and also to determine whether journal special issues are appropriate to propose. A cross-disciplinary committee will be charged with organizing each workshop (see next section for roles), conference participation, and planning for the following year. The University of Georgia will develop and maintain a website for the network over the course of the project.

The workshops will involve exploration of topics that are important to many collaborative research centers:

- Workshop 1: VOSS I: Managing Virtual Collaborative Centers
- Workshop 2: Software I: Managing Scientific Software Ecologies
- Workshop 3: Innovation I: Managing Infrastructural Innovation
- Workshop 4: VOSS II: Leadership & Governance of Distributed Research Centers
- Workshop 5: Software II: Managing Scientific Software Ecologies
- Workshop 6: Innovation II: Organizing for Scientific Discovery & Commercialization

There are three general workshop themes: VOSS, Software, and Innovation. These three themes were identified as particularly relevant to a variety of centers based on current research into the management of collaborative research centers (Berente 2010; Herbsleb & Howison 2009). The first workshop addresses

distributed, virtual collaboration across centers, which is increasingly important to contemporary science and dovetails nicely with the issues addressed by NSF's Virtual Organizations as Sociotechnical Systems (VOSS) program. This topic was intentionally chosen to be first to begin exploring how the findings from VOSS research can inform center management directly. The second workshop explores the particular forms of scientific software – infrastructural software, domain software, and collaborative software. As indicated above, software is fundamental to virtually every aspect of collaborative research centers and understanding how to manage software ecosystems is critical to managing these centers. The third theme emphasizes the innovative elements of managing collaborative centers. Innovation is the fundamental reason for engaging in interdisciplinary collaboration in the first place, and it is critically important to understand the ways that centers can organize for different forms of innovation. Although the topics of the first two workshops are fixed, subsequent workshops may change depending on feedback from the community during the first two workshops, the ideas of the workshop committees, and continued research in these areas.

Workshop locations will rotate among the home locations of the three members of the standing committee: Athens, Georgia (PI - UGA), Austin, Texas (Co-PI - UT), and Ann Arbor, Michigan (Chair – U of M). We may hold subsequent meetings at other locations based on content and domain chairs of particular workshops (i.e., Ann Arbor, Cleveland, or Pittsburgh). There will be no limit to the attendance for each workshop, but honoraria and travel expenses will be covered for fifteen participants for each workshop. See "Network Participants" below for an example list of invitees. The workshop committee for each workshop will determine the list of invitees. The duration of the workshops will each be one and a half days. The format of the workshops will involve (at least) seven presentations and workgroup breakout discussion time. Presentation will include two center manager presentations of "best practices," two theme-related management research presentations, two theme-related social studies of centers research presentations, and one theme-related keynote. Keynotes and center management presentations will be transcribed, whereas research presentations will be expected to have a working paper to support the presentation. On the second day the workshop participants will address issues of value, dissemination, and sustainability of the network, and develop and present reports to the workshop committee.

Finally, we look to propose and deliver two panels or tracks at major conferences over the years. At least one panel will be at a domain / center-related conference where center directors are likely to go anyway (i.e., SuperComputing). One will be in a venue where organizational / social science / information systems researchers who are interested in managing centers are likely to attend. Further, at least one workshop committee will propose a special issue at a top journal.

The workshop committees will look to encourage diversity in a variety of ways. First, the Research Collaboration Network will necessarily be cross-disciplinary, thus encouraging knowledge diversity. The example list of network participants below includes people from a variety of disciplines, including business, information science, communications, computer science, engineering, cyberinfrastructure centers, domain science, private industry, etc. Further, at least half of the participants and presenters of each workshop will be junior faculty, postdoctoral researchers, or PhD students, thus ensuring a mix of experience. Finally, the workshop committees will consciously encourage minority involvement in the workshops, which would include being sure to be inclusive of minority groups and to reach out to minority serving institutions.

Table 1: Work Plan by Quarter: RCN for Managing Research Centers Proposal

	Activities	***Deliverables***
2011- Q4 **2012 – Q1**	Plan for VOSS I and Software I workshops	Develop website & agenda, and invite participants
2012 – Q2	VOSS I: Managing Virtual Collaborative Centers Workshop, Athens, GA	*[workshop lead: Berente]*
2012 – Q3	Software I: Managing Scientific Software Ecologies Workshop, Austin, TX	*[workshop lead: Howison]*
2012 – Q4		annual report
2013- Q1/Q2	Plan for Innovation I Workshop; Propose Conference Panel/Track	Develop website & agenda, and invite participants; panel/track proposal
2013 - Q3	Innovation I: Managing Infrastructural Innovation Workshop, Ann Arbor, MI	*[workshop lead: Howison]*
2013 – Q4		annual report
2014 – Q1/Q2	Plan VOSS II Workshop; Propose Conference Panel/Track	Develop website & agenda, and invite participants; panel/track proposal
2014 – Q3	VOSS II: Governance of Distributed Research Centers, Cleveland, OH	*[workshop lead: Berente]*
2014 – Q4		annual report
2015 – Q1/Q2	Plan for Software II Workshop ; Propose Conference Panel/Track	Develop website & agenda, and invite participants; panel/track proposal
2015 – Q3	Software II: Managing Scientific Software Ecologies Workshop, Pittsburgh, PA	*[workshop lead: Howison]*
2015 – Q4		annual report
2016 – Q1/Q2	Plan for Innovation II Workshop	Identify venue, develop website & agenda, and invite participants
2016 – Q3	Innovation II: Organizing for Scientific Discovery & Commercialization Workshop, Athens, GA	*[workshop lead: Berente]*
2016 – Q4		annual report

Steering Committee

There will be a standing steering committee throughout the five years, then for each workshop there will be two workshop subcommittee members. The standing steering committee will be comprised of three members: the PI, the Co-PI, and the Chair. For each workshop there will also be two workshop subcommittee members: the center management "Domain Chair" and the topical specialist who we refer to as the "Content Chair." Following details their roles.

Standing Committee Members – Nicholas Berente & James Howison
The role of the standing committee members is to plan, coordinate, and lead the workshops. Steering committee members will alternate in leading workshops (as indicated in Table 1). The leader takes the primary role in organizing the workshop and in generating the content, but both committee members will actively participate in managing all workshops. Further, committee members are charged with delivering upon both strategic and tactical issues associated with the network (in collaboration with other workshop committee members and participants) – from recruiting panelists to writing proposals for panels or research tracks at top conferences.

Chair of Standing Committee – John Leslie King
The role of the steering committee chair is to promote the RCN to the funding agencies and centers and to elicit participation from senior ("anchor") scholars and center directors to assure networking sessions have a vibrant mix of participants. Further, the Chair will be critical to recruiting appropriate workshop subcommittee members (the domain and content chairs). Chair will also participate and guide the planning for the workshops, attend and present (as necessary) in the workshops, and join in the writing of panel proposals and annual reports.

Workshop Subcommittee Members
Each workshop will have a different theme and we will recruit two different senior people as committee members for each workshop. These two people combined with the three standing committee members will form the workshop subcommittee. The "Domain Chair" will be a center manager or director who has a strong interest in the workshop theme. The "Content Chair" specializes in the content of the workshop which involves research into collaborative centers. The Domain Chair will be asked to present their "best practices" and aid in the recruitment of another center director to present. Similarly, the Content Chair will be asked to present his or her research and help recruit other presenters.

Network Coordinator
The role of the network coordinator (funded by UGA) is to administer the details of the workshops. The responsibilities of this role includes: coordinating workshop invitations and logistical details; organize the venue, lodging, meals, and refreshments; act as a host/greeter for the workshops; manage submissions, presentations, and other related documents; and maintaining the content of the workshop websites. UGA's Office of Information Technology will develop, host, and maintain the websites at no cost to the grant.

PhD Student Support
A UGA PhD student will be involved the creation and organization of a relevant research database for each workshop. This will include both the materials leading up to the workshop, and those generated within the workshop (i.e., presentations, reports, etc.). This student will also be a full participant in the workshop and be given a chance to present research, if applicable.

Network Participants:
Following is an initial list of potential network participants. This list represents a combination of junior and senior people involved with the management of research centers and related topics. (List does not include NSF, DoD, DoE, etc., personnel who may be interested in the RCN.)

Stan Ahalt, RENCI
Dan Atkins, Michigan
Diane Bailey, UT-Austin
Len Bass, SEI
Fran Berman, RPI
Kent Blackburn, LIGO
Jay Boisseau, TACC
Christine Borgman, UCLA
Geoffrey Bowker, Pittsburgh
Brian Butler, Pittsburgh
Jennifer Claggett, UGA
Elizabeth Corley, Arizona State
Debbie Crawford, Drexel
Kevin Crowston, Syracuse
Jonathan Cummings, Duke
Deborah Dougherty, Rutgers
Paul Dourish, UC-Irvine
Thom Dunning, NCSA
Paul Edwards, Michigan
Thomas Finholt, Michigan
Ian Foster, Chicago / Argonne
Peter Fox, RPI
James Gaskin, Case Western
Sean Hansen, RIT
Tony Hay, Microsoft
James Herbsleb, CMU
Scott Hissam, SEI
Steven Jackson, Cornell
John Leslie King, Michigan
Laurie Kirsch, Pittsburgh
Cory Knobel, Pittsburgh
Patricia Kovatch, NICS
Andreas Kuehn, Syracuse
Charlotte Lee, Washington
Paul Leonardi, Northwestern
Eric Lyons, Arizona / iPlant
Kalle Lyytinen, Case Western
Ann Majchrzak, USC
John McGee, RENCI
Fiona Murray, MIT
Gary Olson, UC-Irvine
Judy Olson, UC-Irvine
Nicole Radziwill, George Mason
Dan Reed, Microsoft
Yuquing Ren, Minnesota
David Ribes, Georgetown
Ralph Roskies, PSC
Joseph Rubleske, UGA
Elizabeth Sexton-Kennedy, Fermilab
Sandra Slaughter, Georgia Tech
Dan Stanzioni, TACC / iPlant
Victoria Stodden, Columbia
David Tilson, Rochester
John Towns, NCSA
John Tripp, MSU
Phil Westmoreland, ICSE
Brad Wheeler, Indiana
Nancy Wilkins-Diehr, SDSC
Youngjin Yoo, Temple
Ann Zimmerman, Michigan