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Research Collaboration: Opportunities for CIC Universities

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Collaborative research is emerging as the principal route to securing substantial research funding. This discussion document reviews shifting emphasis toward collaborative science among federal funding agencies and provides key considerations for collaborative projects at CIC universities. The Appendix includes brief descriptions of six projects illustrating models ranging in scope and mission.

Shift toward Big Science

The federal government is the largest source of support for research activity performed in the academic sector. Although federal expenditures for research and development in the United States declined in recent decades while industry increased its share of R&D expenditures, this trend reversed in 2003 (Science and Engineering Indicators, 2006). Federal agencies continue to be the primary source of support for basic research. However, important changes in funding priorities are reshaping the structure and process of research activity:

- A key change from previous funding patterns is a shift away from small-scale, loosely-organized science performed by somewhat autonomous, individual scientists. Government funding is being directed toward large-scale projects performed by multi-disciplinary teams of specialists. In contrast to the highly decentralized, single-scientist model, large-scale science requires much more coordination and some degree of centralized management.
- Government agencies are making substantial investments in projects that address complex science and technology problems and that produce research which is ready for industrial application and commercialization.[1] Universities are working closely with industry to shape research agendas that have the greatest urgency and development potential.
- Universities and government agencies are increasingly joining forces to promote economic growth and development.

Thus, for federal funders, the model of autonomous scientists loosely-organized in academic departments is giving way to collaborative scientific teams that integrate academic disciplines and span across multiple institutions in government, industry and the academic sector.

Benefits of Collaboration

The National Science Foundation (NSF) set the course for collaborative research when it began funding Engineering Research Centers and Science and Technology Centers

[1] Science and Engineering Indicators 2006 reports no evidence that basic research is on the decline, however. The report does make the point that basic and applied research can be complementary to each other and embodied in the same research, thus making it difficult to distinguish one from the other (National Science Board, 2006).

in the 1980s. Other federal agencies followed suit as universities came to be seen as potential large-scale problem solvers (Bozeman and Boardman, 2003). The advantage of multi-purpose, multi-discipline research centers lies in their problem-based mission and central coordination. Bringing a variety of perspectives to bear on a common problem promotes cross-fertilization of ideas. A dynamic group of specialists coordinated centrally is potentially more stable and more productive than individual scientists working alone. The right partners with the needed expertise can be assembled as projects require. Further, collaborative research models facilitate the transfer of specialized knowledge across university boundaries and accelerate the transfer to technology applications and development. Finally, by sharing the costs of supporting expensive equipment and other resources, collaborative research centers can make possible enterprises that individual laboratories or scientists could not sustain.

With increasing competition for research funding, large-scale, collaborative projects wield critical advantage in attracting federal research dollars. In its FY2006-2011 strategic plan, for example, NSF listed as its first priority that it "will emphasize investigations that cross disciplinary boundaries and require a systems approach to address complex problems" (NSF, 2006). In 2004, the National Institutes of Health (NIH) introduced a program of initiatives to stimulate interdisciplinary team approaches under its Roadmap for Medical Research program: as the "scale and complexity of today's biomedical research problems increasingly demand that scientists move beyond the confines of their own discipline and explore new organizational models for team science" (NIH Roadmap website). Other federal agencies have followed suit.

Supportive Infrastructure for Large Grants

Large, complex projects require financial investments that may exceed the capacity of a single, academic unit, especially at universities with decentralized budget models. Large grant proposals require up front investments to cover such expenses as travel and meeting costs for planning purposes, grant writing and other professional services that are not available in-house, and pilot projects leading to larger collaborations. Such costs could discourage faculty from exploring collaborative projects if assistance is not available.

Without administrative support, the coordination and planning required to prepare and submit large, complex grant proposals could be prohibitive for individual faculty or academic departments. Once funded, the administration of such grants can demand substantial resources in personnel time and expertise. Recognizing the potential barriers these requirements can pose for faculty or departments, some universities are developing central infrastructure and support services to promote large research initiatives. Writing assistance, budget preparation, and secretarial support are among the assistance provided:

- The Office of Collaborative Research Services was established by the University of Minnesota in response to requests by faculty task forces. The office fosters interdisciplinary research by providing technical, administrative, and budgetary

support for grant preparation and submission. For funded projects, the office will also provide grants administration services.

- Indiana University provides funding and staff assistance to help faculty prepare and submit large grants. The university is in the process of developing several large infrastructure centers to encourage collaborations and management of grants.

- Northwestern University recently created the Office for Research Development to foster intra-institutional collaborations and inter-institutional alliances with industry, government, and other universities. The office provides technical and administrative support in the development and submission of large grants and sponsors events such as topic-driven symposia to encourage new research initiatives.

- Ohio State University operates several centrally-supported research centers and institutes that organize large grant proposals. Project teams are provided faculty release time, secretarial and budget preparation support, including outside consultants and grant writers if needed.

Reward structures and reporting lines in the university are organized around academic disciplines and have been cited as a potential barrier to collaboration. For example, Bozeman and Boardman (2003) report challenges faced by multidisciplinary research center directors because faculty tenure is invested in an academic department outside of the center. My conversations with a sampling of project directors and staff at CIC universities revealed no indication that this has been a concern or barrier to multi-disciplinary or collaborative work. Project directors noted that faculty were enthused about multidisciplinary projects, citing several factors motivating faculty to collaborate: belief in the importance of a given problem or issue, desire to contribute to the understanding of very complex problems, access to research infrastructure and respected colleagues, and opportunities to develop their research agenda.

Opportunities in the CIC

CIC universities are well positioned to foster collaborative research projects. The infrastructure to support research activity on each of the university campuses is well developed, with highly sophisticated equipment and world-class facilities across an expansive range of research areas. Collectively, CIC universities expend six billion dollars in research and development (see Table 1. in Appendix) and collectively, the 33,000 full-time faculty employed at CIC universities posses highly specialized expertise across virtually all fields of inquiry.

The CIC members' ultra-high speed regional fiber-based optical networks are connected through the CIC Chicago Fiber Ring. Their collective strategic investments in information technology link the CIC universities together as well as to other national and international research networks giving them unparalleled advantage for collaborative research. This networking infrastructure gives CIC universities access to web-based

services for bandwidth-intensive applications such as streaming media for online learning applications, video conferencing, and digital libraries and databases.

In addition to technological infrastructure, CIC universities have in place administrative infrastructures to facilitate shared access to graduate students and academic courses. For example, the Traveling Scholar program enables students at any CIC university to take advantage of educational opportunities--specialized courses, unique library collections, unusual laboratories--at any other CIC university without change in registration or increase in tuition. CourseShare is a system for sharing unique courses between CIC universities, particularly online courses and those taught in a non-traditional format such as summer intensive sessions or weekend seminars. The CIC American Indian Studies Consortium connects faculty, students and other researchers focused on American Indians through workshops, conferences, seminars, and fellowships.

The history of collaboration among CIC universities is an added benefit, lending a foundation of institutional trust and tradition of cooperation to new collaborative endeavors. The network of peer groups that meet regularly can facilitate the identification of potential stakeholders and promotes communication. Face-to-face interaction and physical access to shared facilities are convenient due to geographic proximity, and that proximity can also suggest shared economic and development interests for the Midwestern region.

Key Considerations

A review of research collaborations involving CIC universities illustrates a variety of organizational models ranging from narrowly-focused, bilateral collaborations to large-scale multi-purpose centers spanning academia, industry and government. (See Appendix for descriptions of six selected projects.) Whatever the organizational model adopted, strong leadership lies at the heart of successful collaboration. Conflicting interests, institutional cultures, and physical distance can pose substantial barriers when reaching across academic disciplines, across sectors and institutions, and across the country. Bureaucratic requirements, disparate incentive and reward systems, and organizational structures can exacerbate those challenges. Thus, elements of leadership include a strong mission and clear goals, role clarity and coordination among collaborators.

Assembling the right set of expertise and facilities to address the project's goals is the first priority in choosing collaborators. Project directors point to the specializations and qualifications of the researchers as the fundamental concern when identifying prospective partners. Frank Busta, director of the National Center for Food Protection and Defense, noted that he is often asked to explain why his consortium includes a partner institution that is not a peer in terms of research activity. He explains, "The researchers in this department are the very best at what they do." Although the university in question is not a tier 1 research university, Busta argues that the project requires the specialized expertise of the faculty based at that university, and the

research being produced in this department is the best work being conducted in this area.

Trust among researchers is critical to successful collaboration because the quality of their own work depends on the scientific work of their partners. Thus, it is essential that collaborators' work is credible, their productivity is reliable, and they are committed to the project goals. To identify prospective collaborators, project participants draw heavily on their own professional networks and on the personal recommendations of their trusted colleagues. Ability to work collaboratively is also important. Project directors indicate that collaborative research is not suitable for all faculty. Collaboration is "way too much work for the money," noted Dr. Busta, in order to be viewed as just another avenue to research funds. Ideal candidates are those who are interested in multidisciplinary approaches and teamwork, who value the importance of the project goals and who recognize that the desired research activity would not be possible without collaboration.

Successful collaboration requires communication. Face-to-face meetings, video and telephone conferencing are necessary for establishing shared commitment to the project goals and clarifying collaborator roles and expectations. Thom Dunning, interim director of the Great Lakes Consortium for Petascale Computing, described how the communication process gave shape to the Great Lakes Consortium. Prospective partners were convened to plan an application for a specific NSF grant, but through their interactions, the group discovered a number of common goals and collaborative activities, determining that they would collaborate regardless of the specific grant outcome. Dr. Dunning also pointed to the advanced networking and video conferencing infrastructure among the CIC universities as significant advantages for research collaboration and sharing academic courses, viewing CIC universities as natural partners for research collaboration.

In sum, to be competitive for large research grants, universities must support collaborative research endeavors. CIC universities enjoy important advantages for collaborations: CIC universities possess great breadth and depth of highly specialized expertise and research infrastructure; CIC universities enjoy a tradition of cooperation and institutional trust; and technological and administrative mechanisms are place to support the sharing of ideas, people and university resources. Yet, the importance of assembling the right partners for the right projects is fundamental to success. For CIC universities, successful collaborations will depend on identifying common goals that match the interests and resources available.

Appendix

Profiles of Research Collaborations in the CIC

Collaborative research projects vary greatly in mission, size, scope, and projected time span. Multi-disciplinary, multi-purpose research centers that are broad in scope can have an enduring outlook while bilateral projects with a singular focus might be conceived with a limited time frame. Collaborations can comprise a stable set of institutional partners committed to a common problem. By contrast, other models may include a single lead institution that solicits collaborating scientists and institutional partners to research specific problems which develop as the research progresses. The research agenda may be fixed, with a specific project funded to address a particular research problem, or, it might be dynamic, with the lead institution identifying research priorities that change over time.

The following section includes brief descriptions of six collaboration models that are currently in place at CIC universities. The selected examples represent a sampling of projects ranging in size, scope, and organizational structure.

Collaborations in Life Sciences and Informatics Research (CLSIR) and Collaborations in Biomedical Research (CBR)

Mission:

To foster and encourage collaboration between Purdue University and Indiana University Bloomington faculty to initiate research projects that have the potential to develop into larger, continuing, externally funded research programs.

Organizational structure:

CLSIR and CBR are joint initiatives between Indiana University and Purdue University. Both institutions contribute equal funds to support collaborative projects involving participation by researchers from both institutions. Researchers from either institution may apply for project funds through their local office of research.

Key activities:

Each program awards $50,000, one-year grants to support collaborative research projects that have the potential to develop into larger, externally funded research enterprises. Five projects were funded by CLSIR in the first round (2006) and three were funded in 2007. CBR funded seven projects in 2007.

Background/Process:

The collaboration programs were designed to capitalize on the complementary strengths of the state's two major research-intensive universities in areas that are promising for economic development of the state. The research grants make possible projects that require the combination of expertise and resources from both institutions and would not be possible without collaboration.

The programs are modeled on the Program of Comparative Medicine, a pilot implemented in 2002 with a start-up grant from the State of Indiana's 21st Century Research and Technology Fund.

PROSPER

www.prevention.psu.edu/projects/PROSPER.html

Mission:

To utilize the combined efforts of prevention scientists, the Cooperative Extension system, and local schools and community leaders to develop community partnerships that strengthen families and help young people avoid substance abuse and behavioral problems.

Organizational Structure:

Penn State University and Iowa State University collaborate in a joint project investigating partnerships that link extension personnel, public school staff, state prevention specialists, prevention researchers, and other interested community partners in 28 communities throughout Pennsylvania and Iowa. Local community teams are led by extension and school co-leaders that are linked to university researchers via prevention coordinators.

Key activities:

PROSPER (PROmoting School-university-community Partnerships to Enhance Resilience) focuses on two successive cohorts of public school 6th graders in participating communities (over 12,000 students). Partnership-assisted school-based and family-focused preventive interventions are delivered in partnership condition communities. The preventive interventions delivered were selected by local partnership teams from a menu of empirically-supported programs.

Extensive data collection activities are conducted with students, families, partnership members, and others. A team of researchers from both universities test and refine models for universal preventive intervention research. Using the first phase results as a guide, the second phase will entail (a) an expansion to additional sites in Iowa and Pennsylvania and, most importantly, (b) the gradual inclusion of an increasing number of states, as part of a national network of partnerships.

Background/Process:

The National Institute on Drug Abuse awarded $11.2 million to Iowa State University and $9.9 million to Penn State to develop the program, which may serve as a national model for other partnerships.

System-wide Change for All Learners and Educators (SCALE)

www.scalemsp.org

Mission:

To improve the mathematics and science achievement of all students at all grade levels in the four partner school districts by engaging them in deep and authentic science and mathematics instructional experiences.

Organizational structure:

SCALE is a national network of more than 50 working groups of educators and researchers. The University of Wisconsin-Madison is the lead institution, partnering with

- Denver Public Schools
- Los Angeles Unified School District
- Madison Metropolitan School District
- Providence (RI) Public Schools
- California State University Dominguez Hills
- California State University Northridge.

A senior management team, including a representative from each partner institution, provides leadership to interdisciplinary "design teams." Each design team is committed to implementing one of the project goals listed below. The project reports annual to its National Advisory Board which includes scientists and mathematicians, teachers, science and mathematics educators, and policy researchers.

Key activities:

SCALE encompasses the following five areas of work:

- Implementing the best current mathematics and science programs system-wide;
- Creating state-of-the-art science, technology, engineering and mathematics immersion projects and implementing them system-wide;
- Reforming preservice and in-service STEM teacher education for teachers in the partner districts;
- Creating mentoring and guidance experiences for middle and high school students, especially women and minorities; and
- Implementing a comprehensive program of research and evaluation

Funding:

The project is funded through a $35,000,000, 5 year grant from the NSF Math and Science Partnership (MSP) program.

Great Lakes Consortium for Petascale Computing

Mission:

To develop a robust petascale computing system.

Organizational structure:

The University of Illinois and the National Center for Supercomputing Applications (NCSA) are lead institutions, with Thom Dunning, UIUC, presently serving as interim director. Partner institutions include

- the CIC member universities
- University of North Carolina at Chapel Hill
- Louisiana State University
- Other, smaller colleges and universities.

IBM is involved in the consortium, and additional partners from industry may become involved in the future.

Key activities:

The consortium will support both research and educational activities.

- Research teams will enhance and develop computing systems software needed to deploy a reliable, robust petascale computing system.
- Research teams will develop a broad range of scientific and engineering applications designed to take full advantage of the capabilities of petascale computing.
- Educational programs will be designed to prepare students and faculty to use petascale computing in science and engineering research and to contribute to the development of petascale applications and technologies.
- Educational programs will include shared courses, faculty exchanges and student workshops.

Background/Process:

Participating universities provided up front funding to pay for their own direct participation in the consortium. Some 100 representatives convened for an initial organizational meeting to plan a proposal to NSF (currently under review). As a result of the meeting, however, participants identified a number of activities that they wished to pursue and decided that they should collaborate whether or not the NSF proposal is funded. It is anticipated that with growing national interest in petascale computing, additional sources of funding will be available to support the consortium projects.

The director noted the intensity of interest expressed by faculty who wanted to be involved with the consortium. In the competitive arena for research funding, faculty seem to welcome collaboration as it makes possible more opportunities for faculty research and development. He noted further that collaborations such as the Great Lakes Consortium are especially suited for collaboration among CIC universities as it builds upon linkages that they already have in place.

National Center for Food Protection and Defense

www.ncfpd.umn.edu

Mission:

To advance the security and safety of the nation's food supply through research, education, and outreach.

Organizational Structure:

Based at the University of Minnesota, CFPD is a multidisciplinary research consortium. Academic collaborators include

- University of Minnesota
- Michigan State University
- University of Wisconsin–Madison
- North Dakota State University
- Georgia Institute of Technology
- University of Tennessee–Knoxville
- individual investigators from 21 other universities

More than150 experts from academia, private sector research organizations, professional organizations, state and federal government agencies, and the food industry are involved in the Center's research and education program.

The Center is housed in the Academic Health Center (AHC) which comprises six schools and colleges and numerous interdisciplinary research and education centers.

CFPD governance structure includes

- A senior leadership team that oversees strategic and tactical programs and management.
- A Research and Advisory Panel makes recommendations to the senior leadership team regarding scientific content and direction for the consortium.
- Co-chaired by representatives from industry, the Industry Workgroup provides technical expertise and guidance from the end-user perspective.
- An External Board of Advisors comprised of representatives from industry, government and academia, provides executive level oversight and leadership. This group evaluates the overall impact of the program and promotes integration of new technologies among stakeholders.

Key activities:

29 NCFPD-funded projects are currently funded across nine research teams. Projects include collaboration across multiple teams and organizations spanning across academia, the private sector and government. Other activities include education workshops, a summer institute for students, hosting visiting scientists from Minority Serving Institutions, and curriculum development.

Background/Process:

The Center is funded through a 5-year grant from the US Department of Homeland Security. The Center has secured additional funding to support its work, including some 200 USDA grants and additional grants from the Department of Homeland Security.

National Nanotechnology Infrastructure Network (NNIN)

Mission:

To provide support in nanoscale fabrication, synthesis, characterization, modeling, design, computation and hands-on training.

Organizational structure:

(NNIN) is an integrated partnership of thirteen user facilities, supported by NSF, providing opportunities for nanoscience and nanotechnology research. NNIN supports education, training and outreach activities.

Partners include:

- Cornell Nanoscale Facility at Cornell University
- Stanford Nanofabrication Facility at Stanford University
- Solid State Electronics Laboratory at University of Michigan
- Microelectronics Research Center at Georgia Institute of Technology
- Center for Nanotechnology at University of Washington
- Penn State Nanofabrication Facility at Pennsylvania State University
- Nanotech at University of California at Santa Barbara
- Minnesota Nanotechnology Cluster (MINTEC) at University of Minnesota
- Nanoscience at University of New Mexico
- Microelectronics Research Center at University of Texas at Austin
- Center for Imaging and Mesoscale Structures at Harvard University
- Howard Nanoscale Science and Engineering Facility at Howard University
- Triangle National Lithography Center at NCSU (Affiliate)

Penn State Nanofabrication Facility:

http://www.nanofab.psu.edu/

Nanofab is an open access national NNIN user facility established to enable advanced interdisciplinary academic and industrial research and development in the semiconductor electronic and optoelectronic, micro and nanoelectromechanical systems (MEMS/NEMS), materials, biological and pharmaceutical fields. It has a designated NNIN focus on materials and chemical and molecular scale technologies. The Nanofab is part of the Materials Research Institute at Penn State,

- contains over $32 million dollars of state-of-the-art 6” and 8” compatible micro and nanofabrication equipment.
- supports the Center for Nanotechnology Education and Utilization (CNEU)
- supports Pennsylvania Nanofabrication Manufacturing Technology Partnership (NMT), a nanotechnology education and workforce development program providing semester-long, hands-on undergraduate and graduate education to students enrolled at more than 30 different institutions across Pennsylvania.

National Nanotechnology Infrastructure Network (NNIN) *con't*

University of Minnesota Nanotechnology Cluster (MINTEC):
http://www.mintec.umn.edu/

The NNIN site at Minnesota addresses nanoparticle-based research and remote processing and characterization. The site encompasses three labs:

- Nanofabrication Center houses processing tools for building micro and nano devices with an annual budget of approximately 1.6 M$,
- Characterization Facility provides capability in microscopy via electron beams, force probes and visible light; elemental and chemical imaging.
- Particle Technology Lab supports research in environmental nanoparticle and nanoparticle application work. The estimated value of the laboratory instrumentation is in excess of $3 Million.

In addition to these physical labs the Minnesota site leverages existing nano research at Minnesota including a MRSEC, four NIRTs, the Nanoparticle IGERT, and several REUs.

Solid State Electronics Laboratory at University of Michigan:
http://www.mnf.umich.edu/

The Solid-State Electronics Laboratory (SSEL) works on the development of electronic and micromachined devices, technologies and systems. Housed in the Department of Electrical Engineering and Computer Science, the SSEL operates the Michigan Nanofabrication Facility (MNF), which provides the latest and most advanced research facilities and capabilities in micro and nano technologieslab. SSEL also interacts with many departments and colleges across the university.

Table 1. R&D Expenditures at CIC Universities, FY 2004

Institution	Total R&D Expenditures	Federal Government	State & Local Government	Industry	Institutional Funds	All Other Sources
University of Chicago	272,390	229,102	4,402	3,098	14,970	20,818
University of Illinois at Chicago	307,699	192,825	9,020	6,369	77,871	21,614
University of Illinois at Urbana-Champaign	506,041	275,896	43,633	13,128	161,294	12,090
Indiana University - All Campuses	384,168	166,913	4,274	7,939	155,170	49,872
University of Iowa	312,914	209,865	10,739	14,075	66,766	11,469
University of Michigan - All Campuses	769,126	521,339	16,232	32,215	156,534	42,806
Michigan State University	325,438	143,473	48,561	8,628	109,154	15,622
University of Minnesota - All Campuses	515,061	308,369	52,924	21,832	71,811	60,125
Northwestern University	358,947	230,593	2,211	9,221	86,051	30,871
Ohio State University - All Campuses	518,088	284,675	61,831	42,763	97,526	31,293
Pennsylvania State University - All Campuses	600,139	347,996	54,553	85,570	110,662	1,358
Purdue University - All Campuses	365,779	144,090	46,851	37,908	136,612	318
University of Wisconsin-Madison	763,875	434,423	35,872	17,911	210,191	65,478
Grand Totals	5,999,665	3,489,559	391,103	300,657	1,454,612	363,734

* Reported in thousands of dollars.

Source: National Science Foundation, Division of Science Resources Statistics, *Academic Research and Development Expenditures: Fiscal Year 2004*, NSF 06-323, Project Officer, Ronda Britt (Arlington, VA 20006).

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