Information Sciences and Technology at Iowa State University

Vision and Directions for Scholarship, Learning, and Engagement

25 February 2000
Executive Summary

Information Sciences and Technology (IST) denotes the fundamental research that occurs within computer science and computer engineering and the application of that research to all academic disciplines, as well as the use of computing and electronic communications technologies in all areas of human endeavor. By its nature, IST promotes multi-disciplinary interactions and has become a critical component of discovery in a wide range of fields spanning the breadth of science and engineering.

Even so, the greatest opportunities remain untapped. For example, it is clear that:

- By providing efficient tools for locating and synthesizing data, the World-Wide Web will become as important to the well-being and economic development of society as reliable power and water distribution systems are today.
- Understanding and making use of the vast amounts of data that are becoming available will require new information display and interpretation technologies that partially or completely automate the process of data analysis.
- This will require continued improvements in computing power and capabilities that will be achieved via advances in networking technology, self-configuring hardware, and software that self-organizes out of available components on a network.
- We have only begun to exploit the potential of the web and other distributed technologies to enhance teaching and learning and to explore radically new kinds of learning environments.
- Enabling students, citizens and scholars to benefit from these advances will require a better understanding of how we interact with technology. We must learn how people turn images and symbols on their computer screens into ideas.
- Web-based training and retraining will become a major part of the education sector. Leaders that emerge today will dominate the web-enabled, life-long learning sector.

Although IST's importance to society as a whole has grown dramatically over the past several years, the rate of change in this technology will continue to grow in ways that challenge our ability to adapt. For example, it has been predicted that computers with the processing power and memory of the human brain will be available within a decade\(^1\). The implications of this are staggering. Hence, while the promise of IST is clear, a great deal of fundamental research will be required to determine how it may best be applied for the betterment of the human condition.

This past year, the U.S. President's Information Technology Advisory Committee (PITAC) submitted a report emphasizing that "information technology will be one of the key factors driving progress in the 21st century—it will transform the way we live, learn, work, and play." The report identifies those research areas within IST that need to be federal priorities, and emphasizes the need for long-term, multidisciplinary research. More recently, the National Science Foundation (with substantial Congressional support) has announced its Information Technology Research initiative that identifies eight major areas for sustained research funding.

Based on our analysis of the developing national research priorities, the Information Sciences and Technology Task Force at Iowa State University has identified six major leadership areas:

- Information Systems and Management
- Advanced Computational Science
- Software
- Human-Computer Interfaces
- Educational, Social, and Economic Impact of IST
- Information Infrastructure

\(^1\) R. Kurzweil, *The Age of Spiritual Machines. When Computers Exceed Human Intelligence*. 1999. Kurzweil discusses this issue in great depth; he predicts that such systems will be commodity $1000 [1999 dollars] systems by ca. 2020.
For each of these areas we identified its national priority, its current strength at Iowa State University, and its recommended priority in an IST initiative at Iowa State University. While not definitive, this process established that Iowa State University has a solid core of excellence upon which to build a successful IST initiative. Our vision for this IST initiative derives from two simple insights:

- IST must be integrated into research and teaching in all fields, and
- IST is a *bona fide* field of study in its own right and of growing importance.

The essential components of this vision include:

- **Peer Leadership**, nurturing a bottom-up, self-organizing multidisciplinary web of faculty partnerships and formal research linkages,
- **An Entrepreneurial Approach**, that encourages innovative, moderate-to-high risk research approaches,
- **Assessment of Clear Outcomes**, whereby formal measures of success in the medium term ensure an ever-strengthening program,
- **The Integration of Research and Learning at the Graduate and Undergraduate Levels**, strengthening linkages between research and our educational programs.
- **Clear Priorities and Incentives**, ensuring that we move from less viable areas to those that increase the national stature of Iowa State in IST, and finally,
- **A Strategy to Ensure Long-Term Cultural Change** at Iowa State, leading to the substantive integration of IST into every area of scholarship, education, and community engagement.

Based upon our analysis of current strengths and future opportunities, our over-arching recommendation is that Iowa State University should embark on an IST initiative that builds upon its traditional strengths and mission as Iowa’s land-grant university of science and technology. This initiative should include:

1. The creation of an Institute for Information Sciences and Technology that will function synergistically with existing administrative structures. This institute should have sufficient institutional priority to ensure that it will develop into a nationally competitive unit.

2. A sustained priority to building multidisciplinary collaborations that depend upon IST and to integrating IST into research and teaching in every area of study.

3. A systematic, long-term commitment to building Iowa State University’s programs in computer science and computer engineering broadly to nationally competitive levels, as well as strengthening other closely allied disciplines.

4. An integrated, long-term strategic plan and implementation process to improve the university’s information infrastructure—academic, instructional, and administrative technologies and services—for ISU faculty, students, and staff.

The body of this report provides additional detailed recommendations for the development of the proposed IST initiative.
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Summary of Recommendations

Each of the following recommendations is developed within the body of the report, based on the consensus of the task force. Recommendations are summarized here for convenience, but are best understood within context.

Recommendation 1: That Iowa State University move to create an Institute for Information Sciences and Technology that would work synergistically with the existing college and department structure. 14

Recommendation 2: That Iowa State University make it a sustained long-term priority to build multidisciplinary collaborations involving Information Sciences and Technology, including hiring faculty with national recognition in IST-related disciplines and providing incentives to existing faculty to participate strongly in such collaborations and to integrate IST approaches into their research and teaching. 17

Recommendation 3: That Iowa State make a systematic, long-term commitment to building its programs in computer science and computer engineering broadly to nationally competitive levels, as well as strengthening other closely allied disciplines. 22

Recommendation 4: That in concert with the creation of the Institute for IST, Iowa State University immediately develop an integrated, long-term strategic plan and implementation process to improve the university’s information infrastructure—academic, instructional, and administrative technologies and services—for ISU faculty and staff. 27
**Introduction**

“Chance favors only the prepared mind.” Louis Pasteur

**Charge to the Task Force**

On August 26, 1999, Vice Provost for Research, Patricia B. Swan, along with colleagues representing the colleges, established a task force to create a vision for Iowa State’s future in research and graduate education related to the Information Sciences and Technology. The charge to the task force was:

1) To consider the directions which the Information Sciences and Information Technology are apt to take in the next few years and to identify associated areas in which Iowa State University has current areas of strength.

2) Based on these considerations, to describe a vision whereby Iowa State University might capitalize on existing opportunities in order to obtain significant national visibility in certain key aspects of the development of Information Sciences and Technology within the next five to ten years.

3) To realize this vision, to describe the expertise needed within the faculty and types of research and graduate education programs that Iowa State should have, as well as major technology (equipment) that would have to be updated or acquired for these programs.

The task force was initially asked not to consider the amount or source of funding needed, nor ways in which the programs might be organized except in the most generic terms.

We use the terms scholarship, learning, and engagement in the title of this report. Scholarship entails “innovation-encompassing research, creative activities, teaching, and extensional/professional practice”; while our emphasis is research, leadership in all aspects of scholarship is essential to our success. Learning, in the context of this report, starts with superior graduate education, but also includes the role of research, outreach, and other opportunities for scholarship and enrichment in educating our students. Just as important, it is through effective engagement that we deploy our knowledge and expertise towards solving problems of importance to Iowa, the nation, and the world. This is achieved in several ways: indirectly through superior scholarship, directly through partnership and new forms of out-

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2 Joining with Vice Provost Swan in creating the task force were: John Mayfield, Associate Graduate Dean; Peter Orazem, Associate Dean of Liberal Arts and Sciences; Ted Okishi, Associate Dean of Engineering; and Colin Scanes, Executive Associate Dean of Agriculture and Interim director of the Plant Sciences Institute.

Interim Vice Provost for Research Bill Lord became the prime sponsor of this initiative in January 2000, as Vice Provost Swan went on leave. Bill Lord, Associate Vice Provost Prem Paul, and the other sponsors just mentioned (including Vice Provost Swan herself) provided substantial feedback on an earlier draft and encouraged us to present as strong a vision as possible.

3 For the source of these terms and their nuances, see: Iowa State University (Fall 1999 [Draft]), Becoming the Best Land Grant University, Iowa State University Strategic Plan for 2000-2005 at www.iastate.edu/~president/2005/draft/.
reach, and most importantly, by ensuring that our students go out to become productive members of the community.

**The Task Force Members**

Peter M. Siegel, Academic Information Technology, Chair
Daniel Ashlock, Mathematics
Carolina Cruz-Neira, Electrical and Computer Engineering
Steven M. LaValle, Computer Science
John Miranowski, Economics
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National Trends in Information Sciences and Technology

“The human history becomes more and more a race between education and catastrophe.”
H.G. Wells

In February of 1999, the President’s Information Technology Advisory Committee (PITAC) submitted its report to the President of the United States. The report⁴, “Information Technology Research: Investing In Our Future”, outlined the vision of its distinguished membership:

Information Technology will be one of the key factors driving progress in the 21st century— it will transform the way we live, learn, work, and play. Advances in computing and communications technology will create a new infrastructure for business, scientific research, and social interaction. This expanding infrastructure will provide us with new tools for communicating throughout the world and for acquiring knowledge and insight from information. Information technology will help us understand how we affect the natural environment and how best to protect it. It will provide a vehicle for economic growth. Information technology will make the workplace more rewarding, improve the quality of health care, and make government more responsive and accessible to the needs of our citizens (PITAC, p.1).

The report goes on to identify five priorities for research, noting a current overemphasis on near-term problems and emphasizing the need for long-term information technology research and development (p. 3). These priorities are summarized in Table 1. While federal directions should not blindly dictate the directions of Iowa State, this report is remarkable in representing broad leadership in the academic community and the federal research enterprise, including strong representation from the scientific disciplines broadly. The National Science Foundation has recently announced a new, Congressionally-supported, initiative in Information Technology Research⁵ that closely follows the PITAC blueprint⁶, with sponsorship from all major directorates, including Biological Sciences, Engineering, Education and Human Resources, and Computer and Information Sciences and Engineering.

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⁴ The President’s Information Technology Advisory Committee, Report to the President, Information Technology Research: Investing in Our Future, February 1999. See also: www.hpcc.gov/ac/report/.
⁵ NSF, Information Technology Research (ITR), NSF Program 99-167, www.nsf.gov/pubs/1999/nsf99167/nsf99167.htm, October 1999. While we initially developed our own categories, we found the NSF terms useful and have adopted them below.
⁶ The solicitation breaks the PITAC Report’s five categories into eight, providing additional definitions and rationales for its priority areas.
The Role of Iowa State University

Iowa State has a strong and unique role to play in the unfolding national Information Sciences revolution. We recognize that:

- 60% of all jobs by 2010 will be Information Technology-related; 
- about one-third of economic growth in the United States since 1992 has been in computing and information technology; 
- Moore’s Law (of Computational Power) is expected to hold over the next ten to twenty years, resulting in a doubling of computing and communications power every twenty-four months at fixed cost.

Multidisciplinary Excellence is a Priority for Iowa State

Iowa State University is Iowa’s land-grant institution, with a strong, historic emphasis on excellence in teaching, engagement (or outreach), and research. Given these initial strengths,
Iowa State has the potential to develop and maintain a premier research program in both the fundamental aspects of Information Sciences and Technology (IST) and their application to a wide range of key applications, including many in the Plant Sciences, Engineering, Materials Science, and Education. Building on this type of multidisciplinary excellence, we have a unique role to play in bringing the benefits of Information Sciences Research into the graduate and undergraduate learning processes. This must be done both by bringing students, graduate and undergraduate, into the multidisciplinary research process and within the context of graduate and undergraduate curricula. Building on existing strengths, adding a strong multidisciplinary focus in the Information Sciences is essential to our ability to compete at NSF, NASA, DOE, USDA, DARPA, and other agencies; federal partnerships, exemplified by the university partnership with the Ames Laboratory (DOE), are an existing strength we must exploit.

Responding to the Trend Towards Globalization
As if this were not challenge enough, the trend towards globalization, itself driven by the impact of Information Technologies, demands significant response from the academic community; new opportunities and challenges arise as society, groups, and individuals struggle to keep up with this pace of globalization. Such a response will take the form of new disciplines and priority research areas in almost every field of study. Notably, the humanities and social sciences are critical, because they will help us understand the nature of this technological change, as well as communicate our understanding to policy makers, as well as the public at large. Surprisingly, the role of these fields in understanding IST has been underemphasized both at Iowa State and nationally\(^{11}\); more study is needed to properly articulate the role these areas should play within an IST program at Iowa State, but it will be significant. Business will be another enormously important contributor to our understanding of IST. This task force strongly recommends that the Iowa State College of Business be invited to be an active participant in additional planning for an IST initiative.

Distributed Learning: A Priority for Iowa State
Along with research, education and engagement are the life of the university. Just as IST is both a tool for advancing research and a research topic in and of itself, IST is coming to be both a key subject area for effective education and training—for undergraduates, graduate students, faculty, and lifelong learners—and a key catalyst for providing such effective education and training in any area of study. As distributed learning becomes a national and state priority, Iowa State must make the decision to be a leader in both its development and use, as well as in characterizing its effectiveness. The demand for distributed learning—which comprises both distance learning technologies and the use of information technologies as an adjunct to traditional on-campus classroom teaching—will fundamentally revolutionize the nature of learning programs over the next ten to twenty years, requiring new approaches to “traditional” undergraduate and graduate learning, including the relationship between educational programs and research. In addition, if we as a society are to keep up with the pace of technological change broadly, Iowa State must find ways to integrate lifelong learning pro-

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\(^{11}\) In recent initiatives, NSF has required significant involvement of sociologists and psychologists in projects relating to collaboration technologies, so that the research community could understand the social and interpersonal issues, as well as the value of an approach to multidisciplinary collaborations.
grams into the life of the university or be left behind. Far from compromising the quality of education, such new approaches will come to provide immediate educational feedback to the learner, flexible ways to create dynamic learning communities, and the potential for real-time assessment of the effectiveness of the instruction process.

**Building on Leadership in Extension**

Historically, outreach has been viewed as derivative to educational and research programs on many campuses; that is, we take great research and excellent course materials and repackage them for the broader community. Iowa State rejects this model, emphasizing through the term engagement the two-way partnership between university and citizen. IST is a natural catalyst in a rapid transition to a model of engagement. With the growth of IST, we will less and less see the edge of campus as the delineation point and see education of the people of Iowa and beyond as a primary goal of academia. To put it simply, we must build on the historical leadership of Extension and others to devise innovative engagement (or outreach) programs that help us sustain distributed learning programs, electronic learning communities, and other collaborative activities with the people of Iowa—any time, anywhere. These programs will be essential to a strong IST program in the next five to ten years, if not sooner.

**Terminology: Information Sciences and Technology**

The above-mentioned federal reports use the term information technology research, where we might have chosen the term information sciences. The charge to the task force used the compound expression, information sciences and technology (abbreviated IST), which we will adopt here, because it concisely encompasses the notion of an intellectual, scientific program that moves the state of the art forward, while at the same time recognizing that the use of information technologies is in and of itself changing the nature of academe and society at large.

**Definition of Information Sciences and Technology (IST)**

By IST, we mean both the “core” research and application of computer science and computer engineering, as well as the use of computing and electronic communications technologies in all areas of human endeavor, from research to teaching to social interactions.

The Internet and the world wide web have fundamentally changed how we collaborate both professionally and personally. They have allowed us to interact with colleagues all over the world nearly instantaneously. They have provided us the ability to create interdisciplinary and institutional partnerships on almost any scale. These effects are not limited to the technologically sophisticated, but impact us all. Thus, we do not limit our vision to specific disciplines, but in fact expect that IST will be a key component of every area of research and practice at Iowa State. This implies that every student, undergraduate or graduate, must develop specific skills in both the art of using information technologies and the fundamental principles and practice of information sciences and technology before graduating, whether an English or Psychology major, a veterinarian or an engineer.
The Domain of Information Sciences and Technology (IST)

IST has as its domain any process in which the data grows beyond the point where humans can effectively use that data without a computing device to assist them; its object is to extract useful knowledge from information or to communicate such knowledge. IST’s domain is growing as its inherent value in supporting both social and technical information-sharing at a distance and asynchronously is recognized.

Because of the rapid rate of change in IST and its widespread impact, IST will lead to fundamental and often unexpected changes to all areas of research and education. For a particular project, educators and researchers may start out with the intent to achieve a specific non-computational goal; yet the very use of advanced computing technologies often leads to a phase change, fundamentally modifying what can be done, both quantitatively and qualitatively. Thus, these same scholars end up having achieved a qualitatively different, often more sophisticated, goal that, in fact, enhances their research or educational programs.

The literature is full of examples where technology has caused such fundamental changes—in printing and transportation to name two—and we should not be surprised that computing will continue to lead to revolutionary change in many areas of research. In addition, the phase change to the educational process will be no less revolutionary in terms of how universities teach, how students learn, and indeed who our students are. While this process is, unfortunately, far slower than change in research areas, it promises to impact society just as access to the Internet has already changed how professionals, students, and even families interact at a distance. Given the long gestation period for substantive change in educational models, the time to begin is now.

National Priorities: Major Leadership Areas

We have identified a number of broad national priorities for a successful program in Information Sciences and Technology. These are organized into six major leadership areas, which should be viewed as thematic and often overlapping, rather than as rigid compartments.

- Information Systems and Management
- Advanced Computational Science
- Software Design and Complex Systems
- Human-Computer Interface
- Educational, Social, and Economic Impact of IST
- Information Infrastructure: Computing and Communications Technologies and Services

We will discuss each area in turn.

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12 Based on the categories of the NSF Solicitation in Information Technology Research (NSF ITR Program, see above).
Information Systems and Management

As computing and communications become relatively less costly, new (applied) information systems are evolving rapidly in many areas in ways that impact society as a whole. Rapid advances are changing the very nature of agricultural production and food systems, as well as all forms of industrial production and commerce. In the agricultural information technology arena, geographical information systems (GIS), precision agriculture, electronic commerce, and quality-assurance and environmental standards (such as ISO 9000 and ISO 14000\textsuperscript{13}) are having major impact. Similarly, information systems are leading to major changes in food information, labeling, and marketing. Many of these information systems are being developed in the private sector with research and outreach support from universities, including Iowa State. Several challenges exist in terms of information management, system design, source identification, and expert systems development.

With its land-grant and applied sciences traditions, Iowa State has numerous repositories of on-line information it makes available worldwide. To be effective, online information must be of high quality, effectively organized, often carefully annotated with metadata, readily restructured to meet user needs, and efficiently shared with many communities. Methodologies for understanding the information organization and management process are extremely important both here and around the world. Application areas include spatial datasets (such as for agricultural surveys), data systems (from Genomics to Astronomical to Atmospheric sciences), as well as the organization, archival, and dissemination of information of a general or specific nature. Data-mining, electronic libraries, and multimedia techniques for distributed learning are current examples.

Advanced Computational Science

Progress in many scientific disciplines depends today on effective use of advanced computational approaches, often developed through interdisciplinary community efforts. Research in advanced computational science includes: advanced algorithms and numerical methods, parallelization tools and methodologies, problem-solving environments, as well as the integration of new software technologies (such as software agents) that mediate between data sources, instruments, and human participants. As well, it involves the use of advanced visualization environments, data mining, and other sophisticated approaches to data, pattern, and feature analysis. Finally, it involves experimentation with the application of new computing technologies (both software and hardware) to significant problems in science and engineering. At Iowa State, significant areas include Bioinformatics, Non-Destructive Evaluation, Survey Analysis, Complex Adaptive Systems, Materials Sciences broadly (including emphases in engineering, chemistry, physics and so on). Here, high-performance computing environments are both essential tools for scientific advancement and objects of study in their own right.

Software Design and Complex Systems

We all are major users of software. We need more effective, adaptable, and “intelligent” software that helps us solve problems without significant distortion. As software becomes

\textsuperscript{13} ISO 9000 and ISO 14000 are international standards that provide practical tools to assist users in business and government in assuring the quality of their products and services, and to manage the impact of their activities on the environment, including sustainable development.
more complex, our ability to understand how it functions decreases. More than ever, teams, not individuals, create sophisticated software. In fact, such teams often depend on both pieces and community codes developed by others, who may never have considered this new use in their original design. We need ways to adopt and adapt software built by others for new uses they may not have anticipated. As well, we need tools that help us manage our complex information environments, providing privacy, reliability, and other measures of confidence.

Open Source is an important new approach to leadership. The key notion of Open Source is that the original texts of programs are made available at no (or nominal) cost to everyone and no one is allowed to restrict the copyright in the future for commercial profit. Many groups at Iowa State develop superior software as part of basic research in nearly every field of study; even more build on software developed as parts of communities or developed by others. Using an Open Source philosophy, Iowa State can show leadership in developing and organizing quality software tools and disseminating them to the international community without compromising its ability to ensure quality. Similar to peer-reviewed publications, the development of quality software whose effectiveness is recognized by peers internationally will come to be seen as significant positive factors in tenure and promotion.

**Human-Computer Interface**

How information is presented has an enormous effect on how humans can understand it and exploit it for their needs; just as important, the tools we have available for communicating with the computer and with others, mediated by computers, have both obvious and subtle effects on our ability to communicate, collaborate, and to gain insight. We need to find new ways of making complex information accessible to new communities and understand how insight relates to information presentation. Visualization, immersive environments, input and display devices from “caves” to “wearable computers”, as well as computer-assisted medical or manufacturing technologies, are important here. Of growing importance is our need to understand the impact of “distributed learning” technologies on learning outcomes. Human perceptual, cognitive, social, and environmental factors must be brought to bear on fundamental approaches to interface design.

**Educational, Social, and Economic Impact of IST**

We are rapidly entering the challenging and exciting new world of IST. The information revolution presents many opportunities but are also accompanied by problems. We are only beginning to understand how information technology may impact society, economic structure, psychological well-being, and the educational process. At the same time, we need to more fully understand how societal needs and consumer demands may be impacting technology development. These impacts will differ by scale (the global economy vs. the decision-making of an Iowa farmer) and by setting (research collaboration vs. family life).

Within the educational community, we need to develop our fundamental understanding of the role that information technologies can play in both on-campus learning, as an augment or alternative to classroom learning, as well as in various modes of distance learning, including both traditional degree approaches and more agile models for lifelong learning and retraining. Every other area of Information Sciences and Technology will have enormous effects in this

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14 (See Open Source, p. 25 below.)
area; constructive dialog, as well as multidisciplinary collaborations, between educational,
social, and economic experts, on the one hand, and information and application scientists, on
the other, is essential to understanding and managing these effects.

With the fast pace of research and development, faculty recognize that research results must
be shared quickly if society is to benefit from new innovations. Likewise, the rules of the
game are changing very rapidly in the world of business and agribusiness (e.g., farm inputs
may be delivered to producers by UPS as opposed to the local co-op in the not-too-distant
future). New service industries are cropping up, both to bring traditional capabilities into a
networked world (e.g., electronic “market-spaces” for farm goods) and to provide new
capabilities not dreamed of even a few years ago (e.g., Internet security). The ramifications of
these changes for society, the economy, and the educational system are mind-boggling. It
may be difficult to protect intellectual property rights through the traditional patent process;
new approaches (such as Open Source) may be needed to facilitate the rapid dissemination of
new ideas and innovations. Businesses are needing to develop new practical strategies, tactics,
and rules of engagement to succeed. Communities will also need to respond or adjust as
traditional businesses disappear and social structures change.

**Information Infrastructure: Computing and Communications Technologies and
Services**

As computing and communications become more and more critical in our economic, social,
and educational spheres, it is becoming essential that they be scalable, adaptable, robust and—
more important than ever—secure. We need to understand both individually and as integrated
systems: computer network topologies and technologies (wireless, optical, etc.); middleware
for managing complex systems for education, research, and national goals; security middle-
ware to manage authentication, detect intrusion, and ensure reliability. As the global infra-
structure develops, we need to understand multi-tiered communications for home or field use,
as well as approaches to ensure cost-effective, reliable communications within the educational
community, among scientific collaborators worldwide, and for the world at large. Such areas
as scalability studies, resource reservation, quality of service, and intellectual property man-
agement are increasingly important, as are such new areas as mobile computing.

**Critical Programs at Iowa State: Building on our Strengths**

If we are to create a strong, sustainable initiative in Information Sciences and Technology at
Iowa State, we need to articulate quite specifically the areas in which Iowa State can and must
show leadership from the very inception of the institute, as well as mechanisms by which
programs in these leadership areas can come together to create a competitive initiative with
systemic impact. We will cover the former issue here and discuss the mechanisms in later
sections.

After much analysis and consideration, we have reviewed a significant range of specific
programmatic emphases within the six major leadership areas described above, which
nationally are seen as key components of strong IST initiatives; each of these emphases was
considered in terms of its potential role in an IST program at Iowa State. These emphases are
summarized in **Table 2** (Appendix A, page 29) along with our analysis of their importance
nationally, current strength at Iowa State, and the recommended priority as part of an IST initiative. Based on this analysis, we have identified six of these programmatic emphases that we believe are **critical to a successful IST Program at Iowa State University**, with their associated major leadership areas (indicated in parentheses).

- Numerical, symbolic, and geometric algorithms (Advanced Computational Science)
- Virtual Reality, Graphics (Advanced Computational Science), and Visualization (Human Computer Interfaces)
- Data and Pattern Analysis (Advanced Computational Science)
- Complex System Building (Software)
- Distributed Learning Technologies, including asynchronous and distance learning (Educational, Social, and Economic Impact)
- Information Infrastructure\(^{15}\)

These emphases should be immediate priorities as the Institute for IST is established and require substantial ongoing new resources for this initiative to be successful. While these should be the initial priorities of the Institute, Table 2 provides a set of *additional* priorities, that need to be considered once the Institute is under way.

*Information Infrastructure* includes both a broad research area, as described above, and the core computing and communications infrastructure for the university as a whole; a strong basic infrastructure for all faculty and students is an essential prerequisite for the specific research and educational programs developed within or in association with the Institute. Specific recommendations regarding Information Infrastructure are developed below (page 27).

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\(^{15}\) For the major area of *Information Infrastructure*, all included programmatic areas were considered critical to the initiative. Thus, these were treated as a single emphasis here.
A Vision for Information Sciences and Technology at Iowa State University

“As for the future, your task is not to foresee it, but to enable it.”
Antoine de Sainte-Exupery

The federal PITAC report, *Information Technology Research: Investing in our Future*, noted the critical role that IST is coming to play in interdisciplinary research, education, health care, government, and indeed society as a whole. As such a pervasive field, IST must be represented in all aspects of the university curricula and research and, at the same time, needs to have a special focus. This dual view adds complexity, but is essential, as we will explain below.

**All disciplines will integrate IST into research and teaching**

Consistent with its tradition as the university of science and technology, we see our university as leading the way in integrating all aspects of information sciences and technology into existing disciplines. New leadership programs, such as the Plant Sciences Institute, already emphasize the critical role that IST will play in ensuring a competitive program at Iowa State. As our broader programs in IST strengthen, IST will be able to make essential contributions to many areas of fundamental research, across the colleges. In turn, our ability to attract the very best faculty and students will grow, leading in turn to more effective facilities for research, teaching, and practice in Plant Sciences areas that critically depend on IST, such as Bioinformatics or Genomics.

In fields like Education, just as much as Bioinformatics, integrating IST into the curriculum and research programs is critical. An understanding of the most effective tools for distributed learning, as well as the effects of new learning models on outcomes, is just one thread which education professionals will grapple with. Programs like the *Center for Technology in Learning and Teaching*16 are models for how IST might become integrated into the core of the university.

It is important to have a cross-disciplinary dialog on how best to integrate IST into both research and curricula, so that efforts are truly joint, as well as to allow the best ideas to move into disciplines that have not traditionally exploited IST in a significant way. The best way to ensure that IST impacts all areas of the academy is to provide mechanisms that engage the faculty intellectually and incentives that provide them the time, motivation, and resources to turn that intellectual commitment into concrete programs.

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16 For more information, see [www.educ.iastate.edu/clt/](http://www.educ.iastate.edu/clt/).
IST will be a bona fide field of study

While we have long recognized the importance of Computer Science and Computer Engineering as disciplines within the university, academia has struggled with how to create critical mass in cross-cutting areas. Computational Science and Engineering programs, which bring together scientific disciplines, applied mathematics, and elements of computer science, have been proposed at many campuses, implemented at many, and rejected by others. Iowa State is even now exploring how it might strengthen its offerings in this area.

IST is unique as an area of study, however, and it is possible to articulate a very clear vision. There is a revolution taking place in both academia and in the world at large. This juxtaposition of pressure to make changes in the academic enterprise and fundamental changes in how society itself functions is remarkable, without recent precedent except perhaps for the process of printing. Overused though this comparison is, few have pointed out that the pace of the IST revolution and the slow diffusion of printing-related societal changes are startlingly different. Because of this pace of change, the university must itself respond quickly, with new approaches to managing and understanding the role of IST in research and education. Universities around the nation are considering how best to reorganize themselves to bring the best interdisciplinary minds to bear on the substantial questions (and challenges) of IST. As pointed out earlier, federal programs with significant funding are being created both to respond to the broader societal concerns and to create incentives to universities to respond.

To contrast IST again with printing, many people benefited from the availability of printed materials without having to understand printing technology itself in any substantive way. While IST will help manage complexity in the longer term, it will add complexity for scholars and ordinary citizens alike over the next fifteen to twenty years. This additional complexity, however transitional, requires careful attention.

Being effective as students, workers, family members, or even as citizens, requires us to have substantial knowledge of computing systems, software technologies, information management systems, and other technologies. Biologists must directly, or through expert colleagues, be able to develop advanced database techniques to search genome databases. Urban Planners must use state-of-the-art geographic information system tools to plan cities. Politicians must endeavor to understand complex simulations of pollutants through soils in order to create effective land-use policy. Citizens must learn new ways of interacting with merchants, as e-Commerce changes how we acquire goods and services.

Given how pervasive IST is coming to be, we cannot assume that islands of expertise sprinkled throughout the university are enough. We imagine an environment where experts in pedagogy, virtual environments, and databases must join together on a sustained basis, whether to create competitive research proposals or to develop adequate curriculum. While new approaches to distributed learning will likely be developed and evaluated within Education Colleges, the expertise to understand the critical issues is going to depend on knowledge from Engineers (looking at new display technologies or chip designs), Computer Scientists (who will understand new software techniques), and others. Similarly, while expertise in core

17 Other remarkable examples, from our more distant past, include the invention of language, writing systems, and mathematics.
18 See Siegel et al. (1999), Creating Electronic Citizens for the 21st Century, Acropolis: A Coordinated Ubiquitous Information Environment at Iowa State University: www.cc.iastate.edu/acropolis/AcropolisOverview.htm,
IST disciplines is essential, progress in physical, biological, and social sciences depend on a close interplay between IST expertise and field-specific insights. Thus, our vision emphasizes the need for new approaches to bring people together across a range of fields in flexible ways, while at the same time recognizing that the fruits of their combined intellectual efforts must be applied to and benefit from specific disciplines as well.

General Recommendations: An Institute for Information Sciences and Technology

Recommendation 1: That Iowa State University move to create an Institute for Information Sciences and Technology that would work synergistically with the existing college and department structure.

Given the developing preeminence of Information Sciences and Technology (IST) as a field of study in its own right, an Institute for Information Sciences and Technology has the potential for enormous programmatic impact at Iowa State. We believe the six major leadership areas described above (p. 7 ff.) form the basis for six centers within the Institute for IST. These areas are:

- Information Systems and Management
- Advanced Computational Science
- Software Design and Complex Systems
- Human-Computer Interfaces and Visualization Studies
- Education, Social and Economic Impact (Educational and Socioeconomic Studies)
- Information Infrastructure: Computing and Communications Technologies and Services

Recommendation 1a: A task force should be created immediately to specify the mission and governance structure of the institute, as well as to identify the initial centers (drawn from the areas identified here). Study groups, reporting to the task force, should develop specific proposals to create these centers.

As schematized in Diagram 1 (below), an Institute for IST at Iowa State will impact many areas of research very directly. Beginning at the bottom of the diagram, these include (1) a significant number of core IST areas, such as visualization and the development of new computing paradigms, as well as (2) the “Grand Challenge” applications, applications in all areas of science and engineering that require substantial computational power, and the innovative algorithmic analysis they require. Similarly, an IST initiative will build on (3) partnerships with educational experts in developing new educational methods, educational technologies, and methods of assessment (such as those required in distributed learning), and extension experts, in building new approaches to engagement. Finally, such an initiative will be highly synergistic with (4) other campus initiatives, both those within colleges and those that span colleges. While a strong IST initiative is not sufficient to ensure the success of disciplinary or

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19 While no critical priorities were identified above for Information Systems and Management, almost all associated programmatic areas were of very high priority. More importantly, key existing areas are already strong at Iowa State. Thus, a Center for Information Systems and Management will be a strong contributor to an Institute for IST at Iowa State University.
multidisciplinary programs, it will be necessary to the success of all such programs within the next five to ten years.

Diagram 1: Example Impact Areas of Information Sciences and Technology
Vision Components for a Leadership Program in IST

Key Components
We envision an integrated approach to IST at Iowa State that emphasizes the following components:

- **Peer Leadership:** an environment that nurtures bottom-up, self-organizing, cross-disciplinary groups of faculty to create informal and formal research linkages; the Iowa Computational Biology Laboratory (ICBL) is an example of this type of self-organizing structure that has had significant impact in the Plant Sciences;

- **Entrepreneurial in Nature:** a model of incentives and support for new models of exploration, new approaches to interdisciplinary research, that may be moderate- to high-risk. It is especially important that we identify areas likely to be important in federal research circles and develop our strengths in those areas, where Iowa State already has (or can come quickly to have) sufficient stature to be competitive.

- **Clear Outcomes:** while encouraging innovation, formal measures of success in the medium term (3-5 years) must be part of any successful approach. Significant outcomes include the development of sufficient federal funding to sustain activities, substantial recognition to the university, and the numbers and quality of formal research citations for interdisciplinary projects.

- **The Integration of Research and Learning at the Graduate and Undergraduate Levels:** our approach must create linkages between basic or applied research and our graduate educational programs. Activities that link interdisciplinary research areas with a strong IST component should include carefully considered interdisciplinary graduate curricula. We see examples of this today in areas such as BioInformatics (e.g., the Bioinformatics and Computational Biology (BCB) program), where new courses and tight research linkages between the Plant Sciences and Information Sciences go hand in hand.

- **Clear Priorities and Incentives:** A robust IST environment at Iowa State will be ever-changing, not static. This means that we must in the longer term be responsive to our developing strengths and changing national research priorities. Thus, we need mechanisms for “mainstreaming” successful collaborations and ensuring appropriate support. There is no poorer investment than to put resources into an activity, make it successful in the medium term, but have no mechanism for building it into the core of the university. Just as important, we must strongly discourage the creation of entitlements: programs that cannot be integrated into the core, research that is not able (despite medium-term investment) to attract support funding, educational programs that cannot get the support of the requisite departments, must not receive ongoing support within this initiative.

- **A Long-Term Cultural Change at Iowa State:** The impact of IST on society and academia has been sudden, dramatic, and complex. Fundamental changes in the research and educational priorities of the university will take time. A clear understanding by the faculty and administration of the long-term nature of the university’s commitment, investment, and priorities in the integration of IST into the fabric of the university is essential. This is not to
suggest that the appearance of change should be slow. On the contrary, clear changes must begin immediately if Iowa State is to be competitive and responsive to this important area.

Two areas identified above—Peer Leadership and Priorities and Incentives—are especially complex. We will discuss each of these in more detail, the latter in the section immediately below.

**Peer Leadership**
The IST Task Force spent significant time reviewing the question of how best to motivate the faculty. We examined existing successful models for nurturing creative, interdisciplinary programs. We believe that a key element in successful programs is the combination of consistent nurturing of innovation over a number of years, since it takes time to develop expertise and to build competitive partnerships in interdisciplinary areas. Consistent, clear support from the university leadership at the highest levels is a second key element. Most important of all, however, is to create a leadership program at the grassroots level. Programs like ICBL/BioInformatics and the Virtual Reality Applications Center (VRAC) are excellent examples of this model. Whether such programs have a single identified lead or not, the critical element is that the faculty themselves are directly involved in evaluating the appropriate priorities and activities within specific guidelines (such as those suggested in the previous section). *In this way, we can provide mechanisms and resources that allow faculty to expand activities in their core competencies into multi-competency, large-scale research programs.***

**Recommendations: Building Multidisciplinary Collaborations**

**Priorities and Incentives**

**Recommendation 2:** That Iowa State University make it a sustained long-term priority to build multidisciplinary collaborations involving Information Sciences and Technology, including hiring faculty with national recognition in IST-related disciplines and providing incentives to existing faculty to participate strongly in such collaborations and to integrate IST approaches into their research and teaching.

In order to institute organizational change at Iowa State and encourage innovative departments and faculty to become active contributors to multidisciplinary IST-centric activities, the university priorities need to be clear and consistent over the long term (ten years or more). These priorities in turn determine where additional incentives and investments might be made.

• Make it a priority within the provost’s office to support the hiring and promotion of interdisciplinary faculty, who will be evaluated partially on direct departmental contributions and partially on broad contributions to Information Sciences and Technology. This process should be modeled on the Biotechnology Council: faculty hired by a participating department would have cost-sharing from the Institute for IST only as long as they meet IST criteria for multidisciplinary leadership.

• Identify significant collocation space for undergraduate and graduate students of IST-participating faculty, with renewable proposals for access to such space.
• Develop models for “virtual” collaboration approaches, to allow more collaboration and informal information sharing among participating students and faculty.

• Create incentive grants to promote new multidisciplinary collaborations that have a high likelihood to lead to sustained external funding, including infrastructure and equipment support, travel funds to build industry, government, or academic partnerships. Ensure strong participation of graduate students in both the research and educational components. An IST-specific initiative might be modeled on the successful Miller program.

• Define a “Master Researcher” program to identify faculty who are highly successful in developing multidisciplinary IST-related research programs and encourage them to work both as facilitators in building additional programs and as mentors to other faculty;

• Create incentives for graduate requirements that are fundamentally interdisciplinary, with strong traditional program elements, but critically incorporating a range of IST-related options. While maintaining core approval within departments, provide mechanisms for IST-participating faculty to review and endorse interdisciplinary majors. Use the model of the Biological Sciences, where requirements are established by major in consultation with faculty within the major and associated department(s). *Do nothing to interfere with the primary role of departments in ensuring curriculum quality.*

• Building on the notion of new IST-related graduate programs, create a specific IST major that includes a disciplinary focus (e.g., Biology or Perceptual Studies), with a range of rigorous graduate courses and interdisciplinary research opportunities.

• Provide specific, documented incentives for faculty and associated students to develop innovative IST-focused interdisciplinary courses and programs, including resources for faculty, graduate students, and research scientists to help develop such programs at the graduate and undergraduate levels.

**Creating A Sustainable Initiative**

In its deliberations on how best to create a sustainable initiative in Information Sciences and Technology, the task force reviewed successful components in existing multidisciplinary initiatives. The recommendations here are based on that review.

**Recommendation 2a:** That Iowa State create an Information Sciences and Technology (IST) Council, along the lines of the Biotechnology Council, which would include exemplary faculty in the IST core and application areas, emphasizing nationally recognized leaders in interdisciplinary IST-centric research and pedagogy.

The Biotechnology Council has already shown itself to be an effective component of an important, sustainable initiative at Iowa State. With a strong emphasis on interdisciplinary IST research, strong ties can be built to other research and educational areas at Iowa State.
**Recommendation 2b:** That we recognize a special symbiosis between IST and key application areas on campus, identifying an appropriate set of common priorities and measurable activities that span these areas. Areas include the Plant Sciences broadly, Engineering, Materials Research, Visualization/VR and related research, Experimental Social Sciences, Expert Systems Development, and Education.

Iowa State has substantial strength in a variety of research areas, including those listed here. The success of each of these areas depends on coordinated advances in both IST research and in the promulgation and effective use of next-generation IST tools within their research, educational, and community outreach activities. Within the Plant Sciences, many areas critically depend on IST advances, including Bio-Informatics, Genomics, Precision Agriculture, and Agriculture Information Technology.

An IST Council with substantial responsibility, strong leadership, and an entrepreneurial character, can encourage multidisciplinary collaborations in such areas based on the potential impact, the likelihood of national peer recognition, and other measures. While some areas are current campus priorities, such as Plant Sciences, there are a number of equally promising applications in Engineering, Social Sciences, Business, and other fields that will develop over time. While we must be prepared to encourage them, strong leadership and clear measures are the key mechanisms to ensure a focused, nationally recognized IST Initiative.

**Recommendation 2c:** That in emphasizing the role of outstanding faculty as drivers for IST-focused interdisciplinary research and graduate programs, we strengthen the faculty's ability to build their interdisciplinary research teams.

Non-faculty researchers play an important, essential role at Iowa State. Yet, in order to have a nationally competitive IST initiative, our priority must be on building faculty research groups (which may include non-faculty researchers under faculty leadership); such groups must stay in touch with national research trends and respond to these trends in innovative and measurable ways. We believe a large infrastructure of full-time research staff or professional developers who have minimal or occasional ties to faculty research programs will not contribute significantly to national leadership within IST.

**Recommendation 2d:** That we immediately develop and support an annual ongoing symposium in Information Sciences and Technology that ties together and is in partnership with symposia in place within colleges.

Iowa State faculty have developed symposia and lecture series on a wide range of topics. Many of these have a direct relationship to IST, yet are not identified as such. To create a symposium in IST in concert with IST-related symposia across the university is a modest, yet valuable, step in developing a cohesive IST initiative.
Recommendations: Interdisciplinary Educational Initiatives

Recommendation 2e: That it be a priority at Iowa State to create new initiatives in IST-related education, including interdisciplinary majors, and to strengthen the IT infrastructure and core services essential to a strong IST program in both research and education.

A strong IST initiative will have an impact on educational programs across the campus. We recognize the need for both new majors and minors that integrate almost every area of study with a focus on information sciences and technologies. At the same time, we believe that the underlying IT-intensive services need to be strengthened across the campus, so that resources can be effectively exploited within and outside the classroom to enhance both learning and scholarship. These recommendations will be developed more fully below.

Recommendation 2f: That Iowa State endorse the creation of innovative interdisciplinary majors and minors within the context of an IST program. Such programs must be closely tied to and built out of existing departmental programs. A Computational Science and Engineering Ph.D. emphasis should be considered.

Existing successful initiatives include those within the Bioinformatics and Computational Biology (BCB) program and Complex Adaptive Systems. With the growing importance of state-of-the-art computing as a key tool in the advancement of research in science and engineering, computational science and engineering competence is of critical importance within graduate curricula and of growing importance in preparing undergraduates in many technical areas. We would consider it a priority of the IST program to identify, nurture, and provide support for the creation of such programs.

Recommendation 2g: That Iowa State recognize the importance of IST as a key area of emphasis for all its students regardless of major, and adopt a “technology across the curriculum” approach to undergraduate and graduate education. This should include the development of specific requirements for graduation that ensure basic skills in the application of IST both within their profession and its role in society as a whole.

Current undergraduate programs across the university require a minimum number of credits in General Education, mostly focused towards humanities-related subjects. As IST continues to grow and affect almost all aspects of our lives, we envision all Iowa State undergraduate programs also requiring courses in IST as a fundamental part of the General Education component. For this recommendation, there are two motivations: first, to prepare students to be effective users of IST within their chosen profession; second, to ensure that Iowa State students are well prepared to contribute to an information technology world of the future. Curricular requirements must go beyond basic technology skills (such as word processing or spreadsheets) to include such areas as: software programming and design, the use of electronic technologies in professional collaborations and communities, the social aspects of IST, as well as discipline-specific methodologies.

The approach needs to encompass all colleges and go beyond the core IST areas of computer science, computer engineering, and MIS. Accompanying this broad focus on information technology requires classrooms and laboratories equipped with the appropriate hardware and software to ensure a successful learning process. Further, incentives need to be provided to faculty to promote the substantive, appropriate, and creative use of information technology in the classroom.
Information Science Curriculum Issues

An essential part of a successful information science initiative will be the development of new courses in information science that will form the basis of an information science curriculum. To see how this might work, one could examine the effects the new course associated with the Bioinformatics and Computational Biology program (http://www.bcb.iastate.edu/courses-new.html) had on the recent expansion in Plant Sciences and BioInformatics.

During its tenure, the Information Science and Technology Task Force discovered a potential roadblock to development of an effective information science curriculum: instructors. The committee also discovered a fragmentation of effort across campus in information science course development. We therefore make the following recommendation:

Recommendation 2h: That an Information Science Curriculum task force be formed to take a leadership position in enabling the human resources, faculty to develop and offer new courses in the information sciences, in ways beyond those currently available.

This taskforce can act as a clearinghouse to aid in coordinating information science course content across the campus.

There are valuable mechanisms in place today to encourage the development of new courses, such as the Miller faculty fellowship. Often the development of a new information science course is not the gating factor in offering new courses in the Information Sciences. The roadblock is often the fact that there are not sufficient Information Sciences faculty, especially with the expertise in the specific area. It is not uncommon for a particular faculty member to be one of a very few members of their department who can teach one or more critical graduate courses. If this faculty member earns release time to develop a new course, or is assigned a new course as part of her teaching responsibilities, there is a substantial negative impact on the home department's program. It is often impossible to hire temporary instructors to cover these courses because they require specialized knowledge that is in high demand.

There are several potential solutions to this problem. We describe some of these solutions. A mentored “teaching postdoc” program in which short-term positions are offered to new Ph.D.s competent to teach the critical graduate courses. These postdocs would teach one course, while being mentored in teaching and research by the faculty member they release to deal with a new course. Another approach would be to aggressively hire in a fashion to alleviate the human resource shortfall. It may also be possible that the administration can come up with incentives to make departments find the offering of such new courses more programmatically palatable.

Experiences in the initial stages of IPRT (Institute for Physical Research and Technology) and PSI (Plant Sciences Institute), and the centers that exist under these institutes, strongly suggest that an effort to create an Information Science and Technology Institute will find competent people its scarcest resource. Task groups acting proactively to address the impact of the new institute on the human resources of existing programs will be of substantial value. A Curriculum Task Force is critical among these.
Recommendations: Core Research Emphases

A strong program in Information Sciences and Technology depends on a strong core in research in computer science and computer engineering. As exemplified in Table 2, many of the critical leadership areas for IST both nationally and, more crucially, at Iowa State, have their homes in these fields. Developments in these areas of science and technology are very pervasive and are currently producing rapid changes in society. Changes are occurring at a very fast pace in semiconductors, computer systems architecture, and various aspects of software and information technologies. Engineering of systems supporting the development, deployment, and usage and application of these technologies is also equally important and challenging. The multi-disciplinary implications of information science and technology are vast and encompass virtually all disciplines of higher education. Preparing future scientists and engineers in these areas, re-educating current scientists and engineers, and producing future citizens who, although not directly involved in developing these technologies, can benefit from being technology literate requires creating new visionary and innovative programs, ideally in partnership with business and industry.

Building Programs in Computer Science and Computer Engineering

Recommendation 3: That Iowa State make a systematic, long-term commitment to building its programs in computer science and computer engineering broadly to nationally competitive levels, as well as strengthening other closely allied disciplines.

For a university like Iowa State to develop strong IST leadership, it must develop strength in both research disciplines that primarily study computing and computing structures, and those that arrive at computing problems within the context of another primary pursuit, be it Chemistry or Economics. Furthermore, an environment must exist in which a symbiotic relationship between these disciplines can develop and flourish. For example, the innovative computational biology program at Iowa State that evolved from the ICBL is a particularly fruitful collaboration of this sort. Working in isolation, biologists might risk overlooking key computer science techniques that might apply directly to their problems, while computer scientists might risk developing techniques that have little bearing on problems that are of interest to actual biologists. Similarly, developing application-specific architectures and computer systems are likely to lead to much more effective solutions to complex computing and information management problem. By working together, some of their differing philosophies are shared, often culminating in the development of groundbreaking research.

Existing Conditions in Computer Science and Computer Engineering at Iowa State

Although Iowa State maintains strong programs in a variety of scientific and engineering disciplines, the research efforts in core computing areas have not reached critical mass. Departments of Computer Science Computer Engineering have reached a crisis as the number of undergraduate majors has increased by approximately 15% per year over the last five years. This trend is expected to continue for the next several years. To sustain this growth, significant increase in resources in terms of faculty and infrastructure is required. The current infrastructure is not competitive with that at other universities. This has led to an unattractive research environment that causes difficulty in both the hiring of new faculty and the retention of existing faculty. This is not a criticism of the past, but a call to action—to respond to our own
findings that excellence in multidisciplinary research in all our areas of core excellence significantly depend on leadership within Computer Engineering and Computer Science.

**GENERAL TRENDS IN COMPUTER SCIENCE AND COMPUTER ENGINEERING**

The rapid growth of IST-related jobs has presented both opportunities and challenges to computer science and computer engineering departments throughout the nation. Universities have been struggling to meet these demands, especially as IST-related industry has been able to offer an attractive environment that competes directly with academia. Both Ph.D. students and faculty have been flocking to industrial positions that offer higher salaries, better-equipped laboratories, and a release from overwhelming teaching burdens. Diminished interest in doctoral programs and faculty positions in computer science and computer engineering could lead to a disturbing future for universities as IST demands expand. A similar trend existed around 1980, in which several coordinated efforts to revitalize university research were implemented.\(^\text{20}\)

**A VISION FOR COMPUTER SCIENCE AND COMPUTER ENGINEERING AT IOWA STATE**

Imagine the emergence of an innovative research environment within the next few years that provides strength and leadership in core IST areas. In each area, there is a critical mass of faculty members and many graduate students conducting critical cutting-edge research, leveraging their talents through strong support and infrastructure. Faculty members are strongly encouraged and supported to engage in pioneering research efforts that cut across traditional disciplines and help shape the rapidly-evolving sciences and engineering of the future. Resources and incentives are available that allow the transfer of research advances and perspectives directly into a state-of-the-art curriculum that benefits the whole campus and community, without conflicting with research goals. Through recognition of innovative software disseminated to the community within an Open Source framework, innovative faculty are encouraged to come to Iowa State to build their careers. By building such a leadership environment for Computer Science and Computer Engineering, we can help stimulate the advancement of IST research around Iowa State, and dramatically increase the visibility of Iowa State in the global community.

**ACHIEVING THE VISION**

To achieve the vision, we identify a number of core recommendations. While mindful of our mandate not to focus on university structure, the task force considered many scenarios in which its vision could be realized. In doing so, we identified several common elements that are essential to the vision’s realization.

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\(^{20}\) See the very important report from the Computing Research Association, *The Supply of Information Technology Workers in the United States* at: [http://www.cra.org/reports/wits/cra.wits.html](http://www.cra.org/reports/wits/cra.wits.html), “a study to improve the understanding of the supply of and demand for information technology (IT) workers in the United States, and the surrounding contextual issues.”
Recommendation 3a: Aggressively increase the number of faculty in core IST areas, notably in Computer Science and Computer Engineering.

One obvious response to the growing IST demands is to hire many new faculty in core computing areas. Following the IST growth areas given in Table 2 (above), there is a strong need to develop or complement expertise in areas such as information management, advanced computational science, software, and information infrastructure. Given that many universities have arrived at this conclusion in the past few years, aggressive hiring strategies are needed that include sizable budgets for startup packages and evidence of strong commitment to IST from Iowa State.

Recommendation 3b: Develop a long-term strategy to improve the teaching and research infrastructure in core Information Sciences areas, notably in Computer Science and Computer Engineering.

Hiring many quality faculty in core computing areas is unlikely to occur without a dramatic improvement in the level of research and teaching infrastructure, given conditions at competing universities. In fact, it may be difficult to retain many of our existing highest-quality faculty. In both Computer Science and Computer Engineering departments, space and support for research laboratories is very limited, the support staff is too small, and the departmental computing network and computers are not adequate to meet current instructional and research demands. In the present setting, innovation is often stifled due to limited resource considerations.

Recommendation 3c: Make innovative courses and research programs a priority through appropriate incentives.

Given the rapid technology changes, it is essential to encourage faculty to use their talents to develop new courses, curricula, and research programs. Faculty should have sufficient time and resources as well as infrastructure to engage in such activities. Interdisciplinary activities should be rewarded appropriately by providing teaching breaks or teaching credit to create a positive environment for faculty to participate in such endeavors.

Recommendation 3d: Build a Basic-Level Teaching Program in core Information Sciences areas, especially, but not limited to, Computer Science and Computer Engineering.

Resources are needed to help faculty and graduate students focus on their research programs, in spite of enormous undergraduate teaching demands that continue to grow. Permanent instructors could be hired to handle the basic curriculum, especially service courses, while tenure-track faculty would manage course content and provide supervision. While more study is clearly needed, it is essential to have Computer Science and Computer Engineering faculty available to develop innovative multidisciplinary courses and research activities in concert with their peers across the university.

For other disciplines to build computer science or engineering expertise within their own programs might be helpful in the short term, but in the longer term this will undermine any

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21 Innovative approaches include hiring existing research groups at other institutions, building advanced laboratories or other resources in target areas, and a sustained commitment to building excellence over the long haul that can be communicated nationally.
move to excellence in either research or curriculum. Critical mass in areas at the leading edge cannot be addressed through pockets of excellence distributed throughout the campus.

**Recommendation 3e:** Raise program standards for Computer Science and Computer Engineering majors, developing strategies for maintaining or increasing enrollment limits in concert with increasing faculty resources. Create a task force to review the current status of Computer Engineering and Computer Science, which together make up the programmatic core of an IST initiative, and determine how best to strengthen them.

If a consistent, excellent program is a priority, admission to the undergraduate programs in Computer Science and Computer Engineering must be based on high standards. Given the high demand and publicity associated with computer science, many majors enter the program without a realistic understanding of the challenging demands of the discipline. Consequently, the lower-level courses serve as a weeding-out mechanism that is frustrating for both the students and the faculty. The frustration is particularly strong for the brightest students in the classes, because it is difficult to deliver to them advanced material that would stimulate their interests. Typically, half of the class is barely able to keep up with the most basic material. Iowa State must have undergraduate programs in IST core areas that are known throughout the state as being strong and competitive, with a size that matches the faculty resources. Otherwise, the brightest students are tempted to study in neighboring states that have higher-ranking programs, resulting in a tragic loss for the residents of Iowa. As the student quality and faculty resources rise, it then becomes feasible to increase enrollment limits in a coherent way.

**Open Source**

The recent explosion of the *Open Source* software movement offers universities like Iowa State an exciting opportunity to greatly increase the impact of their research efforts. Consistent with our traditional role of making our scholarship and educational materials available to our peers and citizens through publications, conferences and other media, an Open Source approach will allow innovative universities like Iowa State to maximize its impact within academe and in the community at large, making its high-quality software and data from every field available to the international community using the most advanced and effective approaches to tool building, packaging, and dissemination. Despite our own belief that this will strengthen scholarship within the university, as well as recognition within the community and among our peers, we realize that there is no one approach that will work in every case. Therefore, we make the following recommendation:

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22 There is a growing literature on the economic, research, and technical motivations for Open Source. General references include the following:


Recommendation 3f: That Iowa State University develop a strategy for adopting the Open Source philosophy, where appropriate, in recognition both of our role in providing value to the citizens of Iowa and beyond and of the rapidity with which innovations need to be disseminated to the community if they are to have significant impact.

The key notion of open source is that the original texts of programs are made available at no (or nominal) cost to everyone and no one is allowed to restrict the copyright in the future for commercial profit. This enables expert users to directly improve and enhance the software, while continuing to keep the open source agreement. This trend, along with advances in distributed software development principles, has enabled the creation of highest-quality software by the efforts of globally-distributed experts. Within the past year, traditional software giants such as Microsoft have begun to worry about such trends, especially given the emergence of Linux, a pervasive open source operating system that is believed by many to be far superior to any commercial operating systems for the PC platform. Many corporations have moved away from commercial operating systems in support of Linux and other open source software systems with the general understanding that all can benefit under this paradigm.

Given this revolutionary trend, a few visionary universities have a unique opportunity to strongly promote the development and distribution of open source products that showcase their best research results and benefit society as a whole, greatly increasing the impact and visibility of the university. The primary role of a public land-grant university is to improve society through the dissemination of its knowledge and expertise. Up to now, this has been achieved through traditional media, such as journal publications, conference presentations, and instruction. Open source is a highly effective mechanism to play the same role by providing immediate benefits to many users across academia and industry. Unfortunately, in many universities (including Iowa State), attempts at making open source software are met with great legal obstacles due to intellectual property issues. Some cultural changes may be needed to capitalize on this opportunity by offering incentives, instead of obstacles, for developing open source software.

Computational Science and Engineering

Iowa State has a strong tradition of excellence in computational science and engineering, including the use of computational models, simulation, and other techniques in both research and educational contexts. As discussed earlier, the President’s Information Technology Advisory Committee (PITAC) and the National Science Foundation have recognized both the importance of this area and the need to create strongly coordinated, multidisciplinary initiatives involving core IST disciplines, the social sciences, and other fields, to accelerate progress nationally in the use of high performance and distributed computing systems.

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23 Linux began eight years ago as a hobby for a Finnish university student, and grew to include millions of faithful users and developers around the world, including major universities and leading corporations.

24 This section benefited from discussion among Glenn Luecke, Mark Gordon, Dick Seagrave, and Peter Siegel and is based on written material they developed in preparation of a proposal.
**Recommendation 3g:** In recognizing Iowa State’s core strengths in Computational Science and Engineering, that a core component of the IST initiative be to build systematic expertise in solving large-scale computational problems and strengthening its impact on graduate and undergraduate education.

It is generally recognized that computational science and engineering are now positioned to play a leading role in solving grand challenge problems that we face in the next decade. These important problems include, but are not limited to, the design of new materials and catalysts with desirable properties, the elucidation of biological processes, and the development of viable methods for environmental remediation. Solution of such compelling and complex problems requires not only state-of-the-art computational hardware, but more importantly the development of the necessary models and algorithms to take optimal advantage of modern computers. The high performance computing environment of the future will undoubtedly include new computing technologies, such as scalable clusters, as a central component.

Developing effective methodologies for creating integrated computing systems, along with concomitant practical implementations in a large scale, international networking environment, should be one aspect of leadership in an IST initiative. In addition to advanced algorithmic development, new approaches to program optimization and software design, and other “traditional” strengths of Iowa State, new approaches to building and managing large-scale systems will be necessary, as national-scale computing environments (such as NASA’s “Global Grid”) become national priorities. Among these new approaches must be the development of secure and fault-tolerant distributed systems, tools for distributed job scheduling and distributed data management, and scalable systems management technologies. The effectiveness of these approaches must be evaluated with leading Grand Challenge applications from all areas of engineering and science, including data-intensive applications in the social sciences.

**Recommendations: Core Information Infrastructure**

**Recommendation 4:** That in concert with the creation of the Institute for IST, Iowa State University immediately develop an integrated, long-term strategic plan and implementation process to improve the university's information infrastructure—academic, instructional, and administrative technologies and services—for ISU faculty and staff.

Iowa State has a wide range of fine services, but these are poorly integrated, funded, and supported by a dizzying array of disparate mechanisms, and too complex to change quickly to meet the needs of the faculty and student community. Even without additional resources, Iowa State must put in place mechanisms that allow it to invest strategically in information technologies. We believe that new areas, such as distance education, will require novel approaches to the organization of information services, integrating student information systems, faculty instructional management systems, integrated telecommunications management for students coming in from the Internet, and electronic commerce—areas for which coordination mechanisms do not now exist. While it is beyond the purview of this committee, we understand that the provost and his peers are developing a strategic planning process and urge that it receive the highest levels of support in the university.
Recommendation 4a: In that a sustained IST initiative will require a significant long-term investment, representing a substantial need for campus-wide reprioritization, we do not recommend that any specific research equipment be designated a priori. Rather, such investments should be determined on an ongoing basis by a standing IST Council as part of an IST Initiative.

Given the longevity required for the success of an IST Initiative, we recommend that resources be allocated as part of the approach outlined above that can be provided to interdisciplinary teams in support of the core priorities. We believe that some “community” resources may be required for research in basic research areas where IST overlaps with the Plant Sciences, Engineering, Education, Materials Science, and other areas. However, it is critical to link the university funding for such resources to the faculty’s ability to secure additional funding through grants or other means. We envision that an IST Council would designate use of the funds, some with multi-year commitments, others on a one-time basis.

Recommendation 4b: That Iowa State provide substantial additional priority to removing access barriers for Internet connectivity and access to computing resources. Detailed recommendations focus on connectivity, classrooms, and computer laboratories.

Iowa State should make it a priority to develop plans to:

- Invest in a higher minimal base of computer technology in computer laboratories throughout the campus. A recent report to the provost outlined a strategy for defining such a base, as well as recommending steps towards implementation.

- Define and support a substantially higher minimal level of computer technology (both for faculty presentation and student use) in all classrooms and teaching spaces. Recognizing that this cannot be done pervasively in a short period of time, we recommend that a master plan be developed to identify priority classrooms, but with sufficient resources to ensure that all classrooms meet standards within a ten-year period.

- Encourage universal connectivity, so that students can choose to bring computers to common work areas, the library, and classrooms. We emphasize quality computer laboratories as a way to ensure access for all, but recognize the critical use of information technologies in both informal and formal environments. Restricting access to IT to home environments and laboratories is a disincentive to our ability to raise the effective use of IT throughout the campus. To encourage such connectivity, rates for access to the Internet from public areas at all levels (department, college, and university) need to be dramatically lower.

Recommendation 4c: To begin the process, we recommend that the university designate a substantial range of public spaces as a university priority and move to provide either wired or wireless Internet access in them. Such areas include the library, selected public areas for each college, and priority classrooms identified above.

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Appendix A: Leadership Areas for Information Sciences and Technology

Table 2 (below) provides a detailed analysis of the six major leadership areas nationally. For major programs or emphases within each area, we identify three factors which we rank as indicated here:

- Priority for IST Nationally, based on a survey of federal programs and reports: Very High, High, Moderate
- Current Strength at Iowa State, based on informal review with faculty within these areas: Strong, Moderate, Limited
- Recommended Priority at Iowa State:
  - Critical (significant and sustained support is essential immediately to create a successful program at Iowa State),
  - Very High (significant and sustained support will be essential in the medium term to a successful program at Iowa State),
  - High (support will be essential in the medium term for a successful program),
  - Moderate (support should be considered in the future, depending on resources and changes in national priorities)

Areas which are of critical priority at Iowa State University are highlighted within the table; these areas require significant and sustained support and should be part of an initial program for Information Sciences and Technology at Iowa State University.
### Table 2: IST Leadership Areas and Program Emphases for Iowa State University

<table>
<thead>
<tr>
<th>Leadership Areas / Program Emphases</th>
<th>National IST Priority</th>
<th>Iowa State University</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information Systems and Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Databases, information retrieval, information processing</td>
<td>Very high</td>
<td>Limited</td>
</tr>
<tr>
<td>Data mining and agents</td>
<td>Very High</td>
<td>Strong</td>
</tr>
<tr>
<td>Imaging, media, archiving techniques</td>
<td>High</td>
<td>Strong</td>
</tr>
<tr>
<td>GIS, Spatial Methods</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Management Information Systems</td>
<td>Very High</td>
<td>Limited</td>
</tr>
<tr>
<td>Field-specific Information Systems</td>
<td>High</td>
<td>Limited</td>
</tr>
<tr>
<td>Field-specific Expert Systems Development</td>
<td>High</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Advanced Computational Science</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numerical, symbolic, geometric algorithms</td>
<td>Very High</td>
<td>Strong</td>
</tr>
<tr>
<td>Virtual reality, graphics</td>
<td>Very High</td>
<td>Strong</td>
</tr>
<tr>
<td>Machine learning, Artificial Intelligence, robotics</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Parallelization</td>
<td>Very High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Data analysis, pattern analysis</td>
<td>Very High</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Software</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design principles: scalability, reliability, adaptability, availability</td>
<td>Very High</td>
<td>Limited</td>
</tr>
<tr>
<td>Complex system building</td>
<td>Very High</td>
<td>Strong</td>
</tr>
<tr>
<td>Languages, operating systems, compilers</td>
<td>Moderate</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Human-Computer Interface</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visualization (see also Virtual Reality)</td>
<td>Very High</td>
<td>Strong</td>
</tr>
<tr>
<td>Virtual prototyping</td>
<td>Very High</td>
<td>Strong</td>
</tr>
<tr>
<td>Interactive hardware technologies</td>
<td>High</td>
<td>Limited</td>
</tr>
<tr>
<td>Cognitive Psychology</td>
<td>Very High</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Educational, Social, and Economic Impact</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* For Table 2, an asterisk indicates areas for which we are making no recommendation; these may be very important at Iowa State, but opportunities for Iowa State leadership within the context of the IST Program did not appear significant.

Field-specific Information Systems include those that manage information in a particular application discipline, such as information systems relating to Genomics, Agricultural products, or geographical information.

Virtual reality, graphics, and visualization (see Human-Computer Interface, below) are combined into a single critical priority in our recommendations; they happen to cross major discipline areas.

This would include Open-Source-related initiatives.
<table>
<thead>
<tr>
<th>Impact</th>
<th>Impact</th>
<th>Emphasis</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributed Learning Technologies (including asynchronous and distance learning)</td>
<td>Very High</td>
<td>Moderate</td>
<td>Critical; must become organized</td>
</tr>
<tr>
<td>Outreach Services, including Extension</td>
<td>Not clearly recognized</td>
<td>Moderate</td>
<td>Very High, with great potential</td>
</tr>
<tr>
<td>Sociology and Psychology of Human-Computer Interaction</td>
<td>Not clearly recognized; new NSF priority</td>
<td>Limited</td>
<td>*</td>
</tr>
<tr>
<td>Behavioral Modeling, Policy Simulations</td>
<td>Very High, mostly outside academia</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Information Economy Impacts, including electronic commerce, e-trading, e-markets</td>
<td>Very High</td>
<td>Strong</td>
<td>Very High, must strengthen assessment of impacts</td>
</tr>
<tr>
<td>Business/economic studies</td>
<td>Very High</td>
<td>Moderate</td>
<td>Further study needed, tremendous potential</td>
</tr>
<tr>
<td><strong>Information Infrastructure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Networks, systems, and security</td>
<td>Very High</td>
<td>Moderate (security), Limited (others)</td>
<td>Critical, needs to be strong in all 3 areas</td>
</tr>
<tr>
<td>Communications technologies</td>
<td>High</td>
<td>Moderate</td>
<td>Critical</td>
</tr>
<tr>
<td>Computer architecture issues</td>
<td>High</td>
<td>Strong</td>
<td>Critical in system integration area</td>
</tr>
<tr>
<td>Advanced computing paradigms and technologies</td>
<td>High</td>
<td>Strong</td>
<td>Critical</td>
</tr>
<tr>
<td>IT-Capable Classrooms and Laboratories</td>
<td>Very High</td>
<td>Limited</td>
<td>Critical to achieving substantive use of IST across the curriculum</td>
</tr>
</tbody>
</table>
Appendix B: Information Science Groups and Resources at Iowa State

The task force identified many Information Science groups, activities, and resources at Iowa State. We mention a few of these here, along with their URL’s (web addresses). This section may also be found on the web, so that the many interesting links may be explored:

www.math.iastate.edu/danwell/istc/istcG.html

There are five broad categories of information science groups identified.

- Those engaged in distance education: www.math.iastate.edu/danwell/istc/istcG.html#dist;
- various graduate programs with an information science component: www.math.iastate.edu/danwell/istc/istcG.html#grad;
- groups that provide infrastructure: www.math.iastate.edu/danwell/istc/istcG.html#infra;
- information science research groups: www.math.iastate.edu/danwell/istc/istcG.html#research; and
- groups that are currently forming: www.math.iastate.edu/danwell/istc/istcG.html#form;

Distance Education

The following groups, organizations, and projects are involved in some aspect of distance learning.

- The Acropolis Project: www.cc.iastate.edu/acropolis/AcropolisOverview.htm
- The College of Agriculture's distance learning page: www.ag.iastate.edu/centers/proag/course.html
- The Curriculum and Instruction Department’s Distance Learning and Research Assessment Unit: www.educ.iastate.edu/ci/treg/homepage.htm
- Distance learning Programs at Iowa State Extension: www.lifelearner.iastate.edu/courses/course.htm
- Engineering Distance Education: www.eng.iastate.edu/ede/about/overview.html
- The Instructional Technology Center's distance learning page: www.itc.iastate.edu/instruct/distance/homepage.html
- The Vet Med college has a distance education effort identified, but no specific information available online: www.vetmed.iastate.edu/
- The Instructional Technology Center has a page to help you construct Web based course tools: webct.cc.iastate.edu:8900/

Graduate Programs

The following graduate programs have been identified as having an information science component in their current efforts. This list is not exhaustive - these departments came to the attention of the committee while it was performing its research.

Agronomy  
Animal Science  
Bioinformatics and Computational Biology  
Biochemistry and Biophysics  
Curriculum and Instruction  
Computer Science  
Electrical and Computer Engineering  
Mathematics  
Mechanical Engineering  
Psychology  

www.agron.iastate.edu/  
www.public.iastate.edu/~ans/  
www.grad-college.iastate.edu/bioinformatics  
molebio.iastate.edu/bbhtml/homepage.html  
www.educ.iastate.edu/ci/treg/homepage.htm  
www.cs.iastate.edu/  
129.186.5.34/  
www.math.iastate.edu/  
www.me.iastate.edu/  
psych-server.iastate.edu/
Infrastructure

These groups, organizations and projects provide infrastructure as at least a part of their function.

- Academic Information Technologies / Computation Center (Acropolis Project):
  www.cc.iastate.edu/acropolis/AcropolisOverview.htm
- The Center for Nondestructive Evaluation: www.cnde.iastate.edu/cnde.html
- The Center for Physical and Computational Mathematics: www.iprt.iastate.edu/cpcm.html
- Cyberstacks: www.public.iastate.edu/~CYBERSTACKS/. Gerry McKiernan's approach to indexing the Internet according to the Library of Congress scheme:
- The Microanalytical Instrumentation Center: www.mic.iastate.edu/
- Parks Library, see for example their Internet Research Guides: www.lib.iastate.edu/scholar/guides.html
- The Virtual Reality Applications Center: www.vrac.iastate.edu/

Research Groups

The following groups are involved in some aspect of information science research.

- The Center for Nondestructive Evaluation at: www.cnde.iastate.edu/cnde.html
- The Center for Physical and Computational Mathematics at: www.iprt.iastate.edu/cpcm.html
- The various Computer Science Research Groups: www.cs.iastate.edu/labs.html
  - Artificial Intelligence Research Laboratory: www.cs.iastate.edu/~honavar/aigroup.html
  - Geometry, Robotics, and Motion Strategy Lab: germs.cs.iastate.edu/
  - Java Modeling Language: www.cs.iastate.edu/~leavens/JML.html
  - Laboratory for Information System Technology: latte.cs.iastate.edu/
  - Multimedia Research Laboratory: www.cs.iastate.edu/~tavanapo/
  - The Microanalytical Instrumentation Center: www.mic.iastate.edu/
- The Plant Sciences Institute (www.plantsciences.iastate.edu/) which includes the following centers:
  - The Center for Plant Genomics.
  - The Center for Bioinformatics and Biological Statistics: www.math.iastate.edu/danwell/CBBS/cbbs.html replacing the Iowa Computational Biology Lab: www.math.iastate.edu/danwell/icbl.html
  - Center for Plant Transformation and Gene Expression.
  - Center for Plant Breeding.
  - Center for Designer Crops.
  - Center for Plant Responses to Environmental Stresses: www.plantstress.iastate.edu/
  - Seed Science Center.
- Center for Crops Utilization Research:
  - There is a Protein structure and function prediction (cyclops.ameslab.gov/~jrmorris/protein/) group connected with physics and the Ames lab.
- The Virtual Reality Applications Center: www.vrac.iastate.edu/
- The Zea Mays Data Base: www.zmdb.iastate.edu/zmdb/whats_new.html
Forming Groups

Bioinformatics searches (www.bioinformatics.iastate.edu/positions.html) are underway in several places at Iowa State.

A recently approved graduate minor in Complex Adaptive Systems (www.cs.iastate.edu/~honavar/alife.isu.html) that spans twelve departments is being chaired by Gerry Sheble.

An initiative to form an interdepartmental graduate program in Computational Science and Engineering is being chaired by Glenn R. Luecke.

Computer Science (www.cs.iastate.edu/gradadm/search2000.html) is seeking to increase its Information Sciences faculty.

Electrical and Computer Engineering (www3.ee.iastate.edu/deptinfo/newsevents/positions.htm) is currently searching for an endowed chair in Information Systems.

The Psychology Department (psych-server.iastate.edu/) is currently performing two searches (psych-server.iastate.edu/news-upcoming/job_ads/cognitvad.htm) in cognitive psychology.