FINAL REPORT

IOWA'S INFORMATION TECHNOLOGY STRATEGIC ROADMAP

PREPARED FOR:
Iowa Department of Economic Development

PREPARED BY:
Battelle's Technology Partnership Practice

September 2005

Battelle
The Business *of* Innovation

Iowa's Information Technology Strategic Roadmap:

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Executive Summary

Two decades ago, powerful changes began to occur in modern western economies—changes spurred by the growing ubiquity of computers and information technology (IT). First, productivity was greatly enhanced by the adoption and rapid spread of the personal computer; but, the real knowledge-driven economy accelerated further through equally prolific advancements in communications technologies and global networking. The current age of "networked intelligence"—a "new economy"—is powered by technology, fueled by information, and driven by knowledge."[1]

In the 21st century economy, networked IT forms the basic underpinning of economic progress. Almost every element of modern economic progress is powered, supported, or driven by IT and its convergence with other technological advancements. It is difficult to find any area of the economy that is not IT driven or empowered; consider, for example, the following:

- *Agriculture*—home to precision agricultural equipment; using global positioning systems and laser guidance, computerized irrigation systems, and planting and harvesting schedules optimized via advanced computer models.
- *Medicine*—home to IT-powered biomedical imaging equipment; robotic surgical equipment; computer-powered high-throughput screening systems for medical compounds; drugs designed via three-dimensional (3-D) protein modeling; and personal medicine driven by bioinformatics, computational genomics, and electronic medical records.
- *Manufacturing*—home to products designed completely by computer, prototyped through computerized rapid-prototyping equipment, sent to production via computer-aided design data, and produced on automated manufacturing lines.
- *Education*—empowered by distance education technologies, interactive multimedia, virtual reality (VR) systems, online information retrieval, and instant feedback testing.
- *Entertainment*—with rapid growth in computer gaming, multimedia entertainment, digital satellite television, digital music, and digital imaging.

Information and communications technologies have obviously become enablers of change—providing the tools for releasing the creative potential and knowledge embodied in people, and thereby empowering economic growth.

Simply put, IT powers economic progress. A recent University of California-Berkeley study examined the economic benefits of only Internet-based business solutions (not all of IT by a long shot) and found that "the adoption of Internet business solutions has already yielded a current, cumulative cost savings of $155.2 billion to U.S. organizations."[2] The IT sector also has a powerful multiplier effect on economies, even when compared with manufacturing. A 1995 study of the effect of software producer Microsoft on the local economy revealed that each job at Microsoft created 6.7 new jobs in the State of Washington, whereas a job at Boeing created 3.8 jobs.[3] A report by the U.S. Department of Commerce attributes most

[1] U.S. Department of Labor. Secretary's Commission on Achieving Necessary Skills, 1991, p. 1.
[2] Varian, Litan, Elder, and Shutter. *The Net Impact Study: The Projected Benefits of the Internet in The United States*, *United Kingdom and France.* 2002.
[3] Mandel, Michael J. "The New Business Cycle." *Business Week*, March 31, 1997, pp. 48–54.

productivity gains since 1995 to IT and its resulting organizational change.[4] It is quite clear that wealth generation and economic growth are very closely tied to the capacity to add value using IT products and services.

Against this background it is clear that, for a modern U.S. state to thrive, it has to have considerable strengths and capabilities in IT and the application of IT to high-productivity business. Without human capital skilled in IT development and application, and without investment in advanced technologies, a state cannot sustain growth in the standard of living of its population and cannot compete effectively in the global economy.

If only we could all see so far into the future!

Is it a fact—or have I dreamt it—that, by means of electricity, the world of matter has become a great nerve, vibrating thousands of miles in a breathless point of time. . . . The round globe is a vast . . . brain, instinct with intelligence.

Nathaniel Hawthorne
The House of Seven Gables
Published 1851

The State of Iowa has recognized the importance of technology in general, and information technology in particular, as a fundamental driver of economic progress. In 2001, Governor Vilsack launched a statewide technology cluster initiative aimed at achieving substantial economic development progress for the state. The initiative identified three areas of focus, with IT being one area (the biosciences and advanced manufacturing represent the other two). Iowa followed through in 2003 with the Iowa Values Fund, dedicating $82.2 million to advance development in these three areas.

Iowa has thus recognized the importance and promise of IT as an economic engine and has begun to take concerted action to grow IT in the state. To further this goal, the Iowa Department of Economic Development (IDED), in the spring of 2005, initiated work on this Information Technology Strategic Roadmap to guide future public and private investment decisions in Iowa. A Steering Committee composed of representatives of the state's IT sector was established to oversee this effort, and Battelle's Technology Partnership Practice (TPP) was engaged to develop the strategy. Battelle is a global science and technology enterprise that develops and commercializes technology and manages laboratories for customers. TPP, which includes leading analysts and practitioners in technology-based economic development, helps clients develop, implement, and evaluate technology strategies, policies, and programs.

This Strategic Roadmap outlines a comprehensive approach to IT development in Iowa that will require a long-term commitment by the state, its institutions, and its commercial sector for implementation. Leading technology states did not become so overnight—it typically takes a decade or more of deliberate, sustained commitment to build a critical mass of research and commercial business enterprise in a core technology field. Iowa will need to take a similarly long-term, committed view.

As will be demonstrated, Iowa comes to IT with some significant strengths and areas of opportunity to build upon. The state's regent universities each contribute to strengths in IT, computer science, and associated engineering disciplines, while Iowa State University (ISU) and the University of Iowa have distinctive research and development (R&D) programs in these fields, with some established centers of focused excellence. Within commercial IT, Iowa is home to a healthy base of IT service/solutions providers, software companies, and some distinctive companies operating in IT and advanced electronics hardware. Iowa is also home to multiple major corporations that are highly intensive IT users, particularly in the finance and insurance sector, but also in a range of advanced manufacturing fields as well.

[4] U.S. Department of Commerce. *Digital Economy 2000,* Economics and Statistics Administration, June 2000.

That said, however, Iowa has not yet reached a critical mass of IT activity that would place it among leading states in either IT R&D or IT commercial activity. Currently, Iowa has not yet reached a true level of specialization in IT; but, the promise to build a notable presence around several IT opportunity areas is clear. This strategy aims to provide the required guidance for seizing that opportunity.

METHODOLOGY

This Roadmap was developed with input from representatives of the IT industry sector and Iowa's universities and other public and private leaders from all regions of the state. The Battelle project team collected and analyzed data on Iowa's IT sector, assessed the sector's competitive position vis-à-vis a number of competitors and peers, and conducted interviews and focus groups to gain an understanding of the issues facing the state's IT sector and to gather input on actions that could be taken to further enhance the global competitiveness of this sector.

This report includes the following:

- Findings from an economic analysis of the state's IT sector
- A competitive assessment of Iowa's infrastructure to support the IT sector as compared with a set of benchmark states
- A strengths, weaknesses, opportunities, and threats (SWOT) analysis that reports findings based on 106 interviews of representatives from industry, associations, government, and educational institutions; small group discussions; and three focus groups
- Proposed strategies and actions to enhance the competitiveness of Iowa's IT sector
- An implementation plan that outlines initial steps for executing the strategies and actions.

Roadmap Methodology

- Economic analysis
- Benchmarking analysis
- SWOT analysis
- Interviews with industry representatives, researchers, educators, and economic development and workforce officials
- Focus groups and discussions

The Roadmap's ultimate goal is to build a stronger, more internationally competitive IT sector for the State of Iowa.

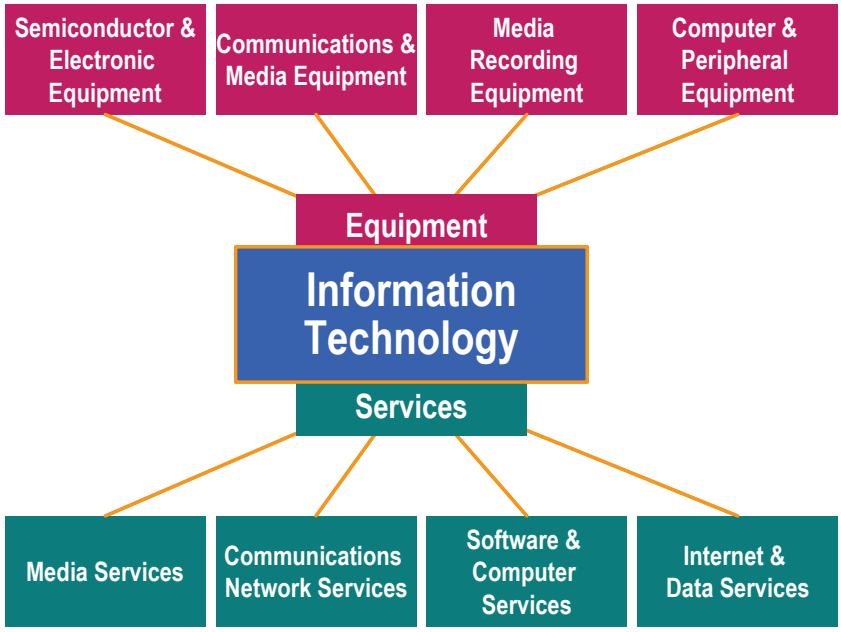
THE INFORMATION TECHNOLOGY INDUSTRY BASE IN IOWA

Because of technology convergence and the diverse nature of the IT industry, analysis requires an approach that accounts for the numerous applications of IT advancements. Additionally, examination of end users of IT products and services is also required to help capture and characterize the unique qualities of the industry. Taking such a holistic approach provides a level of clarity that makes it possible to identify potential strengths and market niches.

In an effort to address the diversity of the IT sector, Battelle used the North American Industry Classification System (NAICS) to identify the industries considered part of the IT industry. Based on an analysis of six-digit NAICS codes, the Battelle team selected 43 industries and organized them according

to the eight major subsectors of the IT industry (Figure ES-1).[5] Each of the subsectors was classified into two categories: equipment and services.

Figure ES-1: The Information Technology Industry and Associated Subsectors



When defined as above, the IT industry in Iowa employs 29,279 individuals across 2,075 establishments. This level of employment represents 2.5 percent of total private sector employment in the State of Iowa, whereas nationally, IT accounts for 3.9 percent of total private sector employment—thus, in Iowa, IT employment accounts for a smaller share of private sector employment than the industry does at the national level. When the ratio of these two measures is significantly above average, i.e., the location quotient (LQ) is above 1.20, a state is said to possess a specialization in the industry. However, in Iowa, the LQ is 0.64, meaning that the IT industry in Iowa represents only 64 percent of the national average. So, IT is not yet a clear economic specialization for Iowa, but rather represents an industry that will need to grow to achieve a specialized critical mass in the state.

Despite the state's below-average employment size, Iowa's IT industry has proved to be more stable than that of the United States (nationally, the industry experienced a rate of employment loss greater than Iowa did between 2000 and 2003). The IT industry in Iowa is also a particularly notable source of good-paying jobs and contributes more than $1.2 billion to the state's economy in the form of wages (3.5 percent of total private sector wages in Iowa). The average annual wage per employee for Iowa's IT industry is $42,536. This is more than $12,000 above total state private sector wages and is growing. Between 2000 and 2003, average annual IT wages in Iowa grew by 2.6 percent versus a 1.0 percent decline nationally.

Information Technology Subsector Classifications for Iowa

The active IT subsectors in Iowa can be categorized into four classes based upon their economic performance between 2000 and 2003. The four categories were based on LQ and growth relative to the United States. Subsectors classified as ***stars*** and ***emerging*** are vital for the overall industry and its future

[5] See Appendix A for a full list of information technology NAICS codes.

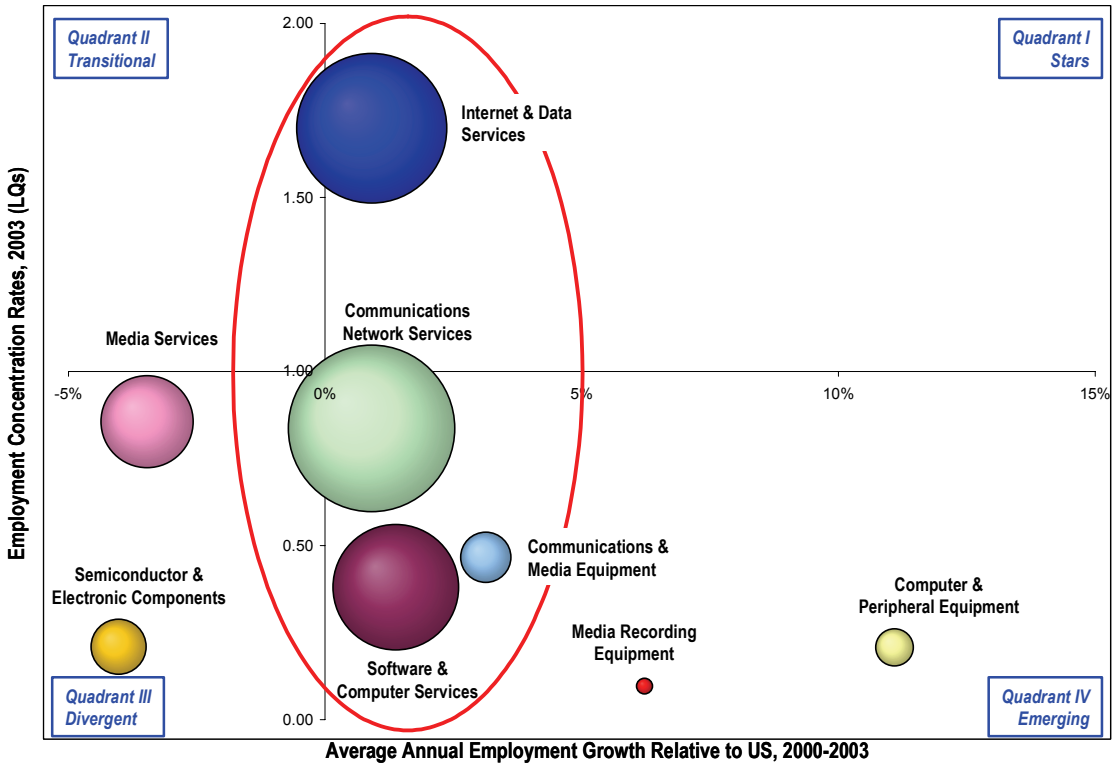
development potential. These subsectors are often seen as the driving forces behind the industry's success. Subsectors classified as ***transitional*** or ***divergent*** are in an intermediary state, though not irreversible. Transitional and divergent subsectors require a strategic response to reposition them.

Figure ES-2 portrays the general performance of the IT subsectors within the State of Iowa. Essentially, the subsectors have exhibited an economic performance slightly better than the national trend between 2000 and 2003. Three IT-service–related subsectors in particular possess strong employment bases and have demonstrated a relatively stable trend: Internet and data services, communications network services, and software and computer services. These subsectors represent the principal foundation of Iowa's IT industry.

A second group termed "emerging" includes three subsectors associated with the IT-equipment segment: communications and media equipment, media recording equipment, and computer and peripheral equipment. Though not very large, this group has above-average employment growth trends. Although their employment concentration rates are below average, these subsectors have the potential to become state "stars" in the future.

Subsectors demonstrating these characteristics are in a stage of evolution. This analysis indicates that the state possesses development potential within critical elements of the equipment segment of the IT industry. The long-term viability of the industry in Iowa requires that the state leverage subsectors exhibiting strengths and support those considered to be emerging.

Figure ES-2: Information Technology Subsector Performance in Iowa, 2000–2003



Source: Battelle calculations based on ES-202 from the Iowa Employment Statistics Bureau, 2000–2003
Note: Bubble size indicates employment base

Economic Data Summary and Conclusions

The IT industry in Iowa is an important industrial sector for the state's overall economic well-being, and the industry has demonstrated resiliency despite challenging national economic conditions. In the face of a national economic downturn that began in 2001, the IT industry in Iowa continues to be a source of economic stability with a growing gross state product, above-average wages, and supportive services and infrastructure for other industrial sectors. Key findings include the following:

Recovering from a national economic downturn, Iowa's IT industry surpassed the U.S. average trend. Although the industry has not grown, IT employment in Iowa fell at a slower rate than it did in the nation. The better-than-average economic performance indicates that Iowa possesses the capacity to increase its industry positioning. While Iowa is not considered a major leader in the industry, the state has preserved its status.

The strength of Iowa's IT industry is based in the IT-service segment. The large IT-service segment of Iowa is the basic foundation of the IT industry in the state. Internet and data services, communications network services, and software and computer services constitute 81 percent of all IT employment. Slightly ahead of U.S. trends, these three subsectors compose the backbone of Iowa's IT industry.

Several major industrial sectors depend on the IT services and infrastructure—most notably in finance and insurance and manufacturing. The service-related IT segment holds its dominant role in Iowa in part because of the state's diverse economy. Several major industrial sectors depend on IT services and infrastructure provided by this segment. Finance and insurance and manufacturing each rely on the communications and information networks to contact customers as well as manage and deliver various products and services. The state is presented with an opportunity to strengthen these inter-industry connections and expand the IT industry, simultaneously advancing the competitive position of these ancillary industrial sectors.

The smaller equipment-related IT sector must be strengthened and leveraged in order to complement the IT-service infrastructure of Iowa. The equipment-related IT segment is part of the emerging base. Equipment-related subsectors outpaced U.S. average growth significantly and typically pay the highest IT wages. In fact, communications and media equipment and computer and peripheral equipment are strong, promising industries that have experienced above-average performance.

IOWA'S STRENGTHS IN IT RESEARCH AND DEVELOPMENT

Clusters of specialized R&D are of critical importance in providing states with a competitive advantage in technology-driven development. In an increasingly innovation-driven economy, the productivity and quality of distinctive expertise in science, engineering, and related technology disciplines are crucial to economic progress.

Iowa is quite well placed, given its size, in regards to its IT knowledge and innovation infrastructure. In particular, some specific areas contain acknowledged clusters of distinctive expertise—both on the academic R&D front and within Iowa's commercial sector. Most notable among these R&D cluster areas are the following:

- In **radio frequency (RF) and radio frequency identification (RFID) technologies,** Iowa, particularly in the Cedar Rapids technology corridor, has a very strong base of expertise in wireless applications. Rooted firmly in the high-technology operations and R&D of Rockwell Collins, the

Cedar Rapids area has continued to grow multiple companies active in the RF/RFID field (including Intermec, Siemens, Fastek, and Skyworks). Wireless technology and mobile IT solutions are high-growth fields, and Iowa is well placed to take advantage of R&D and engineering skills directly and indirectly related to them. There also are pockets of expertise in Iowa related to other wave frequencies, with a special level of expertise in microwaves. Iowa's major universities are working with Rockwell Collins, and others in the field, through programs such as ISU's Very Large-Scale Integration (VLSI) Design Center.

- Centered on the R&D activity of Iowa's two largest universities, a powerful knowledge base has been built in the area of **advanced visualization systems and VR technology**. ISU's Virtual Reality Applications Center (VRAC) is among the recognized national leaders in the development and application of VR technologies and enjoys extensive collaborations with industry both in and outside of Iowa. The VRAC and its affiliated researchers also have been instrumental in the growth of several technology companies in Iowa based on VR technologies and applications. This has now expanded to embrace the broader field of **"human-computer interaction,"** providing applied R&D opportunities related not only to visualization and imaging, but also haptics, ergonomics, interface design, and multiple R&D fields. With links to other areas of expertise at ISU in artificial intelligence and computer science and engineering, the University is well placed to advance a human-computer interaction sector for Iowa. Iowa's strengths in this area are further reinforced by resources at the University of Iowa, which is home to intensive VR and simulation research centered upon the National Advanced Driving Simulator. VR work at the University of Iowa also is notable for the R&D activities at the Center for Computer-Aided Design, which contains specialized research work related to the virtual human/soldier project and distinctive expertise in human factors design, multibody dynamics, and simulation. As with ISU, the University of Iowa's work in VR and related disciplines has resulted in the development of local commercial enterprise. Work in visualization and imaging also has a strong link into biomedical imaging and bioscience platform work in Iowa.
- The development and production of **high-reliability, ruggedized IT systems** also represent an Iowa strength. On the corporate side, Intermec is a power player in the development of mobile high-reliability systems, while Crystal Group (also in Cedar Rapids) is a leading producer of high-end ruggedized servers, with particular emphasis on military applications. Similarly, much of the work of Rockwell Collins relates to product development for avionics and military applications requiring extreme levels of reliability and rugged-duty capabilities. On the academic R&D side, the University of Iowa has focused work on reliability-based design, durability, and optimization in IT systems through the Center for Computer-Aided Design. Related to this technology area is also ISU's Center for Non-Destructive Evaluation and the ISU Information Infrastructure Institute.
- **IT systems security and information assurance** is a fast-growth field and an area where Iowa has some legitimate strengths. On the corporate front, Iowa has high demand for information assurance and security applications for its large financial service and insurance sector. This type of work, for security reasons, cannot be offshored; and much custom application development work occurs between the major companies and smaller, specialized systems consultancies. On the academic R&D front, security-related R&D is being performed within the ISU Information Assurance Center, which has 40 involved faculty members and is a National Security Agency Center of Excellence. Some local Iowa companies have spun out of this technology area at ISU. It also is important to note that ISU is working to become a National Science Foundation cooperative research center for information protection (with ISU as the lead institution), and the ISEAGE (for Internet-Simulation Event and Attack Generation Environment) total Internet simulator allows ISU researchers to simulate security

events such as Internet cyber attacks and associated security issues. The R&D work at ISU is being reinforced by a master's program in information security.

- As noted above, Iowa is home to a substantial base of financial service and insurance corporations. Such operations are, of course, highly IT intensive with large-scale operations in areas such as electronic data interchange, actuarial analysis, data mining, and data warehousing. E-commerce applications are also a growth field within the finance and insurance sector. **Because of the base of finance and insurance operations in Iowa, a considerable number of IT software and systems solutions companies have operations in the state**—these include both locally owned, stand-alone companies and branches of international consultancies. The providers of specialized solutions to Iowa's finance and insurance companies have potential to expand their operations both domestically and internationally—taking the skill sets they have learned locally and applying them to greatly expanded markets. In addition, several distinctive areas of academic R&D relate to IT and the finance and insurance sector. At ISU, the Center for Computational Inference, Learning and Discovery has a particular focus on data mining research and applications; and its application to insurance data analysis is assisted by ISU's very strong statistics department. Also, the University of Iowa College of Business has a technology focus and has specific research programs focused on risk management and the insurance sector; researchers in the College of Liberal Arts and Sciences at the University of Iowa are focused on knowledge and information extraction.
- Iowa also demonstrates strengths in the area of **software quality assurance and testing**. Within the University of Iowa College of Liberal Arts and Sciences (home to the Computer Science Department), researchers are engaged in software verification and correctness analysis. This research uses hardcore testing for assurance purposes using specially developed software tools that themselves are able to probe other software for errors. Similar research interests in high-performance software testing and validation exist at the University of Northern Iowa. There also is a cluster of expertise in smaller consulting organizations in and around Des Moines in quality assurance and specification-based systems, with most of these companies serving the finance and insurance industry.
- The Optical Science and Technology Center at the University of Iowa is a cross-disciplinary science center with 20 faculty members. A number of the engaged researchers have international reputations in **optical science and laser technology;** key research programs at the Center are focused on laser spectroscopy and photochemistry, photonics and optoelectronics, ultrafast laser development, condensed matter physics, materials growth techniques, device physics/engineering, surface chemistry, chemical sensors, environmental chemistry, polymer science, plasma physics, and nonlinear optics. Nanotechnology also is a growth area within the Center. Optics, lasers, and associated technology are obviously important component technologies in multiple areas of IT systems and hardware—this extends from consumer applications for lasers, such as compact disc technology and printing technologies, to ultra high-end military systems using optics and laser sensing in comprehensive missile detection and defense technologies.
- The University of Iowa's work in **quantum electronics and spintronics** also is notable, although commercial application of technology from this research may be long term in relation to IT. Nevertheless, the product potential for work taking place at the University of Iowa, especially in the area of spintronics and its application to reprogrammable transistors based on electron spin and charge, shows great promise. R&D work also is taking place related to quantum-state secure communications and quantum cryptography—very high-end security applications with future IT potential.

Thus, a strong base of R&D expertise exists, both in academe and in Iowa's IT industry, that may be leveraged to produce the next generation of commercializable technology and new entrepreneurial ventures.

FROM R&D STRENGTHS TO PLATFORMS

States such as California, Massachusetts, Virginia, and Maryland have very strong established leadership positions in IT that are both broad (covering most aspects of IT) and deep (covering them in detail). It is unrealistic and unnecessary for Iowa to expect to compete at such an across-the-board level in IT; but, it is realistic to develop niche focus areas in Iowa IT that are still large enough to have a significant and substantial impact on Iowa's relatively compact economy and working population. In other words, because Iowa has a relatively small population in comparison to many other states, huge initiatives and economic advancements are not necessary for a substantial beneficial impact on the state. Rather, Iowa has the good fortune to be able to work on focused programs that target specific, high-value, wealth-creating opportunities.

Qualitative and quantitative investigations of Iowa's IT strengths make it clear that the state has good R&D and production-based IT strengths in areas poised for further growth and development. These strengths may form the basis for IT growth and development platforms, leveraging Iowa's unique skills to attain a leadership position in niche, high-value IT subsectors. As noted earlier, Iowa has signature strengths in several technology areas; but, four stand out as near-term[6] technology platform development opportunities, while two stand out as longer-term advanced technology potential opportunity areas.

Ideally, the criteria for selecting near-term areas of opportunity for development should be as follows:

- Areas with existing research focus strengths at Iowa institutions
- Areas where some base of commercial activity is already emerging or established within the state
- Areas with a distinct opportunity to leverage Iowa's comparative advantages to create competitive marketplace benefits
- Fields with significant product market potential
- Fields that link to or reinforce other IT and technology strengths in the state—thereby helping to enhance other fields as they expand.

Based on these ideal criteria, the following near-term, high-priority platforms for advanced IT development in Iowa are recommended:

Specialized IT Applications in Finance and Insurance—Leveraging Iowa's base of major finance and insurance "original equipment manufacturers" and the base of specialized IT companies to build a major position in advanced IT applications for finance and insurance around "information security and information assurance," "critical applications testing and quality assurance," and "advanced data mining and database analysis."

Radio Frequency (Wireless) Technology—Using Iowa's powerhouse corporate R&D and production presence in these technologies and university R&D skills to design and build the next generation of wireless devices for military and civilian applications.

[6] "Near-term" in this context refers to areas of opportunity with a 2- to 5-year time horizon in which not only *research* growth can occur, but also *broader commercialization and economic* growth.

Advanced Visualization and Human-Computer Interaction Systems—Using Iowa's advanced expertise in data visualization, 3-D graphics, VR environments, and human-computer interaction to develop innovative applications and technologies for interfacing with and controlling technological systems.

High-Reliability, Ruggedized Systems—Using Iowa's strengths as a center for extremely high-quality and high-tolerance manufacturing and expertise in designing robust military electronic systems to develop a signature presence in IT systems that have extreme levels of reliability and in-service durability.

Longer-term platform development opportunities should be pursued that will leverage early leadership among Iowa institutions in two areas that show great promise for the future. These are largely R&D-based platforms at the present time, with limited Iowa industry presence, and include **Optical Electronics and Photonic Systems** and **Quantum Electronics and Spintronics.**

Information Technology Development in Iowa: Key Issues and Gaps

While Iowa has the opportunity to build and reinforce its IT sector based upon clear strengths, some significant needs and gaps also must be met and filled to optimize economic development potential. The detailed SWOT analysis, one-on-one interviews, and in-depth focus groups identified key issues that need to be addressed for Iowa to achieve its goal of IT-driven economic development. Figure ES-3 summarizes the key observed issues and gaps along the continuum from research to commercialization and IT business growth.

Strategies and Actions

Having examined the base of IT industry in the state, the specialized areas of R&D expertise, and the strengths the state holds in this technology sector, it is clear that Iowa has a notable opportunity to advance its economic future using IT-based economic development. Taking advantage of this opportunity does, however, require that the state and its key sectoral stakeholders take actions that will move the opportunity to fruition. Battelle has identified five strategies and 16 specific actions designed to further Iowa's IT research base, build its IT industry, and strengthen the ongoing operations of the existing IT base in the state. At a macro level, the strategies include the following:

Strategy One: **Increase R&D and technology relationships between Iowa IT industry and Iowa universities**

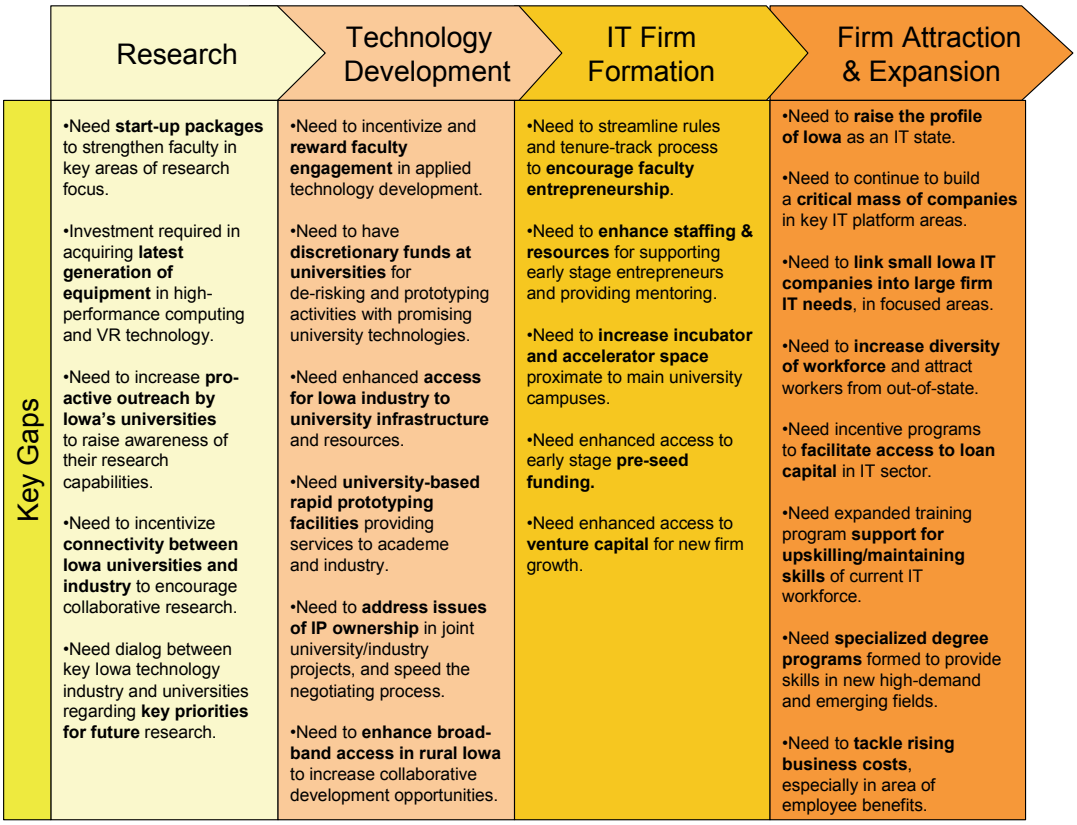
Strategy Two: **Increase small IT firm linkages with larger IT-user firms**

Strategy Three: **Address capital gaps and barriers to business development of IT industry**

Strategy Four: **Retain, attract, and develop the IT workforce**

Strategy Five: **Raise the profile of Iowa as a specialized technology state**

Figure ES-3: Iowa's Key Gaps Along the Information Technology Development Continuum



These strategies and associated actions are summarized in Table ES-1. Implementation of most of these strategies and actions is anticipated within 5 years. *Immediate* actions should be undertaken in the next 12 to 18 months, *short-term* actions should be undertaken in 18 months to 3 years, and *mid-term* actions should be implemented in the 3- to 5-year time period.

Table ES-1: Iowa's Information Technology Development—Strategies and Actions

Strategy	Action	Time Frame
STRATEGY ONE: Increase R&D and technology relationships between Iowa IT industry and Iowa universities	**Action 1: Convene an "Iowa IT Development Summit" to bring university researchers and company technologists together to profile state capabilities in R&D and applied IT commercial development**	**Immediate**
	Action 2: Form a Strategic Technology Platform Fund to strengthen and accelerate the R&D base, talent pool, and university-industry connectivity around the state's core IT platforms through matching grants and collaborative technology platforms	**Short-term**
	Action 3: Develop a structure to facilitate joint-venture development of "orphan" IT innovations at Iowa companies and universities	**Short-term**

Strategy	Action	Time Frame
STRATEGY TWO: Increase small IT firm linkages with larger IT-user firms	Action 4: Develop an awareness program to raise the profile of smaller Iowa IT firm capabilities	Immediate
	Action 5: Provide incentives for larger user firms to work with Iowa firms, vendors, and educational institutions generally and in targeted platforms	Short-term
STRATEGY THREE: Address capital gaps and barriers to business development of IT industry	Action 6: Enhance access to growth and expansion capital for Iowa IT companies	Short-term
	Action 7: Enhance and facilitate entrepreneurship by university faculty	Short-term
STRATEGY FOUR: Retain, attract, and develop the IT workforce	Action 8: Engage Iowa community colleges in development of 2-year programs in identified IT technology skill areas	Short-term
	Action 9: Develop specialized degree and graduate degree/certification courses in key priority technology areas, including, but not limited to, information security, software testing and quality assurance, high-end systems integration, high-reliability engineering, and advanced data mining	Short-term
	Action 10: Develop and implement a communications program aimed at Iowa K-12 teachers and guidance counselors, keeping them up to date on current and emerging career opportunities in IT	Immediate
	Action 11: Develop a state-funded training program specifically geared to assisting in periodic upskilling of existing IT workers	Short-term
	Action 12: Provide continued support for ongoing initiatives aimed at enhancing workforce diversity in Iowa	Mid-term
	Action 13: Provide financial support for Iowa students enrolling in targeted programs	Mid-term
STRATEGY FIVE: Raise the profile of Iowa as a specialized technology state	Action 14: Engage in active promotions and outreach aimed at raising the national profile of Iowa as a technologically advanced state	Mid-term
	Action 15: Use Iowa government as test bed for new government-oriented IT operations and products	Mid-term
	Action 16: Ensure that Iowa's economic development "tool kit" encourages and promotes IT firm development	Immediate

IMPLEMENTATION PLAN

Critical Actions

Realizing the full IT economic development potential outlined by this Roadmap will require that certain critical actions are successfully implemented. Specifically, the ultimate success of the strategy hinges on the forward movement of three activities, forming the fundamentals of Iowa's IT critical path. These three critical actions, quite similar to those recommended as critical actions in the *Iowa's Bioscience Pathway for Development*,[7] will ultimately determine whether Iowa will become a leading state in IT-based economic development. These critical actions are as follows:

- Convene an **"Iowa IT Development Summit"** to bring university researchers and company technologists together to profile state capabilities in R&D and applied IT commercial development.
- **Form a Strategic Technology Platform Fund** to strengthen and accelerate the R&D base, talent pool, and university-industry connectivity around the state's core IT platforms through matching grants and collaborative technology platforms.
- Develop a structure to **facilitate joint-venture development of "orphan" IT innovations at Iowa companies and universities.**

The above actions will ensure that the strengths of Iowa in IT are leveraged and further built; industry and academe work together on joint R&D initiatives to develop commercial innovations from IT research and specific IT platforms; funding and support are available to develop IT entrepreneurs and their business ventures; and the regent universities are actively engaged and encouraging IT development and commercialization in the state.

Immediate Priorities

Immediate work plan priorities are those steps that should be undertaken in the first 12 months of strategy implementation regardless of how critical they are to the overall strategy. Several immediate priorities can be implemented right away, while others will need to be planned and allocated funds before they can become fully operational. The following actions should be undertaken in the first year:

- Convene an "Iowa IT Development Summit" to bring university researchers and company technologists together to profile state capabilities in R&D and applied IT commercial development.
- Develop an awareness program to raise the profile of smaller Iowa IT firm capabilities.
- Develop and implement a communications program aimed at Iowa K-12 teachers and guidance counselors, keeping them up to date on current and emerging career opportunities in IT.
- Ensure that Iowa's economic development "tool kit" encourages and promotes IT firm development.

Resource Requirements

For each action, Table ES-2 indicates the time frame of the action, breaks out state funding needs into two 5-year phases, provides the estimated one-time costs, and indicates the anticipated external leverage. Overall, costs to the state government from general fund appropriations would require total investments of $172.125 million over 10 years, broken out as $62.875 million in the first 5 years and $109.250 million in the second 5 years. In addition to these investments, private sector resources, both direct and matching

[7] See *Iowa's Bioscience Pathway for Development*, prepared by Battelle for IDED, July 2004, for further detail.

funds, will amount to $198.850 million over 10 years, broken out as $83.600 million in the first 5 years and $115.250 million in the second 5 years. These funds could additionally leverage federal and philanthropic dollars; but, the precise amount cannot be determined.

Table ES-2: Iowa's Information Technology Financial Plan

Action	Time Frame	Annual Funding by Year: Years 1–10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds	Comments
1-Convene an Iowa IT Development Summit	Immediate	None	$50,000	$100,000 match or 2:1	Matching funds from private sector
2-Form a Strategic Technology Platform Fund	Short-term	Two elements: Infrastructure Year 1: $1 million; Years 5–10: $3 million Matching: Year 1: $500,000; Years 5–10: $2 million annually		3:1 match on matching program	
3-Develop a structure to facilitate joint-venture development of "orphan" IT innovations	Short-term	Year 2: $ 3 million; Year 5: $5 million; Year 10: $5 million		Leverage other private investments of 3:1 state funds	
4-Develop an awareness program to raise the profile of smaller Iowa IT firm capabilities	Immediate	Private funds of $50,000 per year		All private	
5-Provide incentives for larger user firms to work with Iowa firms	Short-term	Year 1: $500,000 Year 6: $1 million a year		2:1 industry match	
6-Enhance access to financial capital	Short-term		$ 2 million in additional venture fund	3:1 to 5:1 industry match	
7-Enhance and facilitate faculty entrepreneurship	Short-term	Use existing programs and give priority to IT. No additional costs			
8-Engage Iowa community colleges in development of IT programs	Short-term	$250,000 per year for 10 years		Tuition and fees will leverage funds over time	
9-Develop specialized degree and graduate degree/certification courses	Short-term	No additional funds—this program would be funded through the Investment Portion of Action 2			
10-Develop communications program for K-12 teachers and guidance counselors	Immediate	$100,000 per year for 10 years			

Action	Time Frame	Annual Funding by Year: Years 1–10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds	Comments
11-Develop training program geared to periodic upskilling of existing IT workers	Short-term	$200,000 in Year 1, rising to $500,000 in Years 5–10			
12-Provide continued support for workforce diversity in Iowa	Mid-term	To be determined			
13-Provide financial support for Iowa students enrolling in targeted programs	Mid-term	Year 3: $1 million, rising to $5 million by Years 5–10			
14-Raise the national profile of Iowa as a technologically advanced state	Mid-term	Year 3: $2 million, rising to $5 million by Years 6–10			
15-Use Iowa government as test bed for new government-oriented IT operations and products	Mid-term	Use existing resources and budgets. No additional costs			
16-Ensure that Iowa's economic development "tool kit" encourages IT firm development	Immediate	Use existing resources and budgets. No additional costs			

Organization and Structure

Management of strategy implementation should be carried out by IDED in collaboration with the Technology Association of Iowa (TAI). An Iowa IT Development Taskforce should be formed, focused on steering and advising implementation of the IT development strategy; and the Taskforce should be used to confirm support for, and prioritization of, key development platforms. Having representatives of each group of stakeholders involved in the Taskforce will help seed collaborations and avoid drawing the strategy too far in any single direction or driving it by any single group's agenda.

Ideally, the Taskforce should contain senior representatives from the following stakeholder groups:

- Iowa IT industry in both software and hardware systems, both general and platform-specific representatives
- Chief information officers of largest IT-user companies in Iowa (especially those within the financial service/insurance sector)
- Senior research administrative leadership of Iowa's regent universities and deans of key departments engaged in leading IT-platform–related research

- Representatives of the entrepreneurial and business capitalization/investment community
- Senior IDED and Board of Regents leadership.

The Taskforce should be convened immediately to receive a formal presentation of the Iowa IT Strategic Roadmap. The Taskforce will then be responsible for approving key strategy elements and actions and steering their implementation.

Assuming the Taskforce accepts the recommendation for four platforms, four Platform Research Subcommittees should be formed comprising the senior R&D and product planning personnel from industry and the leaders of key R&D teams associated with the platforms at Iowa's regent universities. The Subcommittees will undertake a review of research agendas and capabilities at the universities and work to identify potential matches to the needs and interests of Iowa industry in the sector. Furthermore, industry representatives will be able to profile their needs and opportunity areas for joint R&D initiatives. The Subcommittees will work toward achieving a consensus on high-priority R&D initiatives likely to have the greatest commercialization and economic benefit for Iowa.

The Iowa IT Strategic Roadmap proposes a set of strategies and actions that involve multiple public and private organizations and entities. These strategies and actions have been designed to build on the base of organizational capabilities that currently exist in Iowa and to provide resources and structure for redirecting the efforts of these organizations and forming new organizations to plug critical gaps.

Direction and administration of the implementation of the Iowa IT Strategic Roadmap are critically important functions. Given the important role that industry, academia, and government each must play, it is imperative that an organization be structured that will engage each of these groups in the process. The Iowa IT Development Taskforce would be the logical convening entity, created as a formal collaboration between industry and academia with specific state support, including staffing and funding support. As mentioned above, the Taskforce would oversee industry and academic subcommittees, one for each IT platform and one for IT workforce development.

The IT Development Taskforce should serve as an informal, not a legal, entity, at least initially. Its Board representation should include key public and private representatives including the following:

- Iowa Regents Economic Development Director
- Director of the IDED
- Provosts for research from each of the regent universities and deans of key colleges engaged in platform-focused research
- A legislative representative from each caucus of the Iowa House and Iowa Senate
- Industry representatives from
    - The largest IT-user companies in finance and insurance, and other key industries
    - Software products and services
    - Computer and computer hardware manufacturing
    - Electrical and electronic systems and components manufacturers
    - IT consulting services
    - Communications and networking technology providers

- Product design companies
- Any company active in one of the four primary platform technologies.

Measures of Success and Accountability

The following represent key measures and performance goals, with actual monitoring undertaken on an ongoing basis through the Iowa IT Development Taskforce to determine to what degree performance objectives are being accomplished. Key measures that could be used include the following:

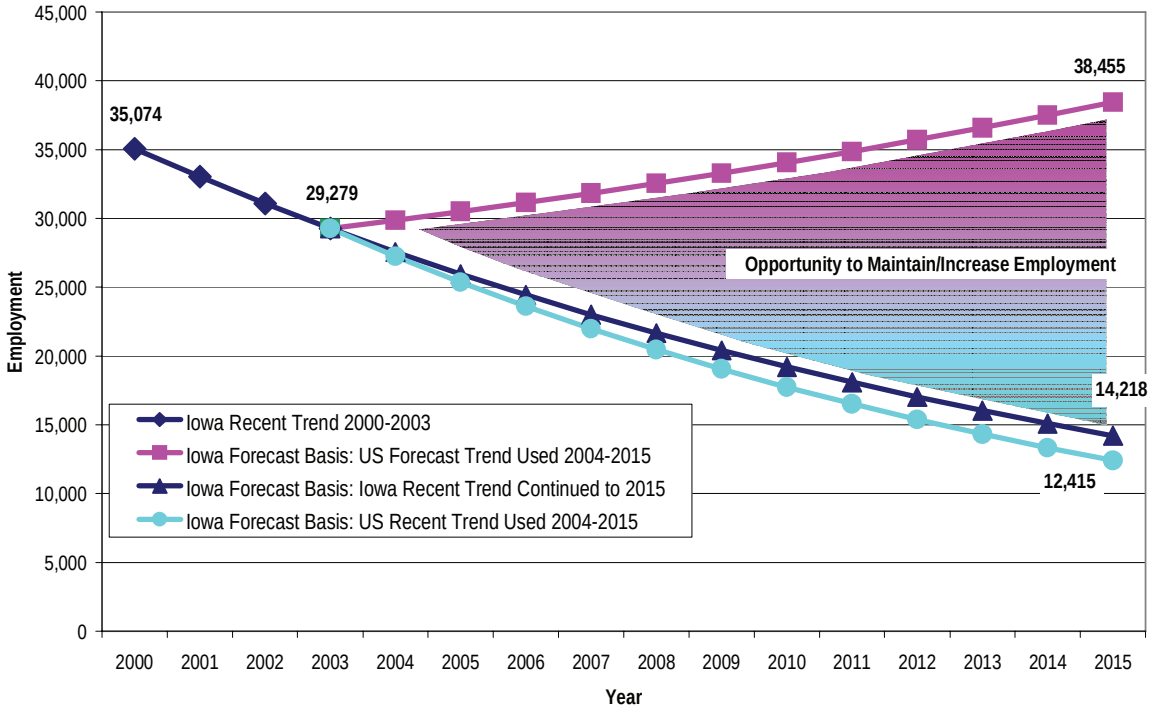
- Increasing IT business start-up rate in Iowa by 100 percent by 2010.
- Doubling R&D funding (primarily from federal sources) for IT-related research by 2010.
- Leveraging federal and other dollars at least three times for every dollar of state support.
- Accomplishing implementation progress on the actions outlined in this Roadmap—at least 70 percent with substantial action after 3 years and 90 percent within 5 years.

Economic Impact Potential of Iowa Information Technology Roadmap

The 10-year potential economic impact of this Roadmap on the IT industry in Iowa is focused on the efforts to (1) grow new firms through the commercialization of university-based IT R&D and (2) enhance the prospects of existing IT firms to ensure their competitiveness, retain (and, if possible, expand) their Iowa-based employment, and maximize their ability to reach their economic potential. In total, the IT Roadmap's potential impacts on the Iowa economy include the following:

- ***Potential New IT Start-Ups***
  - The Iowa IT industry can conservatively grow by an additional 45 firms over the next 10 years.
  - Employment in the state's IT industry can grow, through the employment in these new start-up firms, by more than 900 jobs over the next decade. In turn, this direct IT employment will have a multiplier effect, accounting for nearly 2,400 additional jobs in all sectors of the state's economy.
  - These new IT start-up firms will conservatively generate, over only a 10-year period, annual sales that reach more than $16 million by year five, more than $240 million in year ten, with a cumulative total of more than $620 million over 10 years.
- ***Potential Retention and Expansion of Existing Firms and Jobs***
  - Baseline employment in 2003 (per the economic analysis) is 29,279. If the recent decline from 2000 to 2003 was continued (using a compound annual rate), by 2015 the state's IT employment level would be cut in half to a level of 14,218 (Figure ES-4).
  - Based on the U.S. Bureau of Labor Statistics forecast, which forecasts that the IT industry will have somewhat of an overall rebound by 2012, Iowa's IT employment could increase by approximately 30 percent over 2003 levels to nearly 38,500 workers by 2015.
  - The retention opportunity, or the employment loss risk, could be more than 26,000 jobs over this period.
  - This opportunity area consists of some industries that are forecast to decline at the national level as well as some that are forecast to rebound and/or increase over the next decade.

Figure ES-4: Potential Iowa Information Technology Retention and Expansion Opportunity



CONCLUSION

Currently, Iowa has a relatively small IT economy, largely centered on providing IT services to Iowa customers. However, Iowa's IT sector shows significant promise for growth and has proven itself to be more robust than the national IT sector in weathering IT downturns and challenges.

IT is an important sector to grow for Iowa's economic future. It provides good-paying jobs and the fundamental technological underpinning for advancement in a broad range of other sectors, from finance and insurance to manufacturing and the biosciences. Given the relative size of the Iowa economy, the state does not need to be a leader in all facets of IT; rather, it can afford to concentrate on specialized niches of IT activity where it already has established and emerging strengths based in R&D and business operations. For niche development, Iowa shows distinct promise for further developing its IT economy around (1) specialized IT services for finance and insurance companies; (2) RF/wireless technology; (3) advanced visualization and human-computer interaction systems; and (4) high-reliability, ruggedized systems and devices.

Distinct strategic actions are needed to achieve the promise of IT development for Iowa. Key stakeholders in private industry and public and academic sectors in Iowa will need to come together in a collaborative environment to drive progress and mitigate barriers. In particular, action is needed in five key strategic areas: increasing R&D and technology relationships between Iowa IT industry and academe; increasing small IT firm linkages with larger IT-user firms in the state, addressing capital gaps and barriers to IT business development, retaining and enhancing the IT workforce, and raising the profile of Iowa as a specialized technology state. This Iowa IT Strategic Roadmap details the actions required to make these strategies work, providing a pathway for achieving the true promise of IT-based economic development in Iowa.

Introduction

WHY FOCUS ON THE INFORMATION TECHNOLOGY INDUSTRY?

Information technology (IT), like many technology-oriented industry sectors, is a highly innovative industry segment that is increasingly becoming the backbone of commerce. As scientists, engineers, and programmers develop new, faster, and more proficient methods of transferring and processing data, firms and establishments become better equipped to operate and function more efficiently. Enhancing and managing the flow of information have thus become driving forces for growing an economy.

During the 1990s, IT was seen as a strong economic sector driving growth at the national and state levels. Though not experiencing the double-digit growth demonstrated in the late 1990s, the IT industry is still regarded as an important sector offering good, well-paying jobs; diversifying the economic base; and providing the information infrastructure that contributes to overall economic productivity. IT is an industrial sector that has become a critical medium for enhancing the capacity of commerce. Therefore, it is appropriate that the private and public sectors jointly consider and address ways to ensure Iowa's competitive base and future in this industry cluster.

Is it (IT) Really a Sector?

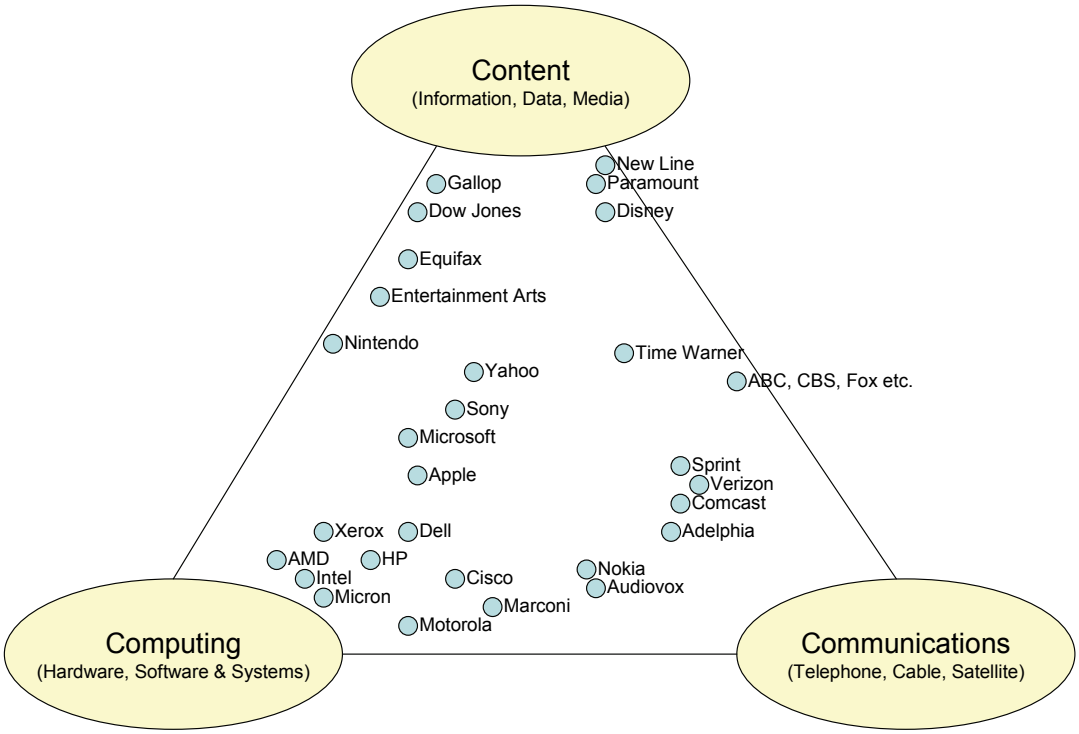
It is important that Iowa understand the implication of the above question because it frames the use and usefulness of an IT development strategy.

IT can be thought of as a broad economic sector (and traditionally has been) because sector members produce tangible products and services. Companies in the IT-"producer" sector produce devices (semiconductors, computers, telephony equipment, robots, etc.), software to drive devices and applications, and services (broadband access, IT consulting, Web site design, systems maintenance, information provision, etc.). Under the IT "sector" definition, companies actually slot into specific niches (subsectors) within the overall IT sector. Moreover, in terms of *occupations,* a majority of IT workers in the United Staters are working in "user" industries such as insurance, finance, and health care. For the purposes of this study, opportunities in Iowa include not only the "producer" IT industries such as software, but also those that user industries such as insurance and finance offer to grow and develop the IT sector in terms of industries and jobs, as well as contributing to the growth and competitiveness of the Iowa's insurance, finance, and other industries.

While IT subsectors capture much of the activity, it is becoming increasingly difficult to place many individual companies and technologies into a single subsector because of the overriding theme of "convergence." Company, industry, and technology lines are becoming blurred by interaction and symbiosis between and across subsectors. At a macro-level, this convergence is being driven by three primary elements: computing, communications, and content. Figure 1 illustrates these convergence areas, with the theoretical placement of various companies in the convergence space.[8]

[8] Design adapted from work by New Paradigm Learning Corporation. Reported in Don Tapscott. *The Digital Economy: Promise and Peril in the Age of Networked Intelligence*. McGraw Hill, 1995.

Figure 1: Information Technology Convergence Areas



As convergence occurs, companies that originally specialized in one subsector become active in multiple subsectors. Microsoft, for example, started as an operating system software company, expanded into applications software, introduced hardware products (such as mice, keyboards, etc.), and became a content provider through MSN and also through collaboration with NBC (MSNBC). Convergence is happening across a substantial variety of IT and IT-related industries, for example:

- Sony Corporation—Owning movie studios and music production and publishing companies and manufacturing computing, multimedia devices, and electronic devices.
- Adelphia Cable—Originally providing cable television services, then diversifying into broadband, Internet service Provider (ISP) services, and Web hosting.
- Nintendo—Manufacturing video game systems, video game content, and branching into networking to facilitate networked games across communications systems.
- Sprint—Originally providing basic mobile phone services, then expanding into providing multi-media content over branded mobile devices.

It is also reasonable to view IT, not as a sector, but as the application of enabling technologies. In this context, IT crosses into most areas of industry and society, with varying levels of IT-use intensity. For example, a bank is not an IT company, but it is highly IT intensive (using electronic data interchange, online banking, etc.) and likely to have many skilled IT occupations on its payroll. Similarly, a manufacturer of auto parts is not an IT company, but it may be an intensive user of IT in computer-aided design and manufacturing, robotics, and various other business processes, such as supply chain

management and customer service. The linkages between intensive IT users and local IT companies can be important economic drivers, and consideration of IT occupations outside of the purely IT subsectors is important to include in analysis (as has been done in this analysis).

DEVELOPING IOWA'S INFORMATION TECHNOLOGY ROADMAP

Recognizing the importance of IT to technology-based economic development, the Iowa Department of Economic Development (IDED), in the spring of 2005, initiated work on this IT Strategic Roadmap to guide future public and private investment decisions in Iowa. A Steering Committee composed of representatives of the state's IT sector was established to oversee this effort, and Battelle's Technology Partnership Practice (TPP) was engaged to develop the strategy. Battelle is a global science and technology enterprise that develops and commercializes technology and manages laboratories for customers. TPP, which includes leading analysts and practitioners in technology-based economic development, helps clients develop, implement, and evaluate technology strategies, policies, and programs.

This Roadmap was developed with input from representatives of the IT industry sector, Iowa's universities, and other public and private leaders from all regions of the state. The Battelle project team collected and analyzed data on Iowa's IT sector, assessed the sector's competitive position vis-à-vis a number of competitors and peers, and conducted interviews and focus groups to gain an understanding of the issues facing the state's IT sector and to gather input on actions that could be taken to further enhance the global competitiveness of this sector.

This report includes the following:

- Findings from an economic analysis of the state's IT sector
- A competitive assessment of Iowa's infrastructure to support the IT sector as compared with a set of benchmark states
- A strengths, weaknesses, opportunities, and threats (SWOT) analysis that reports findings based on 106 interviews of representatives of industry, associations, government, and educational institutions; small group discussions; and three focus groups.
- Proposed strategies and actions to enhance the competitiveness of Iowa's IT sector
- An implementation plan that outlines initial steps for executing the strategies and actions.

Roadmap Methodology

- Economic analysis
- Benchmarking analysis
- SWOT analysis
- Interviews with industry representatives, researchers, educators, and economic development and workforce officials
- Focus groups and discussions

The Roadmap's ultimate goal is to build a stronger, more internationally competitive IT sector for the State of Iowa.

Iowa's Information Technology Sector

KEY FINDINGS

The following statistics highlight the importance and potential of IT as an economic sector for further development in Iowa.

IT gross state product (GSP) is growing in Iowa at a rate above the U.S. trend. The IT industry contributed approximately $3.8 billion to Iowa's total GSP. This represents 4.4 percent of total Iowa GSP. Nationally, the IT industry accounts for 6.4 percent of U.S. gross domestic product (GDP). Although smaller in scale than that of the United States, the economic growth of Iowa's IT industry outpaced the country (Table 1).

Table 1: Information Technology GSP in Iowa and GDP in the United States

Sector	Iowa	Share of Total Private Sector		Average Annual Growth, 1998-2000		Average Annual Growth, 2000-2002	
	2003 GSP ($ million)	Iowa GSP	U.S. GDP	Iowa GSP	U.S. GDP	Iowa GSP	U.S. GDP
Total Private Sector	86,837	n.a.	n.a.	4.0%	6.1%	2.4%	3.1%
Information Technology	3,794	4.4%	6.4%	11.0%	8.2%	-2.0%	-1.8%

Source: Battelle calculation based on GSP data from the U.S. Bureau of Economic Analysis

Iowa's information technology GSP grew at an impressive average annual rate of 11 percent between 1998 and 2000. This increase is significantly above even the strong 8.2 percent growth demonstrated at the U.S. level. Even as the national economy began to slump after 2000, Iowa managed to keep pace with the U.S. trend. Information technology GSP in Iowa fell by 2.0 percent, virtually mirroring the 1.8 percent decline across the United States between 2000 and 2002. Data from the entire 4-year period indicates that exceptional growth in the late 1990s positioned Iowa's IT industry as an important economic industrial sector, regardless of short-term fluctuations.

IT is driving gains in productivity as a result of the rapid deployment of the Internet, increased broadband capacity, mobile communications, and smaller and smaller computing devices. Industries distinct from the IT sector are increasingly integrating various services and devices in order to conduct commerce in a more efficient manner.

Businesses are no longer bound by physical locations. Interaction with customers is profoundly changing as the use of computer/network-driven technology becomes pervasive. This model promises uninterrupted communications and transactions among firms,

> Convergence of technologies is allowing users to access and exchange information and content in ways that were not possible before. Industries such as media and communications that once had clearly defined boundaries are seeing business models converge and perhaps collide as technologies change the possibilities. Change is painful and absent a clear solution, many companies will choose to defend the current business model rather than exploit new opportunities.
>
> Gartner, Inc., *One Gigabit or Bust Initiative: A Broadband Vision for California,* prepared for the Corporation for Education Network Initiatives in California, May 2003, p. 6

customers, suppliers, and other stakeholders. This concept of ubiquitous commerce will provide a level of value over, above, and beyond traditional commerce.

These advances are having a tremendous impact on industries that are not exclusively part of the IT industry. Financial institutions now offer online banking transactions for customers. Farmers are able to monitor soil and field conditions remotely, enabling precision agricultural techniques. Manufacturers are able to send and receive engineering design specifications electronically, streamlining the product development process and reducing the time to market. These advances enabled by the IT infrastructure are making a much broader set of user industries more competitive in the global marketplace.

The IT industry is a source of well-paying jobs. The average salary for workers in the IT industry ($42,585) is significantly above the statewide average wage ($30,220) (Table 2). IT is also a higher-paying industry relative to other leading industry sectors in Iowa. The average wage of an IT worker in 2003 surpassed the manufacturing and the agricultural industrial sectors.

It is these reasons—respectable share of state economic activity, a diverse industrial base, and high-paying jobs—that make it reasonable to support initiatives that focus on the IT industry.

Table 2: Information Technology Average Annual Wage per Employee in Iowa

Iowa Industry Sector	Iowa Average Annual Wage per Employee, 2003
Advanced Manufacturing	$44,357
Information Technology	**$42,585**
Manufacturing	$39,865
Total Private Sector	$30,220
Agriculture, Forestry, Fishing, & Hunting	$24,112

Source: Battelle Calculations based on ES-202 data from the Iowa Employment Statistics Bureau

IOWA'S INFORMATION TECHNOLOGY INDUSTRY

Between 1990 and 2000, the national economy experienced one of the largest economic expansion periods ever. The IT industry was a major contributor to the nation's overall economic success. During this 10-year period, the IT industry experienced employment increase at an average annual rate of 4 percent. This expansion occurred at a time when the U.S. economy exhibited a 2 percent annual increase in total employment. Nationally, the IT industry grew at twice the average annual rate of the entire economy.

> From 1994 to 2000, the information technology (IT) industry served as the uncontested "engine" of economic expansion in the U.S. Although it comprises 8 percent of the U.S. economy as a whole, the IT sector accounted for nearly 30 percent of real growth in the Gross Domestic Product (GDP) over that period, a greater contribution than any other sector of the **economy, including retail trade, services and transportation.**
>
> Information Technology Industry Council (http://www.itic.org/reports/economy/tax_exp.htm)

Subsequent to March 2001, the National Bureau of Economic Research (NBER) determined that the economic expansion that began in the early 1990s ended and a recession began. This marked the end of the longest sustained economic expansion recorded by the NBER.[9] The ensuing economic downturn affected all sectors of the economy, including IT.

> As we move further into the 21st century, it looks more and more as though we are witnesses to another pivotal episode of innovation and productivity growth. A few fundamental break-throughs in technology provide most of the basis for the recent rise in labor productivity. The microchip is one of the most dominant innovations. Others that are complementary to the microchip include lasers, digital data storage devices, and software. Today, we are seeing stunning improve-ments in these technologies and, more importantly, rapid expansion of their applications in production processes and products.
>
> Furlong, Fred, "Shaping the Economy," Center for the Study of Innovation and Productivity, *Federal Reserve Bank of San Francisco 2003 Annual Report,* p. 8.

Despite economic restructuring, the IT industry is expected to follow in the footsteps of the overall economy and make a recovery. The Bureau of Economic Analysis has already released some promising indicators that signify that the recovery has begun. The BEA reported on March 30, 2005, that the GDP rose by an annual rate of 3.8 percent in the fourth quarter of 2004. A combination of recent preliminary economic data and new market opportunities within the IT industry suggests that the industry is on the verge of an economic turnaround.

[9] The NBER's Business Cycle Dating Committee maintains a chronology of the U.S. business cycle. The chronology identifies the dates of peaks and troughs that frame economic recession or expansion. The period from a peak to a trough is a recession, and the period from a trough to a peak is an expansion. According to the chronology, the most recent peak occurred in March 2001, ending a record-long expansion that began in 1991. The most recent trough occurred in November 2001, inaugurating an expansion. http://www.nber.org/cycles/november2001/recessnov.html

The IT industry in Iowa possesses an employment base of 29,279 individuals across 2,075 establishments. As seen in Table 3, this level of employment represents 2.5 percent of total private sector employment in the State of Iowa. Nationally, information technology accounts for 3.9 percent of total private sector employment. Despite the state's below-average IT employment penetration, Iowa's IT industry proved to be more stable than that of the United States. Nationally, the industry experienced a rate of employment loss greater than Iowa between 2000 and 2003.

Table 3: Information Technology Industry Performance in Iowa and the United States, 2000–2003

Metric	STATE OF IOWA			UNITED STATES		
	Total IT Industry			Total IT Industry		
		Equipment	Services		Equipment	Services
Establishments, 2000	2,170	99	2,071	242,782	15,719	227,063
Establishments, 2003	2,075	71	2,004	249,587	13,906	251,270
Change in establishments	-95	-28	-67	6,805	-1,813	24,207
Average Annual Establishment Growth	-1.5%	-10.5%	-1.1%	0.9%	-4.0%	3.4%
Employment, 2000	35,074	3,706	31,368	5,126,261	1,383,453	3,742,808
Employment, 2003	29,279	2,601	26,678	4,141,803	961,983	3,647,280
Change in employment	-5,795	-1,105	-4,690	-984,458	-421,470	-95,528
Average Annual Employment Growth	-5.8%	-11.1%	-5.3%	-6.9%	-11.4%	-0.9%
Employees per establishment, 2000	16	37	15	21	88	16
Employees per establishment, 2003	14	37	13	17	69	15
% Share of private sector employment, 2000	2.9%	0.3%	2.6%	4.7%	1.3%	3.4%
% Share of private sector employment, 2003	2.5%	0.2%	2.3%	3.9%	0.9%	3.4%
Employment location quotient, 2000	0.62	0.24	0.65	n.a.	n.a.	n.a.
Employment location quotient, 2003	0.64	0.25	0.67	n.a.	n.a.	n.a.
Change in employment location quotient	0.02	0.00	0.02	n.a.	n.a.	n.a.
Total Private Sector Activity						
Total Employment, 2000	1,217,722			110,023,983		
Total Employment, 2003	1,177,611			107,065,553		
Average Annual Establishment Growth, '00-'03	-5.1%			1.4%		
Average Annual Employment Growth, '00-'03	-1.1%			-0.9%		
Employees per establishment, 2003	14			13		
Population, 2003	2,941,976			290,788,976		
Average Annual Populations Growth, '00-'03	0.2%			1.0%		

Data Source: Battelle calculations based on data from the Iowa Employment Statistics Bureau ES-202 data series, 2000 & 2003

Note: *% Share of private sector employment* is the % share of the reference region

Since the "technology bubble" burst, Iowa's IT industry demonstrated greater resiliency than that of the nation. Since 2000, information technology employment fell at an average annual rate of 6.9 percent across the United States. In Iowa, the IT industry faired better. Over the course of 3 years, employment in Iowa decreased by 5.8 percent annually. More importantly, employment trends indicate that the IT industry in Iowa, compared with the nation, has begun to stabilize.

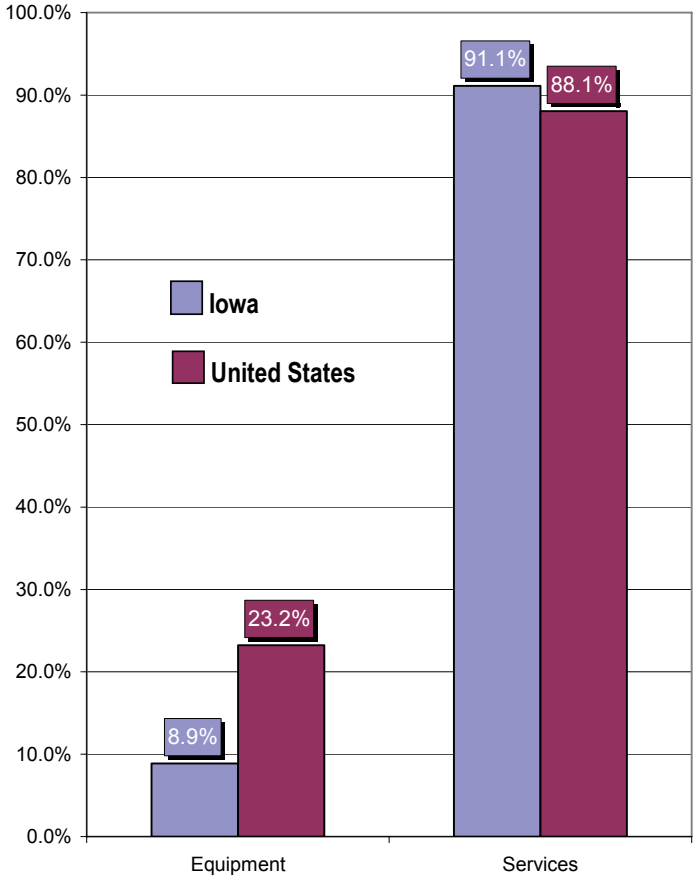
An in-depth analysis reveals that, between 2002 and 2003, U.S. IT employment loss was double the rate demonstrated in Iowa. Nationally, IT employment dropped by 7.2 percent, while in Iowa it fell by only 3.3 percent. This indicates that the IT industry in Iowa possesses a degree of durability. In the midst of economic recovery and transition, especially for the IT industry, Iowa IT seems to be an industry sector that is regaining its vibrancy.

More than 91.1 percent of IT employment in Iowa is service oriented, and the service sector is ultimately the foundational strength of Iowa's IT industry. Nationally, only 88.1 percent of IT employment is considered service-related employment (Figure 2). This may be an indication of the value-adding services offered by the IT industry based in Iowa.

One potential factor contributing to the state's dominant IT-service sector is the broad array of IT customers throughout Iowa. Primarily, IT services represent the technology infrastructure of the state. Industries not traditionally considered part of the IT sector depend on and utilize the technology infrastructure to conduct commerce. Given the strong specialized nature of Iowa's finance and insurance sector as well as the manufacturing sector and their need for a solid technology infrastructure, it is reasonable to see why the IT-service segment dominates Iowa.

Online customer banking and electronic fund transfers are services offered by many financial institutions. These types of financial services require a sophisticated IT-service platform in order to operate. Insurance providers also depend on IT network architectures that enable customers to file claims online and obtain direct service. Such technologies allow companies to directly interact with customers, thus reducing the need for insurance agents. These online services also require sophisticated software applications and safeguards to assure customer privacy and information security.

Figure 2: Equipment and Services Share of Total Information Technology Industry in Iowa and the United States



Source: Battelle Calculations based on ES-202 data from the Iowa Employment Statistics Bureau, 2003

Manufacturers also depend on IT services. A large portion of the gains in manufacturing productivity can be attributed to new production automation software and more efficient software tracking databases. IT services help manufacturers achieve "leaner" production operations and shorten remittance processing cycles.

Despite stronger local performance, the level of employment concentration in the IT industry in Iowa remains below the national average. In Iowa, the IT employment base accounts for a smaller share of

private sector employment in the state than the industry does at the national level. When the ratio of these two measures is significantly above average, i.e., the location quotient (LQ) is above 1.20, a state is said to possess a specialization in the industry. [10] However, in Iowa the LQ is 0.64, meaning that the IT industry in Iowa represents only 64 percent of the national average employment concentration rate. This represents, therefore, an industry that will need to grow to achieve a specialized critical mass in the state.

Selection of Information Technology Subsectors

The IT industry is a sector of the economy offering services and products that provide access to information networks through voice, video, and computing. The IT industry enables and creates data and content flows, facilitating a new paradigm in which commerce takes place. Therefore, as the IT industry matures and develops, this model suggests that more traditional businesses stand to benefit from new technological advances.

> Fundamental change is under way across the Information, Communication and Entertainment industries. Markets that were formerly distinct, discrete and vertical in nature are coalescing across their old boundaries. Horizontal competition, focused on value chain layers, is becoming as important as vertical competition spanning entire value chain.
>
> Christopher Mole et al., "The New ICE Age: Focusing around the individual," PriceWaterhouseCoopers (PWC), 2002, p. 3.

In fact, IT products and services have become so embedded in day-to-day transactions that it is increasingly difficult to differentiate the producers and users of information technology. IT services and products are engrained in society in the form of personal computers, personal digital assistants, satellite television, cellular phones, digital recording devices, radio frequency identification tags (RFIDs), and software applications such as Internet privacy controls and data security.

Not only has the IT industry become embedded across traditional industry sectors, but the IT industry itself is becoming more integrated. The industry is broadening in scope, as established hardware equipment, software, and communications service segments begin to converge.

The clear lines between traditional "telcos," cable companies, ISPs, and software developers are blurring. The functions of communications, computing, and content have become horizontally integrated. Industry leaders understand that they must have a presence across all three areas. In an emerging world of pervasive networks, firms must have the ability to offer customers a full suite of business solutions in order to remain competitive. McLeodUSA, for example, has been an example of this, offering local and long-distance telecommunications as well as cable television, Internet access, and hosted exchanged services for e-mail and data storage support.

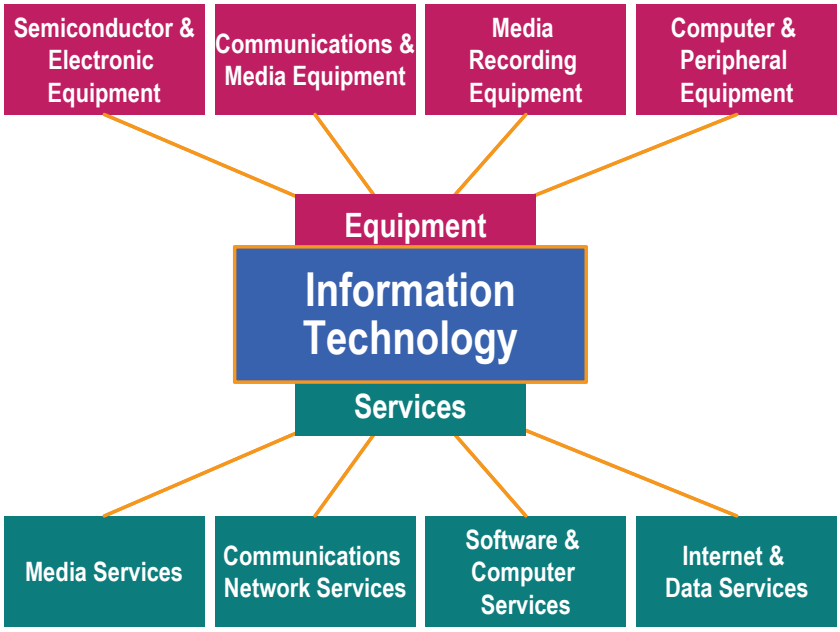
Because of technology convergence and the diverse nature of the IT industry, analysis requires an approach that accounts for the numerous applications of IT advancements. Additionally, examination of end users of IT products and services is also required to help capture and characterize the unique qualities

[10] Location quotients (LQs) are a common measure of the concentration of particular industry in a region relative to the nation (reference area). The LQ consists of the ratio of the share of total regional employment that is in the particular industry and the share of total employment in the nation (reference area) that is in the particular industry. An LQ greater than 1.0 for a particular industry indicates that the region is relatively concentrated, whereas an LQ less than 1.0 signifies a relative under-representation. An LQ above 1.20 denotes employment concentration well above the national average. Throughout this report, LQs are used to report regional industry concentrations relative to the United States as a whole. The minimum concentration threshold for declaring a regional specialization is a matter of judgment and varies somewhat in the relevant literature. In this analysis, regional specializations are defined by LQs of 1.2 or greater.

of the industry. Taking such a holistic approach provides a level of clarity that makes it possible to identify potential strengths and market niches.

In an effort to address the diversity of the IT sector, Battelle used the North American Industry Classification System (NAICS) to identify the industries considered part of the IT sector. Based on an analysis of six-digit NAICS codes, the Battelle team selected 43 industries and organized them according to the eight major subsectors of the IT industry (Figure 3).[11] Each of the subsectors was classified into one of two categories: equipment and services.

Figure 3: The Information Technology Industry and Associated Subsectors



Information Technology Equipment Subsectors

Hardware and equipment consist of those industrial subsectors that are involved in engineering, designing, manufacturing, and installing new cutting-edge devices and apparatus used for constructing novel network architectures. The following four major subsectors of the IT industry were identified as hardware and equipment.

Communications and Media Equipment: This subsector includes establishments primarily engaged in manufacturing equipment, components, and devices used to construct sophisticated information networks and receive wireless communication signals. These firms develop cutting-edge network equipment used to increase information and content transmission. Companies found within this subsector are Winegard and Sabre Communications Corporation.

Computer and Peripheral Equipment: This subsector contains firms that manufacture and assemble computing equipment and devices that store and process data. Machines can be programmed to run and analyze algorithmic computations according to user-defined criteria. Devices utilize multiple data collection methods for processing and storing information, including optical scanning. Machines are often

[11] See Appendix A for full list of information technology NAICS codes.

networked and connected to one another to allow for electronic communication and information transmission. Companies found within this subsector include Crystal Group Inc. and Intermec Technologies.

Media Recording Equipment: This subsector consists of establishments engaged in manufacturing equipment used to replicate or record information and content. This subsector also includes firms that are involved in mass reproduction of previously developed and programmed software and content. Companies found within this subsector include Advanced Home Plus and Transcend Software Inc.

Semiconductor and Electronic Components: This subsector is made up of companies that engage in the manufacturing of semiconductors and various electronic components fashioned from semiconducting material. Semiconductor material is used in the production of miniaturized electronic components, such as transistors, resistors, and capacitors. Companies assemble these electronic components to produce integrated circuits, which are then placed on electronic printed circuit boards. Integrated circuits are used for a variety of devices, including microprocessors, audio and video equipment, and automobiles. Integrated circuits are often classified by the number of transistors and other electronic components they contain. Companies found within this subsector include Precision Resistive Products, Celestica, and Iowa Thin Film Technologies.

Information Technology Service Subsectors

Software and service subsectors consist of those industries that are involved in designing, developing, programming, and processing new software and communications network technologies for transmitting voice, video, and data. The following four major subsectors of the IT industry were identified as software and services.

Internet and Data Services: This subsector encompasses companies providing information data management and retrieval services. It includes companies that operate as access points to the Internet. The wide range of establishments within this subsector makes use of equipment and technology to provide access to information sources. Some establishments operate exclusively in an online format, while others tailor information services directly to meet client needs. Establishments engaged in unique data runs and processing administer their services either on-site or remotely, using the most efficient and secure network system architectures available. Companies found within this subsector including VGM Forbin, Fiserv, Communications Data Services, and Regulus Group.

Communications Network Services: This subsector comprises companies that operate and maintain area-wide communications networks. These firms constantly upgrade network infrastructures with technologically advanced communications components that enhance the quality and speed of information and content transmission. These networks transmit data utilizing both wired and wireless routing technology standards. These firms apply the hardware developed by communications and media equipment manufacturers. Network providers may also engage in software development that operates over the network infrastructure in order to route data transmissions. Companies found within this subsector include McLeodUSA, Iowa Telecommunications Services, and Iowa Network Services.

Software and Computer Services: This subsector contains firms developing and designing computer software programs and applications. These companies write computer code that operates specific commands over computer hardware network systems. These programs are often embedded within hardware equipment. Companies found within this subsector include CarteGraph, Kingland Systems, Riverdeep, and Shazam Network.

Media Services: This subsector is composed of establishments involved with transmitting and broadcasting media content. These companies integrate novel content distribution technology in order to relay media content with the highest degree of quality. Content is disseminated using wired and wireless technology, including digital transmission. Companies found within this subsector include Mediacom Communications and Meredith Communications.

INFORMATION TECHNOLOGY SUBSECTOR CLASSIFICATIONS FOR IOWA

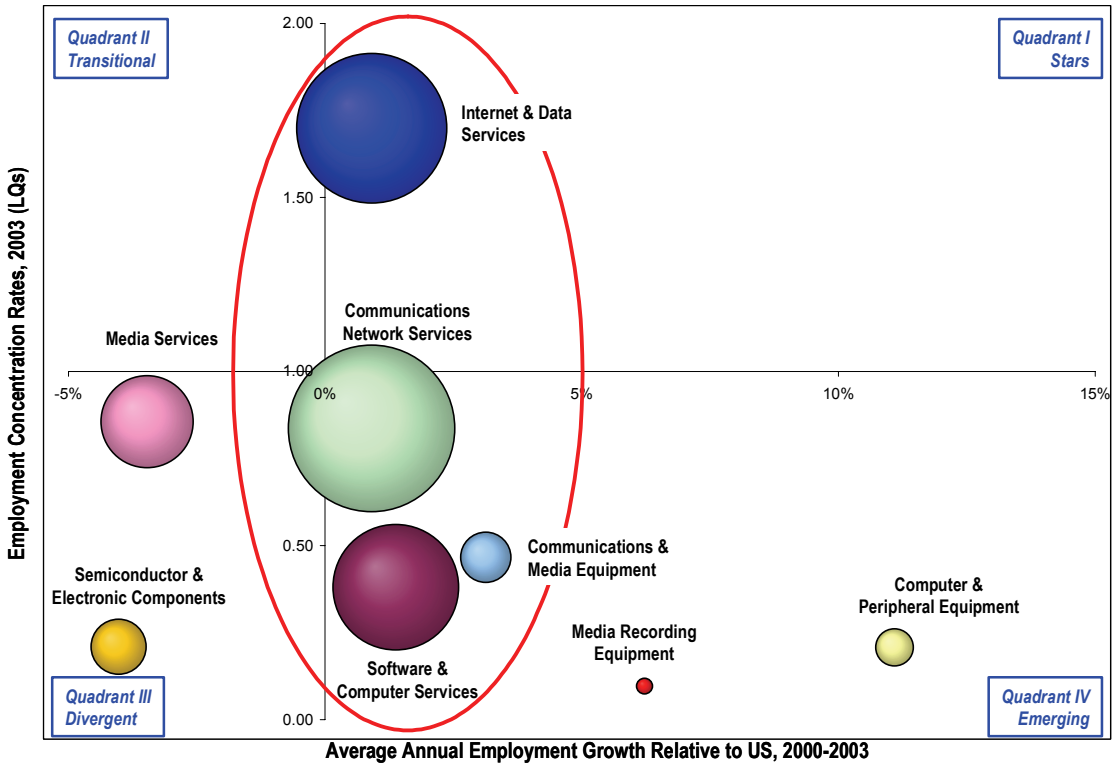
The IT subsectors in Iowa can be categorized into four classes based upon their economic performance between 2000 and 2003. The four categories were based on LQ and growth relative to the United States. Subsectors classified as ***stars*** and ***emerging*** are vital for the overall industry and its future development potential. These subsectors are often seen as the driving forces behind the industry's success. Subsectors classified as ***transitional*** or ***divergent*** are in an intermediary state, though not irreversible. Transitional and divergent subsectors require a strategic responsiveness to reposition them.

Figure 4 portrays the general performance of the IT subsectors within the State of Iowa. Essentially, the subsectors have exhibited an economic performance slightly better than the national trend between 2000 and 2003. Three IT-service–related subsectors in particular possess strong employment bases and have demonstrated a relatively stable trend: Internet and data services, communications network services, and software and computer services. These subsectors represent the principal foundation of Iowa's IT industry.

A second group termed "emerging" included three subsectors associated with the IT-equipment segment: communications and media equipment, media recording equipment, and computer and peripheral equipment. Though not very large, this group illustrated rather above-average employment trends. Although their employment concentration rates are below average, these subsectors have the potential to become state "stars" in the future.

Subsectors demonstrating these characteristics are in a stage of evolution. This analysis indicates that the state possesses development potential within critical elements of the equipment segment of the IT industry. The long-term viability of the industry in Iowa requires that the state leverage subsectors exhibiting strengths and support those considered to be emerging.

Figure 4: Information Technology Subsector Performance in Iowa, 2000–2003



Source: Battelle calculations based on ES-202 from the Iowa Employment Statistics Bureau, 2000–2003
Note: Bubble size indicates employment base

Stars

The Internet and data service subsector is the most regionally specialized IT subsector and the second-largest subsector employer. In 2003, Internet and data services employed 8,070 workers across 238 establishments. This level of employment represents 26.7 percent of total IT employment in Iowa. At the national level, the subsector represents only 9.4 percent of total IT employment.

The average firm size of the Internet and data service subsector in Iowa further illustrates its magnitude. Internet and data service establishments in Iowa employ roughly 34 individuals on average. Across the United States, these establishments have an average of 16 employees. Larger average firm size indicates that Iowa possesses corporations of significant size.

Although not growing in terms of employment, Iowa performed better than the nation. Between 2000 and 2003, Iowa experienced a loss of employment that was less than that for the United States. The average annual rate of employment loss in Iowa was 7 percent, compared with 8 percent nationally. Remaining ahead of the national trend has enabled Iowa to maintain its preeminent position in the Internet and data service subsector.

The Internet and data service subsector in Iowa possesses a level of employment concentration that is 70 percent more concentrated than the national average. This concentration rate is significantly greater than expected, given the size of Iowa's overall economy. At this level of employment concentration, Iowa is considered to possess a regional specialization within the Internet and data service subsector. Yet, it

should be noted that the subsector has lost more than 2,000 employees since 2000. If this trend is not reversed, Iowa's level of specialization could be threatened.

Examining Iowa's customer base illustrates why the Internet and data service subsector holds such a strong position. Some of the data services in Iowa are uniquely tailored to serve the state's robust financial and insurance service sectors, as well as the manufacturing sector. Major financial institutions and insurance agencies in Iowa depend upon back-office data processing centers across the state. Iowa's manufacturing industry benefits from the remittance data processing and supply chain tracking services. Uniquely tailored services, combined with Web hosting and point-of-presence Internet access, offer clients streamlined information transactions.

Emerging

The communications network service subsector is the largest IT subsector in the State of Iowa. The employment base of the subsector is 9,933 employees across 662 establishments. This level of employment represents 32.9 percent of all information technology employment. At the U.S. level, the industry subsector possesses a 23.4 percent share of total IT employment. Unfortunately, this large subsector has experienced a scaling back in Iowa in terms of its employment base, but this follows national trends.

Over the course of the past 3 years, the communications network service subsector exhibited a 4.3 percent average annual loss of employment. Nationally, the subsector demonstrated a drop in employment indicates an average annual rate of 5.2 percent. The subsector's marginally above-average performance in Iowa contributed to a strengthening employment concentration.

The communications network service subsector possesses an employment concentration rate that is 84 percent of the national average. This level of employment concentration in Iowa indicates an increase from the 2000 concentration level. The increasing concentration rate is the result of a stronger local performance.

The communications network service subsector in Iowa operates in a somewhat unique environment. Few national telecommunications providers have major operations in Iowa, making it possible for Iowa-based telecommunications companies to enter the market. This explains why this subsector constitutes the lion's share of total IT employment. Several of the state's major communications network providers built and operate diverse network architecture specifically to serve Iowa's unique communications needs. These state-based providers represent a substantial portion of the state's overall technology infrastructure.

The software and computer service subsector represents the largest share of establishments engaged in the IT industry in Iowa. With a strong employment base of 5,625 employees across 950 establishments, the software and computer service subsector accounts for 43.3 percent of all IT firms in Iowa. This mirrors the national trend, with software and computer services firms representing 58.8 percent of all U.S. IT establishments.

Despite the pervasive nature of the subsector, software and computer service firms tend to be small. Nationally, these firms employ an average of nine workers. Again, Iowa parallels this national trend. On average, establishments in Iowa employ six workers.

Between 2000 and 2003, this subsector demonstrated a declining employment base at the national and state levels. However, the United States illustrated a greater rate of loss. Software and computer services across the nation experienced an average annual loss of 5.1 percent. In Iowa, the subsector fell at an average annual rate of only 3.8 percent. In-depth analysis reveals that, over the last year, software and

computer services actually saw an employment increase of 596 employees. Although this is only one year of data, this may indicate an initial recovery for the industry subsector.

There are a variety of companies in Iowa engaged in software and computer system design and development. The depth and breadth of subsector activity is exemplified by the shear number of firms. Establishments range from companies developing software programs for education applications to companies designing computer systems and services for electronic funds transfer. The varying types of software solutions offered by these firms and the inherent diversity make it difficult to identify a specific market niche.

Communications and media equipment is the second-largest IT-equipment–related subsector. The subsector employs 903 individuals within 12 establishments, accounting for only 3.0 percent of total IT employment but representing more than 35 percent of the equipment segment. Nationally, the subsector possesses 3.8 percent share of total IT employment and 18 percent of the equipment segment. This indicates that communications and media equipment is a crucial piece of Iowa's IT-equipment segment.

Unfortunately, the communications and media equipment subsector experienced substantial loss of employment between 2000 and 2003. During this time in Iowa, employment fell by 11.2 percent annually. Though a large decrease in employment, it is in keeping with the national trend. In fact, the United States lost a greater share of its communications and media equipment employment base. Nationally, employment fell at an annual rate of 14.4 percent.

This employment loss leaves Iowa with a below-average employment concentration rate in the communications and media equipment subsector. Presently, the subsector holds an employment level that is 47 percent of the national average.

The communications and media equipment subsector is largely still experiencing the aftershocks of the "technology bubble" burst. During the late 1990s, communications providers made substantial investments in equipment to improve and upgrade network infrastructures. As the national economy began to wind down, equipment suppliers began to feel the repercussions of a slowing economy.

However, according to the Telecommunications Industry Association, "a turnaround is in sight for U.S. telecommunications equipment spending." Bottoming out in 2003, the network equipment market was predicted to grow by 2.3 percent to $14.4 billion for 2004. Bundled services such as on-demand TV are expected to generate and drive revenue growth, which will require new investment in equipment. This trend will lead to $18.5 billion in network equipment spending by 2007.[12]

Computer and peripheral equipment experienced the largest rate of growth relative to the United States, demonstrating a rise in employment between 2000 and 2003 in Iowa. In 2003, the subsector employed 508 workers across 10 establishments in Iowa. Although this represents a small portion of overall IT employment, computer and peripheral equipment grew by an annual average rate of 2.6 percent in Iowa. This rate of growth is quite significant in light of the national trend. During the same 3-year time period, the subsector at the U.S. level declined by 8.5 percent annually.

The better-than-average performance in Iowa has contributed to a rising employment concentration rate. The computer and peripheral equipment subsector rose from a 15 percent employment concentration rate to 21 percent. However, the level of employment concentration is still more than 75 percent below the national average. Care must be taken to support this fledging industry.

[12] Telecommunications Industry Association, P.A. Release 04-03/01.14.04: http://www.tiaonline.org/media/press_releases/index.cfm?parelease=04-03

It is difficult to say why the computer and peripheral equipment subsector in Iowa differed from the national trend. Industry investment into computing and networking systems has slowed since 2001, reducing orders for equipment. Yet, one industry in particular continues to upgrade system architectures. The financial service industry is constantly seeking faster and more efficient ways to manage funds and assets effectively.

The communications providers in Iowa also may be shielding the computer and peripheral equipment subsector. The fact that communications providers in Iowa are primarily independent and based in the state may be fostering a backward linkage to equipment suppliers. The state should cultivate these types of forward and backward linkages to help support and expand the overall computer and peripheral equipment subsector.

Media recording equipment is the smallest IT industry subsector and is substantially below the national average employment concentration rate. In 2003, the subsector employed only 91 people across 16 establishments. The subsector represents less than 1 percent of total IT employment. At the U.S. level, the subsector accounts for 2.1 percent of IT employment. Between 2000 and 2003, the subsector in Iowa did perform better than the nation. Media recording equipment lost 9.6 percent annually at the national level, whereas in Iowa the subsector lost 3.4 percent annually.

Even with an above-average performance, the subsector is sparsely concentrated. Composed of only a few small firms, the subsector holds an employment concentration rate that is only 10 percent of the national average. Examining average firm size further illustrates that the media recording equipment subsector in Iowa is undersized. Nationally, the average firm employs 37 people, compared with six people in Iowa. However, this subsector can be positioned as a valuable mechanism for the state to increase the capacity of its software base. As software developers offer pervasive commercial applications, the media recording equipment subsector could become the means for production and distribution.

Transitional

No Iowa IT subsectors were considered transitional.

Divergent

The media broadcast service subsector possesses the second-highest employment concentration rate in Iowa's IT industry. The subsector has a considerable employment base of 3,050 workers across 154 establishments. This level of employment represents 10.4 percent of total IT employment in the state. Nationally, the media broadcast service subsector accounts for only 7.8 percent of IT employment.

Though not considered a regional specialization in Iowa, the media broadcast service subsector holds an employment concentration rate that is 86 percent of the national average. Unfortunately, Iowa's level of concentration has dropped from 95 percent in 2000.

Between 2000 and 2003, the media broadcast service subsector in Iowa experienced above-average employment losses. Over the 3-year period analyzed, Iowa's employment base fell at an annual rate of 4.9 percent. Across the United States, the subsector demonstrated a 1.5 percent rate of annual employment loss. The sizable employment loss in Iowa caused the drop in the state's concentration rate. The state must find ways to reverse this trend in order to reposition this important subsector.

As demand for digital content has risen, so too has competition in media markets. This may be a contributing factor to rising competition and consolidation to control management and access to content. Media communications companies are continually vying for increasing market share and control of media

broadcast networks. As a smaller media outlet, it is increasingly difficult for local media companies in Iowa to achieve economies of scale.

New standards for digital media and a market driving demand for bundling of voice, video, and data are altering local media markets. Industry experts have coined the phrase that "content is king" and therefore will drive markets. This trend has affected the media broadcast service subsector across the nation and in Iowa, creating a highly competitive and volatile market. This has led many industry analysts to believe that content on-demand will be one of the next major drivers of the IT industry.

Semiconductor and electronic components experienced the greatest rate of employment loss, more than any other IT subsector. In 2003, the semiconductor and electronic component subsector employed 1,099 individuals across 33 establishments. This level of employment represents a 15.8 percent annual loss of employment. Although this follows the general trend at the national level, the rate of loss across the United States was not as large. Nationally, employment in semiconductor and electronic components fell at an annual rate of 11.8 percent.

The semiconductor and electronic component subsector is well below the national average employment concentration rate and has eroded since 2000. The subsector's level of employment concentration has fallen from 24 percent to 21 percent of the national average. This is troubling, given that the semiconductor and electronic component subsector plays a crucial role in the IT-equipment–related industry segment. If Iowa seeks to increase its IT-equipment segment, the state needs to better understand the unique situation facing semiconductor establishments in order to reposition this subsector. Access to global markets is a key issue.

The semiconductor and electronics component subsector in Iowa, however, is small in global terms. This complicates access to global markets for Iowa, which faces very heated global competition. According to the Semiconductor Industry Association, "the electronic equipment and semiconductor industries have evolved into a truly global market."[13]

Manufacturers in Iowa must be agile and flexible to confront the offshoring of manufacturing and growth of global end markets. Asia has become not only a source of low-cost semiconductor assembly and low-end consumer electronic products, but also a growing end market for sophisticated electronics.

The global economic downturn of 2001 was due in part to an excess world inventory. In the future, the Semiconductor Industry Association predicts that semiconductor suppliers will need to refine their view of global markets, as devices will need to support such uses as MP3 players, text messaging, and picture cell phones. Iowa's ability to answer these global challenges will determine the level of success that the semiconductor and electronic component subsector has in the state.

Information Technology and Subsector Wages in Iowa

Analysis of Information Technology Wages

The IT industry in Iowa contributes more than $1.2 billion to the state's economy in the form of wages. This accounts for 3.5 percent of total private sector wages in Iowa. Nationally, the IT industry represents a greater share of total private sector wages, accounting for 7.1 percent. However, nationally, total wages have fallen at an average annual rate of 7.8 percent. The rate of decline in Iowa was much less, with total

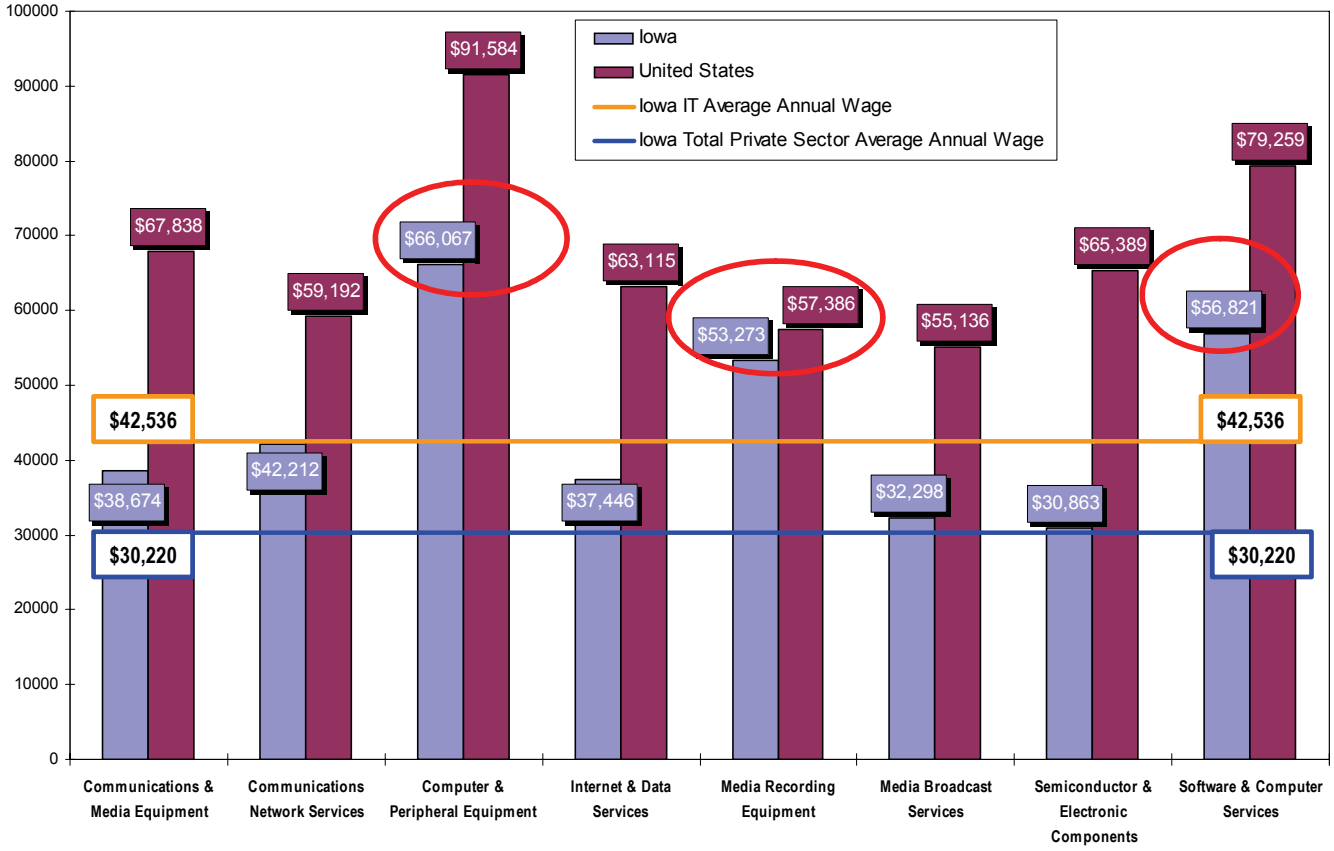
[13] The Semiconductor Industry Association (http://www.sia-online.org/iss_economy.cfm)

IT wages decreasing by only 3.3 percent annually. This may indicate that, relative to the nation, Iowa has been better able to maintain its share of higher-wage IT employment.

Iowa's IT industry is a good source of high-paying jobs relative to the state's total private sector. The average annual wage per employee for Iowa's IT industry is $42,536 (Figure 5). This is more than $12,000 above total state private sector wages and is growing. Between 2000 and 2003, average annual wages grew by 2.6 percent versus a 1.0 percent decline nationally.

Though above total state private sector wages, IT wages in Iowa are below the U.S. average annual wage per employee. Nationally, the IT industry as a whole pays an average of $68,582 per employee.

Figure 5: Information Technology Subsector Average Annual Wages per Employee in Iowa, 2003



Analysis of Information Technology Subsector Wages

Analyzing the average annual wage per employee for each subsector illustrates critically important aspects of the IT industry. This analysis helps to pinpoint subsectors that provide a relatively high wage and indicates the potential of the overall industry to add high value.

The software and computer service subsector pays the second-highest wage. At $56,821, the software and computer service subsector is the only subsector in the IT-service segment that possesses an average annual wage per employee above the Iowa IT average annual wage. This indicates that the subsector is one of the highest value-adding industries within the state's overall IT sector.

In addition to a higher relative wage, the software and computer service subsector represents a sizable portion of the IT industry, accounting for 19.2 percent of total employment. High wages combined with a large employment base positions the software and computer service subsector as a critical piece of Iowa's overall IT industry.

Two of the highest-paying subsectors in Iowa's IT industry, computer and peripheral equipment and media recording equipment, are part of the IT-equipment segment. Computer and peripheral equipment is the highest-paying subsector in Iowa, with an average annual wage of $66,067 per employee. Though below the U.S. subsector average annual wage, the subsector is substantially above both the total private sector annual wage and the overall IT average annual wage.

Media recording equipment ranks above the state IT average annual wage, paying nearly as much as the U.S. subsector. In 2003, the average annual wage for the media recording equipment subsector was $53,273 in Iowa. This is only about $4,000 less than the U.S. subsector average. Though high-wage subsectors, both media recording equipment and computer and peripheral equipment possess rather minor employment bases.

The relatively high average annual wages per employee for these subsectors suggest that these subsectors add high value. By targeting business development initiatives and job creation efforts at high-paying subsectors, the state can concentrate on those segments that add the highest value and potentially raise the overall industry annual average wage per employee.

The majority of Iowa's IT industry is below the average annual wage. Combined, the five remaining subsectors account for 78.8 percent of IT employment but have an average annual wage per employee that is only $38,553.

IT wages in Iowa, while higher than the statewide private sector average, are below the national IT average annual wage per employee. This may indicate a cost advantage in Iowa. IT business seeking to expand in Iowa or relocate to the state could potentially experience labor cost savings by establishing an Iowa presence. This also benefits the state by providing jobs that pay above statewide average wages. So, this cost differential helps to encourage the retention and expansion of existing companies as well as to attract and begin new ones.

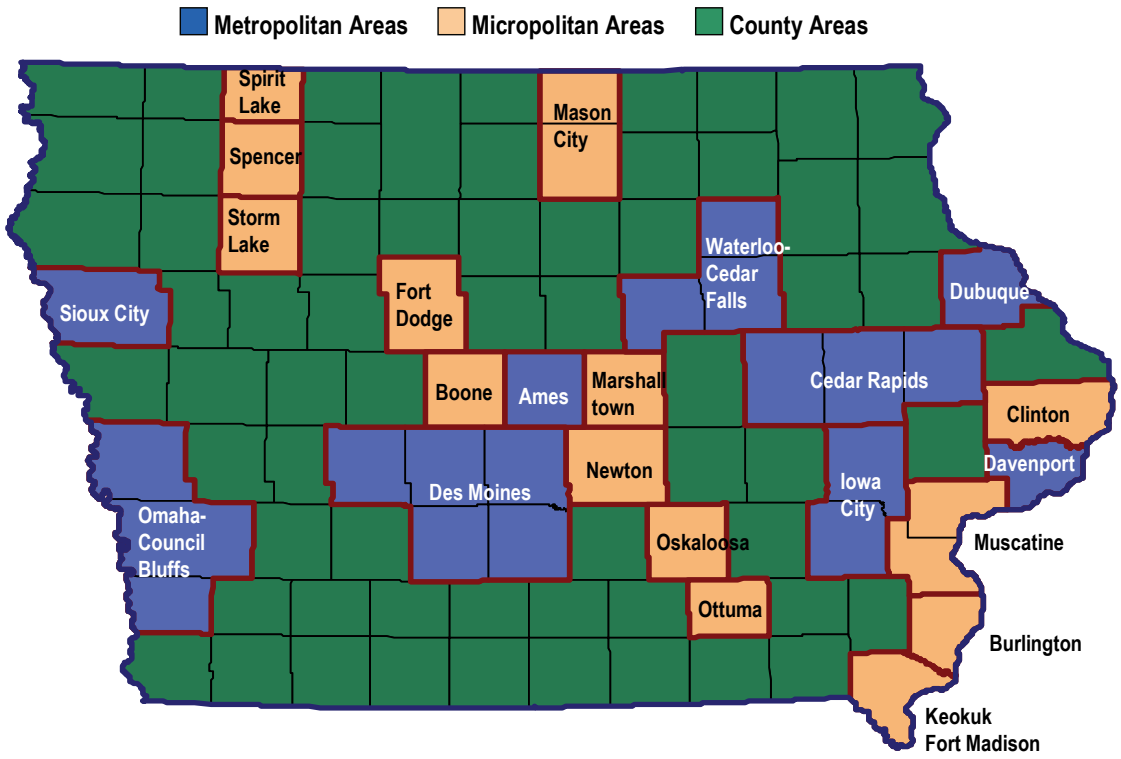
State leaders must, however, proceed with caution. The cost differential will not spur development indefinitely. As a critical mass of companies is achieved, the cost advantage will likely dissipate, reaching a point of equilibrium. Leaders and officials must seek a comprehensive development strategy for the IT industry in Iowa.

INFORMATION TECHNOLOGY GEOGRAPHIC DISTRIBUTION

Metropolitan, Micropolitan, and County Areas in Iowa

The geographic distribution of Iowa's IT industry is illustrative of the diverse economic impact the industry has on the state. The spatial allocation of employment and establishments across metropolitan, micropolitan, and county areas illustrates that different regions of the state specialize in different aspects of the IT industry (Figure 6). [14] Recognition of this distribution will better enable economic development professionals to structure initiatives to target the IT industry across Iowa.

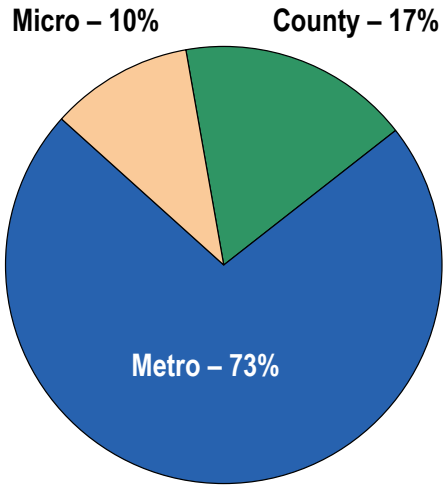
Figure 6: Iowa and Associated Metropolitan and Micropolitan Areas



[14] A metropolitan statistical area or a micropolitan statistical area is an area containing a recognized population nucleus and adjacent communities that have a high degree of integration with that nucleus. Each metropolitan statistical area must have at least one urbanized area of 50,000 or more inhabitants. Each micropolitan statistical area must have at least one urban cluster of at least 10,000 but less than 50,000 population.

The metropolitan areas of Iowa represent the majority of the state's IT industry, according to county-level data obtained from ES-202 data from Implan (Figure 7). The metropolitan areas account for more than 20,800 employees. Approximately 73 percent of all employment in the IT industry in Iowa is in metropolitan areas and is primarily IT-service oriented. This is not surprising given that metropolitan areas accounted for 54 percent of the state's population in 2003.[15]

Figure 7: Information Technology Employment Distribution across the Regions of Iowa



Source: Battelle calculation based on ES-202 data from the Minnesota Implan Group, 2003

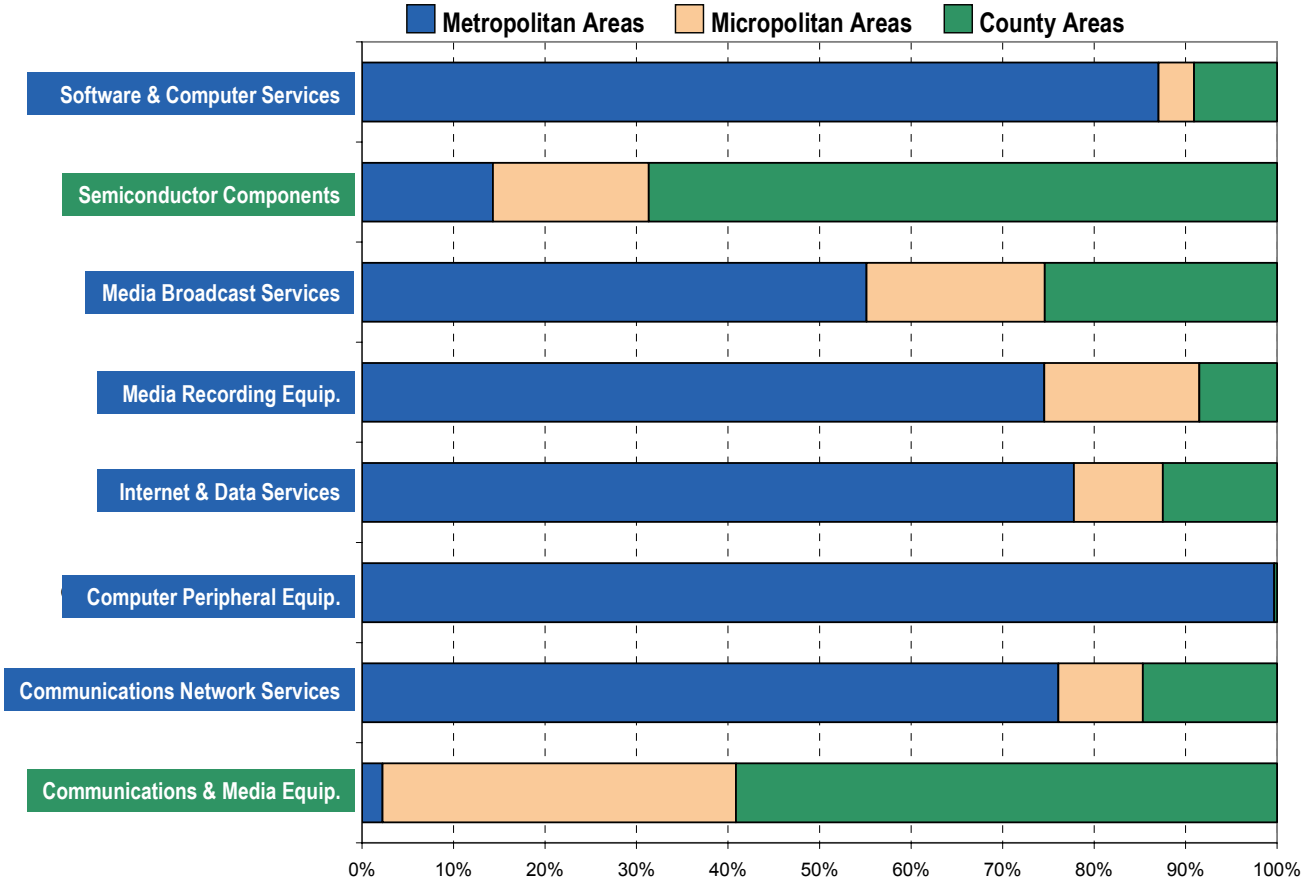
Service-related IT employment in Iowa is concentrated in major metropolitan areas, meaning that the top-performing IT subsectors that are service related are based in the urbanized regions of Iowa (Figure 8). More than 75 percent of Internet and data services, communications network services, and software and computer services are located in metropolitan regions. In fact, service-related employment accounts for 96 percent of all IT employment in metropolitan areas.

Iowa's micropolitan areas, combined with the state's remaining nonmetropolitan areas, account for 27 percent of IT employment. Further analysis demonstrates that IT-equipment employment, though a smaller share of total IT employment, is concentrated in these areas. Micropolitan areas and nonmetropolitan counties represent the majority of IT-manufacturing jobs. Accounting for 1,804 employees, these regions of Iowa represent 71 percent of all IT-manufacturing employment.

Semiconductor and electronic components as well as communications and media equipment are mostly concentrated in nonmetropolitan areas of the state. Though a relatively small share of total overall IT employment, these subsectors constitute 22 percent of nonmetropolitan IT employment in Iowa.

[15] Annual Estimates of the Population for Counties of Iowa: April 1, 2000, to July 1, 2004 (CO-EST2004-01-19). Source: Population Division, U.S. Census Bureau, April 14, 2005.

Figure 8: Distribution of Subsector Employment across Iowa, 2003



Source: Battelle calculation based on ES-202 data from the Minnesota Implan Group, 2003

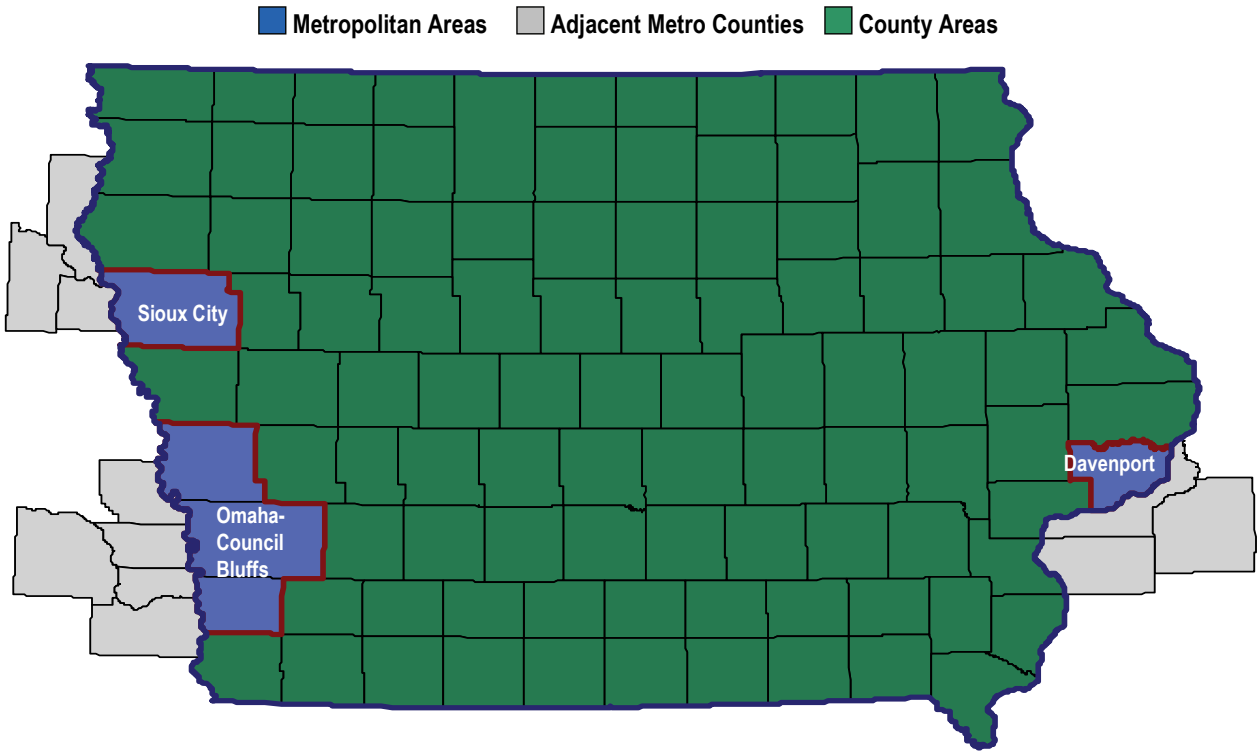
Adjacent Metropolitan County Employment

Three metropolitan statistical areas in Iowa are part of a region that extends beyond the state boundary (Figure 9). The Sioux City metropolitan statistical area encompasses one county in Iowa, one county in South Dakota, and two counties in Nebraska. The Davenport metropolitan statistical area includes one county in Iowa and three counties in Illinois. The Omaha-Council Bluffs metropolitan statistical area contains three Iowa counties and five counties in Nebraska.

Adjacent metropolitan area counties roughly account for an additional 21,000 IT employees. This equates to more than half the size of Iowa's entire IT industry, which employs 29,279 workers statewide. The Nebraska counties that make up the Omaha-Council Bluffs metropolitan statistical area represent a large IT-industry component outside of Iowa. Omaha, Nebraska, is home to companies such as First Data Corporation and several other data processing centers related to Mutual of Omaha.

The IT industry strength in Omaha, Nebraska, presents Iowa with an opportunity to grow. Developing collaborative initiatives with Nebraska will help bolster Iowa's IT industry within the Omaha-Council Bluffs region. Furthermore, leveraging the success of Omaha, Nebraska, may potentially provide a model for Iowa to apply to other regions within the state.

Figure 9: Metropolitan Areas of Iowa Associated with Counties of Adjacent States



This analysis clearly illustrates that the economic reaches of Iowa's IT industry stretch beyond the reaches of the state's borders. Therefore, as Iowa moves forward to strengthen the IT industry, it must be recognized that state officials will need to coordinate with neighboring states. Economic development and commerce do not cease at the state line. Given that metropolitan area counties in Iowa represent the lion's share of the state's IT industry, this means interstate commerce and connectivity could play a significant role.

SUMMARY

The IT industry in Iowa is an important industrial sector for the state's overall economic well-being. The industry demonstrates resiliency despite challenging economic conditions. In the face of a national economic downturn that began in 2001, the IT industry in Iowa continues to be a source of economic stability with growing GSP, above-average wages, and supportive services and infrastructure for other industrial sectors. Key findings include the following:

Recovering from a national economic downturn, Iowa's IT industry surpassed the U.S. average trend. Although the industry has not grown, IT employment in Iowa fell at a slower rate than it did in the nation. The better-than-average economic performance indicates that Iowa possesses the capacity to increase its industry positioning. While Iowa is not considered a major leader in the industry, the state has preserved its status.

The strength of Iowa's IT industry is based in the IT-service segment. The large IT-service segment of Iowa is the basic foundation of the IT industry in the state. Internet and data services, communications network services, and software and computer services constitute 81 percent of all IT employment. Slightly ahead of U.S. trends, these three subsectors compose the backbone of Iowa's IT industry.

Several major industrial sectors depend on the IT services and infrastructure—finance and insurance and manufacturing. The service-related IT segment holds its dominant role in Iowa in part because of the state's diverse economy. Several major industrial sectors depend on the IT services and infrastructure provided by this segment. Finance and insurance and manufacturing each rely on the communications and information networks to contact customers as well as manage and deliver various products and services. The state is presented with an opportunity to strengthen these interindustry connections and expand the IT industry, simultaneously advancing the competitive position of these ancillary industrial sectors.

The smaller equipment-related IT sector must be strengthened and leveraged in order to support the IT-service infrastructure of Iowa. The equipment-related IT segment is part of the emerging base. Equipment-related subsectors outpaced U.S. average growth significantly and typically pay the highest IT wages. In fact, communications and media equipment and computer and peripheral equipment are strong promising industries that have led above-average performance.

Iowa's Competitive Position in Information Technology

In this section of the report, general trends in the U.S. IT sector are discussed first, including how they may impact Iowa's IT development and direct analysis toward areas of opportunity. This discussion is followed by a specific assessment of Iowa's comparative IT position against four benchmark states**:** Colorado, Georgia, Indiana, and North Carolina.

NATIONAL INFORMATION TECHNOLOGY TRENDS

As Iowa begins to set a vision and establish a course of action for advancing its position in IT development and services, it is important to recognize the broad national and global trends underway.

The IT sector is characterized by fast-paced innovation and high levels of competition. The RAND Corporation predicts that "the pace of technological change . . . will almost certainly accelerate in the next 10-15 years, with synergies across technologies and disciplines generating advances in research and development, production processes, and the nature of products and services."[16] Change brings opportunity—opportunity for Iowa to use its research and development (R&D) resources, educational and IT-sector skills, infrastructure, and corporate base to achieve strong positions in new and emerging technologies and applications in IT.

As technology, and specifically information technology, advances, certain key trends are likely to move to the fore. These likely trends should be considered in relation to Iowa's strengths and challenges, highlighted elsewhere in this report, in formulating Iowa's IT Strategic Roadmap. Some of the key trends predicted include the following:

- **Human/Technology Interaction—**Whatever the term used (be it usability, interfacing, human-computer interaction), there is a clear trend toward R&D and associated products aimed at simplifying and streamlining the interface between humans and the information technology they must increasingly use. In addition to simplifying the interface, complex datasets also lend themselves to manipulation through highly advanced visualization, haptics, virtual reality (VR), and three-dimensional (3-D) modeling technologies that are emerging.
- **Information Security and Integrity—**Because reliance on data and information systems is central to economic, business, and governmental functions, extremely serious consequences stem from breaches in data integrity, reliability, and security. Because of the threat to both internal and external security, applications, services, and equipment that are designed to assure data security and accuracy will experience increasing demand.
- **Software and Systems Testing**—Today's software applications typically run to millions of lines of code. In this environment, there is an increasing challenge in assuring reliable, bug-free applications. The challenge will, however, become more complex. Bell Labs notes that today's testing and debugging tools "support a style of programming that is at odds with the needs of the types of applications that will soon dominate. They provide good support for the development of sequentially

[16] RAND Corporation, *The Future at Work—Trends and Implications*, 2004.

executing code, but have only limited support for multi-threading and concurrency. Today it is almost impossible to test or to debug a truly distributed application."[17]

- **Data Processing Power**—New IT applications, such as bioinformatics, are generating datasets of truly immense size and complexity. Given the value of information, the ability to mine these huge datasets for novel insight, protectable intellectual property, or simply information that provides efficiencies or competitive advantage is becoming of preeminent commercial importance. Access to high-performance computing is becoming an increasingly important differentiating factor.
- **Data Acquisition and Input**—Gathering data inputs for IT systems places demands on a range of data acquisition and input technologies. Growth is anticipated in sensors in a range of applications providing automated data gathering and reporting. The real-time collection of data via biosensors, national security environmental sensors, microclimate sensing devices, and a host of applications will generate huge volumes of data. In human data input, use of real-time voice recognition and transcription will be more widespread.
- **Data Storage**—Demand for greatly enhanced data storage capacity and increased speed of access/retrieval, together with 100 percent reliability and redundancy of stored data, will accompany the pressures on processing power. As data are accessed more frequently over large-scale networks, the reliability and redundancy of those networks will be equally important.
- **Data Transmittal**—More data, requiring higher processing speeds, accessed over networks, means that data transmission and associated communications systems have the potential to become bottlenecks. Complex multimedia IT applications will require transmission of high-resolution imagery and full-motion video in addition to standard data streams. Development of, and access to, high-performance data transmission networks will be a crucially important IT development and usability determinant.
- **Wireless IT—**Wireless technologies have been around for several years; but, as network backbones become more robust, integration of wireless communications will reshape the computer industry and society, no longer binding computers (by wires) to homes, offices, or buildings. Improvements in data compression and transmittal technologies will be required to allow for even larger amounts of information to be squeezed through limited bandwidths with the necessary phenomenal speed.
- **Changes to Business Processes—**IT applications and hardware have transformed workflow and business processes over the past decade. Mainstream corporations have established strategic goals to migrate toward "paperless" operating environments and are reengineering business and workflow processes to accommodate the change. The move toward integrated computer-based business processes brings opportunities and demand for specialized portable devices, wireless operability, high-security data transmission, and high-reliability systems.
- **Integrated Design and Production Systems—**For highly developed economies, such as the United States, to maintain competitiveness in the global market, it is imperative that production processes be as productive as possible. In a high wage U.S. environment, this means that computer-integrated automated design, fabrication, and assembly equipment will be required to maintain the necessary level of productivity. Applications and equipment in computer-aided design, computer-aided manufacturing, and associated technologies such as robotics will continue to advance. High-flexibility

[17] Holzmann, Dr. Gerard J. "The Future of Software: the reliability of interaction," Bell Labs, Lucent Technologies, http://spinroot.com/gerard/future00.html.

systems able to rapidly produce short-run, highly customized products will also see increasing demand.

- **Satellite Communications Systems—**Since the 1950s, satellites have become central to multiple communications and information service processes. The rapid pace of globalization, combined with the promise of new work opportunities through IT in remote locations (such as much of the third world) will greatly accelerate satellite demand, applications development, and associated technologies. Satellite phones and high-bandwidth satellite data transmission and broadcasting are likely to win on the world stage over fixed fiber and wire infrastructures. Geographic data, facilitated by the global positioning system, will also add greatly to the amount of information attached to specific data records.
- **Collaborative Communications—**Video teleconferencing and associated IT provide distance-shrinking communications capability. Business uses such communications technology to facilitate work-group interactions, while distance education and telemedicine applications have been developing rapidly. Given the promise contained within enhanced collaborative communications, a consortium being led by 207 universities, working in partnership with industry and government, is working to develop "Internet2" with the goal of developing greatly enhanced networking capabilities, novel applications, and improved capacity.[18] It will be a test bed for advanced technologies like digital video, multicasting, and distributed storage.

> Convergence of technologies is allowing users to access and exchange information and content in ways that were not possible before. Industries such as media and communications that once had clearly defined boundaries are seeing business models converge and perhaps collide as technologies change the possibilities. Change is painful and absent a clear solution, many companies will choose to defend the current business model rather than exploit new opportunities.
>
> Gartner, Inc., *One Gigabit or Bust Initiative: A Broadband Vision for California,* prepared for the Corporation for Education Network Initiatives in California, May 2003, p. 6.

- **Knowledge Management—**Technology provides the platform for creating, disseminating, and storing enormous amounts of data. Adding effective business processes and capabilities to manage and make that data accessible turns "data" into information. Most definitions of knowledge management state that it is a discipline that promotes an integrated and collaborative approach to the process of information creation, capture, organization, access, and use. Information alone has economic "potential"; but, realizing that potential requires quality analysis and decision making in using the data, facilitated by modern IT applications and infrastructure. Ultimately, knowledge management is centered on realizing the promise of IT to (1) speed business processes (enhancing productivity), (2) reduce or eliminate non–value-added work and errors (lowering costs), and (3) leverage information to generate knowledge that provides a market edge (enhanced competitiveness).

It is also notable that IT facilitates advancement in a wide range of other scientific and R&D disciplines. IT, for example, empowers bioscience discoveries in genetics, proteomics, biomedical imaging, and multiple areas of the life sciences. Indeed, the biosciences and computer sciences are converging in the prospect of bio-based computer systems. Similarly, IT and materials science continue to converge as work is conducted in superconducting materials, ceramics, and nanomaterials. It is virtually

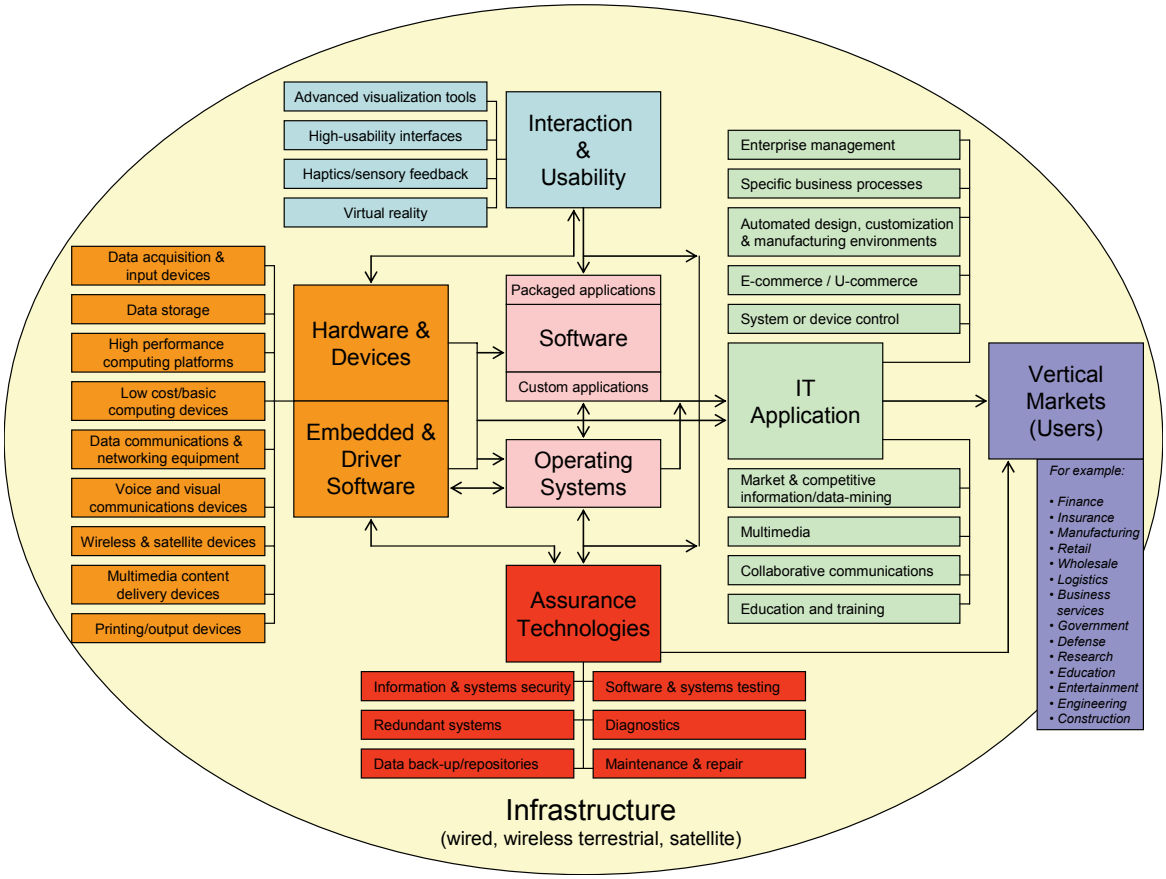
[18] http://www.internet2.edu/about/

impossible to find an area of science that has not been greatly advanced through the application of computing and information technologies.

These trends suggest that large-scale opportunities for economic development may exist in a broad range of IT fields—hardware, software, information security, systems usability, and applications development—and also in the application of IT to enhance R&D and commercial and public enterprise. The challenge is to identify the opportunity areas at the individual state or regional level.

The IT industry and IT-related economy is highly complex and characterized by multiple interactions and co-dependencies. That said, it is important to attempt to provide an overall picture of the broad IT sector in which Iowa has activity and opportunity. Figure 10 is a generalized overview of the IT realm (not intended to be an exhaustive listing of all IT and IT applications) showing major components to include hardware and the embedded code within hardware devices, operating systems and software, human-computer interaction tools, systems security and assurance technologies, and the application of these systems and tools to specific IT functions within multiple vertical markets. These "market" activities are supported by the overall communications infrastructure.

Figure 10: Generalized Information Technology Environment and Market Characterization



Some of the trends discussed may proceed incrementally, but most will likely happen in quite radical bursts of innovation and adoption. The complexity of the IT environment and its opportunities will certainly require that Iowa's IT strategy be developed with consideration to both near-term and long-term components.

Converging Communications, Computing, and Content

Contained within the trends discussed above is an underlying theme—that of "convergence." Convergence is taking place between communications, computing, and content—providing opportunities and challenges for new technologies and applications. The rapid deployment of the Internet, increased broadband capacity, mobile communications, and smaller and smaller computing devices are introducing an age some have called "ubiquitous networking" where communications, computing, and content generation are coming together.[19] In today's world, anyone can access rich content and/or communicate anywhere and at any time via high-speed and always-on networks using a diverse range of devices such as mobile phones, personal digital assistants, televisions, information appliances, car navigation systems, and, of course, personal computers. With the advanced use of smart agent software, sensors, and radio frequency (RF) tags, the ability to remotely manage and monitor operations from inventory control to equipment maintenance to home security is quickly approaching. This convergence has applications to the needs of industry, commerce, health care, education, government, and consumers. PriceWaterhouseCoopers (PWC) explains as follows:

> To date, the component segments of the information, communications and entertainment market have operated largely in parallel, each defined essentially in supply side terms, with their own distinct definition of the end-customer: television is marketed to viewers and subscribers, fixed telephony to subscribers, radio to listeners and print to readers and so on. The fact that these people are one and the same has not yet shaped the marketplace, but it soon it will.[20]

This convergence of communications, computing, and content generation is now blurring the boundaries of industries. For example, telephone and cable companies are increasingly vying to provide similar services, with both offering broadband access to the Internet and, with the rise of voice-over-Internet protocol technology, basic voice communications. The separate devices of telecommunications, computers, and media/entertainment electronics are overlapping, in both uses and production. Mobile phones now offer both voice and data capabilities. Entertainment electronics makers now produce computers, and computer equipment manufacturers now offer multimedia devices such as MP3 players and televisions.

What may emerge from this convergence is the rise of what PWC calls the "hyper-connected" individual who has integrated services provided across formerly discrete services of telephone, Internet, and television, saving time and reducing inconvenience. New opportunities will be opened to support shopping, health care, education, and managing personal affairs. The emergence of the hyper-connected individual will change the nature of business activity in information, communications, and entertainment, according to PWC, focusing competition on the more horizontal business activities of consumer relationship management, transport, and applications/content.

[19] For an in-depth discussion of ubiquitous networking, see Murakami and Fujinuma, "Ubiquitous Networking: Towards a New Paradigm," Nomura Research Institute, April 2000.
[20] Christopher Mole et al., "The New ICE Age: Focusing around the individual," PriceWaterhouseCoopers, 2002, p. 5.

Reaching Across Industries, Redefining Commerce

The new IT era also differs from the rise of dot-coms and the technology boom of the late 1990s because it reaches far beyond just a handful of companies and industry niches. Industry upon industry is now being affected by the application of new information technology. UPS uses the Internet to help customers track their shipments and even manage client inventories. Wal-Mart is well known for its advanced, computerized supply-chain and inventory management systems and is now requiring its suppliers to use RFID tags to track all of their products. Delta Airlines now enables cell phone and personal digital assistant users to access arrival and departure information through mobile communications. In-car data systems record vehicle operating parameters and provide diagnostics and other tools for manufacturers that facilitate both vehicle maintenance and the development of the next-generation vehicle.

The opportunities for more traditional businesses are also significant. With the advent of ubiquitous networks, businesses no longer will be bound by physical locations and their interactions with customers will profoundly change as the use of computer/network-driven technology becomes pervasive.

Management faculty members at the University of Georgia, for example, are advancing a new business model concept termed "ubiquitous commerce" or "U-commerce." This model poses the use of pervasive networks of rich, multimedia content to support personalized and uninterrupted communications and transactions among firms, customers, suppliers, and other stakeholders. This concept of ubiquitous commerce will provide a level of value over, above, and beyond traditional commerce.[21] Imagination and market research are needed to determine profitable services enabled by ubiquitous networking across nearly all industries and activities.

Focusing on Applications

Realizing the commercial promise of convergence requires a strong focus on applications development. Gartner predicts that breakthrough applications for next-generation broadband will allow the simultaneous transmission of audio, video, images, and data for multiple participants in real-time over long distances.[22]

F. Duane Ackerman, Chairman and Chief Executive Officer (CEO) of BellSouth, believes the opportunity for start-up companies in telecommunications is found in "applications, applications, applications." He notes, "Who would have believed that downloading ring tones would be a $2.5 billion market?"

But, many of the applications changing daily lives will also be specific to particular devices. Using the cell phone as an example, Red Herring reports that the imminent arrival of high-value applications for mobile phones will launch computing and communications into the next era. While it is not clear what the next killer application will be, Red Herring suggests that the general nature of the application concepts are known, will be deployable within the next 2 to 3 years, and have the potential to assist all human interaction. The applications and services that result will shift billions of dollars into new markets and create an entirely new competitive landscape.[23]

Ultimately, the focus on applications will establish an entirely new way for individuals and organizations to use communications, computing, and content technologies.

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[21] Watson et al., "U-Commerce: Expanding the Universe of Marketing," *Journal of the Academy of Marketing Science,* Volume 30, No. 4, 2002, pp. 329–343.
[22] Gartner, "One Gigabit or Bust Initiative: A Broadband Vision for California," prepared for the Corporation for Education Network Initiatives in California, 2003, p. 11.
[23] Winarsky, Norman, "The Quiet Boom," Red Herring Innovation, Capitalization Report, January 2004, pp. 15–16.

The adoption of advanced technology, the degree to which companies and other user groups have invested in IT, and the geographic distribution of IT enterprise are far from uniform within the United States. As with other industries, e.g., steel manufacturing, automobile assembly, aerospace, insurance, etc., IT enterprise grew first in places with comparative advantages (such as focused research universities and early-stage successful start-up enterprises and innovators). Large clusters of IT expertise have formed in places such as Silicon Valley, Austin, and Boston. Content expertise clusters exist in Los Angeles, New York, and Atlanta. However, as with other industries, areas of IT expertise have diffused across the country (and in many cases across the globe). IT has reached a level of ubiquity whereby any decent-sized community may have firms focused on the provision of IT services, communications services, and the development of IT components or software.

IOWA COMPARED WITH THE BENCHMARK STATES

Purpose of Benchmarking

Benchmarking, which is commonly undertaken in the corporate and financial communities as a way of improving efficiency and calibrating performance, is just as important in planning for technology-led economic development. Benchmarks allow one to identify, analyze, and draw useful lessons from the practices of other communities. Benchmarking can help in the following:

Identifying the competition. Benchmarking forces a community to identify clearly the kind of region against which it competes for business investment in the targeted sectors. Benchmarking forces planners to examine in a broad, qualitative way who is pursuing similar strategies and how they are succeeding or failing. This may yield important insights into how the competitive landscape looks to those in business who make decisions on locational investment.

Isolating the strategic issues. To design a regional strategy for technology-led economic development, any region must understand what its key choices are and how various potential uses of resources trade against each other. Examining how competing regions have positioned themselves can give insight into what strategic choices must be made in view of the home region's strengths and weaknesses, and the opportunities and threats posed by the broader marketplace.

Figuring out what works. There is no point in reinventing the wheel. Strategies and initiatives that work in other regions facing similar challenges can often be adapted to local conditions, avoiding the risks of investing in entirely untried approaches.

Selection of Benchmarks

The widespread adoption and development of IT means that multiple locations can serve as examples to Iowa in terms of IT strategy development and achievements against which Iowa's comparative performance may be benchmarked. As Iowa considers how to respond to national and global opportunities and trends, it is important to consider how other leading states have advanced their development and are positioning themselves today.

For benchmarks to be useful, they must share at least some common features. Although no community will be like Iowa in all respects, a balanced representation can be achieved across the entire set. In early discussions with Battelle, the IDED indicated interest in a range of benchmarks that span regional peer competitors in the Midwest, leading IT states, and those with active programs to develop the cluster. In consultation with the project steering committee, four states were selected for comparison to Iowa for IT benchmarking: Colorado, Georgia, Minnesota, and North Carolina. (The latter state also was selected for

the concurrent advanced manufacturing benchmark exercise as part of the development of the Iowa Advanced Manufacturing Strategy or Roadmap.)

Summary of Findings by Benchmarked State

Colorado

- IT development exploits historic strengths in hardware, software, and content—but mainly the desire of IT professionals to live in the Mountain region.
- Computation expertise at federal laboratories (**National Institute of Standards and Technology [NIST]** and **National Oceanic and Atmospheric Administration [NOAA]**, both dating to the 1950s) helped bring **IBM** to the region (1965), and IBM alumni formed **StorageTek**. This began a data-storage cluster that attracted branch operations from other firms and eventually expanded "outward" technologically to include photonics and optical computing/communications.
- A parallel history in cable television (predecessors to **Liberty**) and telecommunications (**Qwest**) caused a brief campaign to brand the region as the "convergence corridor."
- For a time, the University of Colorado and Colorado State University were funded through the "Colorado Advanced Technology Institute" to conduct industry-relevant R&D (e.g., in data storage and optical computing), but state support for these efforts ended a decade ago. Programs established in that era carry forward on their own momentum, taking their direction from where funding is available.
- At the height of the IT boom, the state created an industry-funded **Colorado Institute of Technology (CIT)**, a very different vehicle to create new curricula and generate graduates along cross-cutting themes: enterprise systems, digital media, global telecommunications, bioinformatics, and homeland security.

Georgia

- Georgia Tech's long history of industry engagement made the region friendly to the telecommunications sector. Key anchor **Scientific Atlanta** was formed in 1952 by Tech researchers who left to pursue commercial interests, and many others followed.
- IT was one of three sectors championed for a decade by the **Georgia Research Alliance (GRA),** a public/private board that allocated $400 million in state funds over a decade to Eminent Scholars, umbrella research facilities (e.g., the **Georgia Center for Advanced Technology and Communications**), and commercialization initiatives (**VentureLab** and the **Advanced Technology Development Center [ADTC]** incubator).
- Over the last decade, there was a specific focus (the **Yamacraw Initiative**) on recruiting firms interested in partnering with Tech on design of chips for broadband. Over the years, many chipmakers with interest in communications have located labs nearby. Examples include **National Semi, Broadcom, Nortel, Cisco,** and **Anadigics.**
- Now the state and GRA are collaborating on a broader strategy for **Communications, Computing, and Content (C3),** spanning Georgia Tech, Georgia State University, and the University of Georgia at Athens.
- The strategy focuses on building on these successes and attaining "critical mass" especially by expanding models proved at Tech to the entire public university system, funded with sufficient resources.

Minnesota

- The legacy of the mainframe and supercomputing era of the 1950s through 1980s (e.g., **Honeywell**, **Control Data** and later ventures like **Cray**) was a trained IT workforce that did not want to leave Minnesota and found other ways to stay employed after this era ended.
- The state, however, never adopted a specific IT strategy, and its university partnership programs have largely atrophied. The last major investment by the state in the University of Minnesota (UMN) in this area was a **Digital Technology Initiative** in 1998, including support for faculty and a new building but not operations.
- Eventually, the independent software, Internet, and Java associations joined a multisector **Minnesota Technology Council** where their interests sometimes seem secondary to those of the bioscience sector.
- Software is increasingly seen as a sector that can thrive in the state's rural areas without a necessary connection to the university itself, and a broad network of small-scale and community-oriented venture capital funds are available to finance these "outstate" deals.

North Carolina

- The state's original strategy focused on the **Microelectronics Center of North Carolina (MCNC),** founded in the 1980s to pursue this sector by supporting collaborative research. However, as Austin emerged as the national leader, MCNC migrated to a focus on advanced materials, for both telecommunications and power applications, exploiting particular strength at NC State University.
- MCNC no longer receives any state resources, and its remaining programs (except for a venture fund capitalized by exits from advanced materials deals) were recently acquired by the **Research Triangle Institute**, a nonprofit R&D institute created in the 1950s as one of the initial anchors for the **Research Triangle Park (RTP)**.
- In the Triangle, the hardware part of the IT sector is represented by R&D operations of the manufacturers of telecommunications equipment, such as **Nortel, Cisco,** and **Sony-Ericsson.** All these centers arrived in the park long after the initial IT tenant, a manufacturing and development center for **IBM** (1965).
- Software is represented by **Red Hat Linux**, which, after the IT boom, moved into a building on the NC State **Centennial Campus** that had originally been designed for Lucent, taking advantage of trained students in the NC State **Engineering Research Center**.
- In Charlotte, IT development has taken a different emphasis. Civic leadership supported development of research capacity at University of North Carolina at Charlotte through a **Charlotte Research Institute**, which focuses on two IT subsectors: optical communications (recognizing the regional presence of **Corning** and **Commscope)** and e-business, serving the banking sector (Wachovia, Bank of America) and also competing with it (**lendingtree.com**).

Strategy Environment Comparison

The state showing the strongest growth in IT-related sectors as a share of its total economy is Georgia, which is also the only state with an explicit IT strategy adopted by its agency for technology-based economic development, the Georgia Research Alliance (Table 4). In the other benchmark states, either there is no explicit state strategy or one has atrophied, dissipated, or yielded to local action since the time of the IT boom. In all the benchmarks, IT shares the spotlight to some degree with a state focus on the biosciences—and both Minnesota and North Carolina share Iowa's interest in bioprocessing. All the benchmark states also have identified their IT subsectors, most of which depend on the accident of genealogy—which anchor company gave rise to which series of entrepreneurial start-ups. The benchmark that most closely parallels Iowa's interest in the financial sectors as a source of demand for IT innovation is the Charlotte region of North Carolina, where a focus on e-business has grown to serve the huge commercial banking sector and in some cases (lendingtree.com) to compete with it.

Table 4: Information Technology Strategies and Leaders in the Benchmark States

State	Strategy/Agency	Other Sectors Targeted	Example IT Leaders	Identified IT Subsectors
CO	No explicit IT strategy except CIT workforce initiative	Biosciences	StorageTek and cluster; Qwest; Liberty	Peripherals (storage, photonics), software, broadcasting/telecommunications
GA	Communications, Computing, Content through GRA	Biosciences, environmental, other	Scientific Atlanta; Earthlink, BellSouth and chip-design cluster	Advanced communications, multichip packaging, optical nets, sensors, telecommunications, ultrafast optical physics
MN	No explicit IT strategy in Minnesota Technology, Inc. (MTI)	Biosciences, bioprocessing, manufacturing	Imation, ADC, Honeywell, Plato	Data storage, telecommunications, software/Internet
NC	Formerly microelectronics through MCNC; now dispersed	Biosciences, technology-intensive manufacturing including biomanufacturing	SAS, Cisco, Nortel, Sony-Ericsson, IBM, Red Hat, Cree, CommScope, Corning	In RTP: advanced electronic materials, signal processing and software; in Charlotte: optical communication and e-business

Sources of Innovation and Collaboration

Table 5 summarizes the primary, *organized* sources of university-based innovation and collaboration for the IT sector across the benchmark set. Only in Georgia is there ongoing, directed state funding of the research enterprise, while capital construction funds have been made available from time to time in both Minnesota and North Carolina. Colorado's efforts to direct university-based innovation to the needs of the IT sector have been minimal for some time.

Table 5: University Centers for the Information Technology Sector in the Benchmark States

State	University Centers	State funded?	Other
CO	Center for Information Storage, Center for Opto-Electronic Computing Systems	No longer	Joint research institutes with resident federal laboratories (JILA paired with NIST)
GA	Georgia Centers for Advanced Telecommunications Technology umbrella for 20 research centers, plus Eminent Scholars in IT	Yes, through appropriations steered by GRA	Electronics Design Center (industry funded); $5 million GRA Innovation Fund underwrites collaborations
MN	Digital Technology Initiative (1998)	One-time funding of capital construction and 12 faculty lines	Collaboration funds through MTI are no longer available

NC	Charlotte Research Institute's e-Business Institute and its Opto-Electronics centers	Capital construction only	At NC State, Center for Advanced Computing/Communication is the umbrella. MCNC projects now absorbed into Research Triangle Institute

Table 6 shows that each of the benchmark states has at least some programs to promote commercialization of IT. The set of programs observed includes university-based funds suitable for development of IT intellectual property, business incubators focused on IT, and initiatives to build venture capital. Surprisingly there are some gaps in the benchmark set, Minnesota lacks a strong incubator program, and North Carolina's programs remain heavily focused on the biosciences.

Table 6: Information Technology Development Funds, Incubators, and Venture Capital in the Benchmark States

State	Development Funds Suitable for IT	IT Incubators?	Venture Capital
CO	University of Colorado (CU) Proof-of-Concept award	Independent CTEK incubator; Colorado Advanced Photonics Center incubator; Colorado Springs Tech incubator	State revoked second tranche of its CAPCO and sold tax credits to capitalize a Colorado Venture Capital Authority, which will run an internally managed fund of funds
GA	GRA VentureLab and Innovation Fund; GTRI Product Realization Unit	ATDC (Atlanta, Columbus, Savannah, Warner-Robins); Athens New Media Accelerator	Seed capital program
MN	SOTA TEC commercialization fund (now in reinvention)	Few—at Bemidji and other Minnesota State Colleges and Universities institutions	Ample interest from community-development financial institutions and venture capital funds (e.g., NE Ventures)
NC	None outside the biosciences	RTP and NC State at Centennial and Charlotte all have incubators with some IT focus	State-backed venture capital funds are active only in the biosciences.

Workforce and Infrastructure

In addressing workforce need, states in the benchmark set have followed several broad strategies outlined in Table 7. Research parks are an important component—few realize that the original justification for the RTP was precisely to attract corporate R&D laboratories that would provide local job opportunities for the enormous numbers of trained students emerging from the Triangle Universities. A second important strategy is the creation of new curricula developed with the active involvement of local industry. Some states have created entirely new schools (such as the College of Information Technology at UNC Charlotte), while others like Colorado have preferred meta-institutes that serve only to create curricula for dissemination. A third area of activity is the development of interest in entrepreneurship among business

and engineering students who may stay in-region if they have the skill sets to contribute to new business formation.

Table 7: Specialized Infrastructure and Workforce Initiatives Relevant to Information Technology in the Benchmark States

State	Specialized Infrastructure Relevant to IT	Workforce Initiatives Relevant to IT	Other
CO	CU Boulder Research Park anchored by Qwest	CIT—not a school but a curriculum development program	Note cross-cutting themes: enterprise systems, digital media, global telecommunications, bioinformatics, homeland security
GA	ATDC anchors GA Tech's Midtown Technology Square Development	ICAPP program links public university system to workforce needs statewide	Entrepreneurial program combines students in law, economics, management, engineering on real commercialization programs
MN			Center for Development of Technological Leadership in the "Institute of Technology" at UMN
NC	RTP and NC State Centennial Campuses	UNCC has new College of Information Technology, linked to the Charlotte Research Institute	Note the Small Business Development Center (SBDC) is now rebranded an SB**T**DC (for "and Technology")

R&D Tax Credit

The benchmark states all offer R&D credits, most except Minnesota with quirks that make them not directly comparable (Table 8). Georgia appears to be making the transition to a credit on total qualifying R&D expenses. None of these credits is refundable, though several have carryforward provisions.

Table 8: R&D Tax Credits in the Benchmark States

State	Nominal Rate	Nature of Credit	Other	Refundable?
CO	3%	Keyed to increase over past 2 years in enterprise zones only	Apportioned over 4 years	No
GA	10%	Incremental over ratio of qualified R&D to taxable net income over past 3 years	Applied against up to half tax liability after all other credits; 10-year carryforward	No
MN	5%	Incremental credit per federal rules—5% on first $2 million of excess over base, 2.5% after that	15-year carryforward	No

State	Nominal Rate	Nature of Credit	Other	Refundable?
NC—current	5%	Keyed to state's apportioned share of increased R&D over base level (federal rules)	Or 25% of state's apportioned share of federal credit claimed in case of "alternative" credit	No
NC—2006	1, 2, or 3%	Total qualifying R&D, scaled by size of expenses with top rate also for small businesses	Applied against up to half tax liability after all other credits	No

Key Findings

- ***Iowa has a small IT sector by absolute size, but it is generally competitive (albeit at the low end of the range) with the benchmark range when normalized by population size or measured as a share of overall GSP.*** This share, however, has been stagnant versus a steady rise in competitors like Georgia and cyclical behavior in Colorado and North Carolina.
- ***In defining an IT strategy, Iowa is exploiting a strategic opportunity***. Of the benchmark states, only Georgia is similarly focused on an IT strategy. In most of these states, IT competes for attention with bioscience development efforts including bioprocessing or biomanufacturing in Minnesota and North Carolina. Most of the benchmarks are defining IT subsectors that track the strengths of emerging clusters.
- ***Again with the exception of Georgia, Iowa is competing against benchmarks with relatively weak signature initiatives in university-based IT R&D***. Many programs are either defunct or have provided only one-time capital injections. Georgia seems determined to provide operating resources to build research capacity in areas of interest.
- ***Absent strong state involvement, university-based IT innovation has followed the availability of funding***. Iowa ranks about in the middle based on absolute size of university research budgets, though second from the top when normalized by population size. Relative to the benchmarks, Iowa is experiencing robust growth in research funding in both engineering and mathematical sciences, but falling behind in computer sciences.
- ***Overall, Iowa trails the benchmark set in venture-capital funding, and the pattern is the same in the IT-related subsectors.*** Overall, the benchmark set is paying considerable attention to commercialization initiatives, including university-based funds for technology commercialization, provision of incubators specializing in IT sectors, and state-level venture capital initiatives (except in Georgia or North Carolina where the emphasis is heavily on the biosciences).
- ***Iowa's production of students with IT-relevant degrees tops the benchmark set when normalized by population size, with relatively strong performance in degrees for computer hardware and electronics and management information systems.*** Growth rates are similar to those in the benchmark set.
- ***Notwithstanding its degree production, Iowa trails the benchmark set in the number of persons actually employed in IT job functions, with the exception of a relatively strong performance in***

those with computer and mathematical duties. When normalized by population size, Iowa does not lead in employment as it does in degree production, suggesting that trained students may out-migrate because they cannot find positions in their particular degrees within Iowa.

- ***Since the end of the IT boom, IT occupational employment in Iowa has fallen, as it has across the benchmark set, with a particularly notable decline in electrical and computer engineering employment, where at the same time degree production was unusually strong.***
- ***Iowa faces a benchmark set that has adopted several strategies to promote IT-relevant workforce development and retention: research parks with at least partial IT focus, development of new industrially driven curricula; and development of entrepreneurial talent among university students who can contribute to new business formation.***
- ***Iowa's R&D tax credit compares well with the credits offered in the benchmark set, which are unremarkable and quirky in ways that do not necessarily assist early-stage business with features such as refundability.***

LESSONS LEARNED

- *Work to identify talent leaving leading IT companies and capture them for the region.* Clusters form not only through attraction (as in the case of the telecommunications chip manufacturers gathering around Georgia Tech), but also when trained engineers and managers leave one employer and choose to stay local by starting their own businesses. The seed may be a large firm like IBM in Research Triangle or a smaller firm such as StorageTek in Colorado or Scientific Atlanta. The need to capture talent trained in the management of early-stage technology becomes particularly acute in times of economic downturn when employers of all size shed jobs. For example, Minnesota found that many employees trained in the mainframe computer sector during the 1970s and 1980s remained to form the core of a software and Internet sector as the region recovered from the recession of 1990 to 1991.
- *Pay attention to IT demand embedded in other sectors and try to build supply chains.* Probably the best example in the benchmark set is Charlotte, North Carolina, where regional civic leadership has recognized the opportunity to build an "e-business" sector that both supplies the region's giant commercial banks (Wachovia and Bank of America) and also competes with them (lendingtree.com).
- *Don't neglect overlap of IT sectors with manufacturing and biosciences.* Virtually all the benchmarks recognize that their interest in IT overlaps with manufacturing in the area of advanced materials and development of novel devices for inclusion in information systems. This does *not* mean exclusively microelectronics fabrication, but rather also includes advanced technologies for broadband communications (North Carolina and Georgia) and data storage (Colorado and Minnesota). A similar case can be made for the linkages of IT to bioprocessing and other biosciences areas that use the tools of IT to undertake their research, development and manufacturing.
- *In supporting IT research, give preference to programs that flow students to employers.* Iowa's apparent mismatch between degree production and workforce employment in IT makes this a particularly crucial lesson. Virtually all the benchmarks are adding IT curricula (through existing

programs as in Colorado or new schools as in Charlotte) that are heavily driven by input from local industry.

- *Develop space near campuses where IT companies can tap these students.* Experience at NC State's Centennial Campus showed clearly that IT recruitment thrives when companies have ready access to a pool of IT-trained students. In fact, this is the very reason that Research Triangle Park was first created in the 1950s—to provide local employment opportunity for trained students who would otherwise out-migrate after graduation.
- *Emphasize entrepreneurial education*. Management skills pertinent to early-stage IT enterprise are just as important as technical skills. Some IT students can be cross-trained in management of technology, and business students can be provided outlets for entrepreneurial energy. A goal of entrepreneurial programs should be to assemble a ready pool of both mid-level management and executive talent suitable for start-up IT enterprises.

Iowa's Current Strategic Position

Strengths, Weaknesses, Opportunities, and Threats Analysis

This section presents an analysis of the strengths, weaknesses, opportunities, and threats (SWOT) facing Iowa in building its IT and information service sector. This analysis is based on 106 interviews conducted with leaders from industry, academia, government, and technology intermediaries, in addition to data analysis and benchmarking conducted and reported earlier. This analysis was accomplished through one-on-one interviews and small group discussions involving leaders throughout the state. In addition, a preliminary version of this section was shared in three focus group sessions held across the state.

This SWOT analysis follows a methodology similar to a business planning process. In preparing its business plan, a company undertakes a similar exercise, identifying its internal strengths and weaknesses and taking into account and addressing external factors, including markets and opportunities and adverse events and threats. In the following review, Iowa's IT and information service base is examined much as a business would examine itself. It should be understood that, in some instances, perceptions of a significant nature have been included. While such perceptions may not be universally supported, they become potential barriers if believed to be true, and therefore must be overcome.

Strengths

The quality of Iowa's workforce is a key differentiating asset. Hard-working, dedicated, well-educated, and inventive—Iowa's workforce provides a keen competitive edge for employers.

It is not unusual for a state development agency to claim it has a great workforce—however, it is very unusual for this to be confirmed by every employer interviewed. Companies time after time noted that Iowa consistently provides employees who are well-educated, reliable, and have a strong work ethic. These strong work characteristics appear to be just as notable in new college graduates in Iowa because they are among the more established members of the workforce—again, this is unusual. These highly positive workforce characteristics should be seen as a key Iowa strength—certainly one that is very hard for other states to duplicate and lay claim to.

In the IT space Iowa's workforce is also a good value. Average annual wages in Iowa's IT sector are consistently lower than national sectoral averages, often by more than 30 percent (see "Iowa's Information Technology Sector" section). However, these still represent good, high-paying jobs relevant to Iowa standards where Iowa's IT wages average $42,536 per year versus the statewide average for private sector jobs of only $30,220. Wage inflation in the sector is also low, with growth of only 2.7 percent between 2000 and 2003 (versus 3.1 percent in Iowa across all private employment sectors).

Iowa has demonstrated strengths in some specific IT and IT-related areas. A number of these show promise for future growth and development.

While the size of Iowa limits the overall breadth of its IT sector, some pockets of distinctive clustered expertise do exist. Strengths are apparent in both the academic and corporate settings (although not always in the same areas in both). IT and related sectoral strengths identified during interviews include the following:

Corporate (Private Sector) Strengths	Academic R&D Strengths
Rugged, high-reliability information systems (including servers and mobile platforms)	VR (3-D visualization, modeling, haptics, and associated software and applications)
Embedded software	Human computer interaction
RF/wireless and microwave technology	Software quality assurance and testing
Custom software applications for insurance and financial service applications	Sensors and optics
Communications and networking equipment	Quantum electronics/spintronics
Security and information assurance	Applied mathematics for finance and actuarial analysis

Quantitative analysis using LQs shows that Iowa has a state specialization only in Internet and data services (where the LQ = 1.7, a 70 percent greater concentration in this subsector versus the national average). Promise for growth, however, can be seen in a broader array of IT subsectors. Examining average annual employment growth relative to the United States for the years 2000 through 2003 show Iowa exceeding average U.S. growth rates in the following IT subsectors: computer and peripheral equipment, media recording equipment, communications and media equipment, software and computer services, Internet and data services, and communications network services. The two fastest-growing subsectors in Iowa (relative to U.S. growth) are computer and peripheral equipment and media recording and equipment; however, both have relatively low levels of total employment with 508 and 91 employees, respectively.

Iowa's safe and friendly family environment is an attractor and anchor for more established, family-oriented, skilled professional and technical staff.

Iowa has had recent negative press regarding the retention of its young adults within the state post graduation. This is, however, not an unusual characteristic among U.S. states; although, Iowa perhaps does lack the sort of dynamic, fast-paced environment that appeals to certain youth categories. What Iowa does have is a stable, predictable, and uniquely midwestern quality of life that appeals strongly to those familiar with it who desire its safe and nurturing environment for their families. As a result of this, Iowa is being successful in recruiting family-oriented and mid-career skilled personnel who recognize the tangible benefits of Iowa's quality public education system, traditional values, short commutes, and family-friendly living conditions. Once this more mature workforce puts down its roots within Iowa, they have a high tendency to remain; workforce retention among employers is cited as excellent.

Iowa's major cities have ample fiber-optic broadband telecommunications capacity.

Companies such as The Principal, Wells Fargo, John Deere, and Rockwell Collins require a state-of-the-art transnational and international communications infrastructure to maintain competitive. While service to rural areas is less than optimal, Iowa's major cities are well served by high-speed communications infrastructure. Companies note that they are able to get the high-quality, and above all, reliable service that they require for modern business operations. An added bonus is that, post-9/11, companies perceive their infrastructure to be more secure when located in Iowa-sized communities, rather than in major cities such as New York, Chicago, and Atlanta.

The industry has organized itself into the Technology Association of Iowa (TAI).

The growth of IT industry in multiple states and regions throughout the United States has been significantly enhanced through networking access to ideas, capital, workforce skills, and other key inputs provided though regional and statewide IT associations. Iowa, likewise, is home to such an industry group. Formerly named the Software and IT Association of Iowa (SITI), TAI currently comprises 240 member companies and has a number of associated organizations engaged, such as Iowa's leading colleges and universities. Unusual in being originally founded by the state (under IDED), TAI is now membership driven—funded by membership dues, event fees, and administrative grant fees. TAI has a 26-member board, which is composed of mostly CEOs and chief information officers (CIOs), and has achieved considerable influence on matters such as public policy, especially given its comparatively small budget of only $350,000 per year. Interviewees within the IT and information service sector throughout the state consistently cited TAI as an important and effective force for promoting conditions for positive sectoral growth.

Weaknesses

While Iowa's IT sector provides employment for 29,279 persons across 2,075 establishments, it does not employ a high enough percentage of the workforce to be considered a state "specialization."

The percent of the Iowa workforce employed in the IT sector is only 64 percent of the national average. As such, Iowa has an IT LQ of less than 1.0 and the sector as a whole cannot yet be considered a state specialization. Iowa has an LQ greater than 1.0 in only one of eight IT subsectors, Internet and data services, with an LQ of 1.70.

IT, of course, goes deeper than just employment directly within IT sector companies. IT occupational categories exist in most other sectors, with particularly heavy concentrations of IT professionals in the finance and insurance sector (an important sector in the Iowa economy). However, considering IT occupations in general (both within and outside of the IT sector), Iowa still does not demonstrate a level of specialization in IT and IT-related occupations. In terms of computer and mathematics occupations, for example, Iowa is at only 69 percent of the national average, while in media and communications it is at 86 percent. Even though it is home to Rockwell Collins, Iowa has only 30 percent of the concentration of electrical and computer engineers as would be expected given national averages.

Only in the occupation category of telecommunications equipment installers and repairers does Iowa have a strong LQ, at 1.55, and high levels of employment (3,350 jobs). However, the high relative levels of employment in this sector are likely the result of Iowa's unusual telecommunications delivery structure, which is divided between a large volume of small, local, independent and municipal telecommunications and service providers.

The comparative weakness of Iowa's current IT base (relative to other states) is highlighted in statistics contained in some recent reports. In *Cyberstates 2003,* the American Electronics Association (AEA)[24] measured various "high-tech"[25] trends across the 50 states and the District of Columbia. Iowa ranked lower in high-tech than in state population. Iowa ranks 30th in the nation in terms of population, but

[24] Platzer, Michaela. *Cyberstates 2003: A State-by-State Overview of the High-Technology Industry*. The American Electronics Association. Washington, DC 2003.

[25] The AEA report does not include biotechnology or the life sciences in its definition of "high-tech." High-tech, under its definition, includes computers, electronic equipment, measuring equipment, communications services, and software and engineering services.

ranked 32nd in high-tech employment and 43rd in high-tech average wage. Work by the Milken Institute in its State Technology and Science Index[26] similarly showed Iowa to be underperforming relative to its population ranking. In the 2004 Milken Index, Iowa ranked 37th (down from 35th in 2002). The Milken Institute ranks state performance on a number of important science and technology metrics; and, for the most part (except in human capital investment), Iowa is not performing strongly on the following measures:

Metric	Iowa's Ranking
Overall Science and Technology Index	37
R&D Inputs	36
Risk Capital and Infrastructure	45
Human Capital Investment	16
Technology and Science Workforce	41
Technology Concentration	41

Attracting talent from outside of the state is a multidimensional challenge for Iowa. The state is small, has distinct climate extremes, lacks certain distinctive amenities, and is not viewed as a vibrant technology-driven state.

Employers noted that, while they are able to access excellent personnel in Iowa, attracting workers from outside of Iowa (those with specialized IT and management skills) can be quite challenging. Software, IT, and engineering professionals who possess certain high-demand skills are hard to recruit to the state. Companies also noted that they can find recruiting for certain senior executive positions (particularly in finance, marketing, and sales) to be difficult. Because of hard-to-combat perceptions about the state, out-of-state recruiting is most successful with those who have lived in the Midwest and understand the benefits of the safe and family-friendly Iowa environment.

Employment in the comparatively large "service" side of IT in Iowa is largely an urban phenomenon—with little dispersal of jobs into more rural areas.

Iowa's leading IT sectors in terms of employment are heavily concentrated in metropolitan areas of the state; overall, 73 percent of IT employment is concentrated in urban areas. This may represent a problem in promoting the growth of the industry in a state where the Legislature is concerned about economic development in both its largest cities as well as its small and medium-sized communities. The small, but growing, IT hardware sectors, however, show a higher propensity to locate in micropolitan and county locations.

Lack of faculty incentives and rewards limits the engagement of the excellent state universities in Iowa in regards to applied work for the IT and information service industry.

As will be seen in the "Recommended IT Platforms for Development" section of this report, Iowa's universities do excel nationally in certain areas and fields related to IT. They also have generated a number of IT spin-off firms and are graduating more students than the state economy is currently absorbing. That said, faculty and department heads interviewed across Iowa's state universities note that current university policies and procedures, particularly those pertaining to achieving tenure, do not favor faculty engagement in industry consulting, industry-sponsored applied research, intellectual property generation, or entrepreneurial activity. Untenured faculty at ISU and the University of Iowa are largely

[26] DeVol, R., Koepp, R., and Ki, J. *State Technology and Science Index: Enduring Lessons for the Intangible Economy,* Milken Institute, March 2004.

judged on scholarship (measured in terms of publication frequency and quality), and little incentive or reward exists for applied commercially oriented R&D. These barriers to applied or commercial R&D cause multiple problems: (1) they limit Iowa universities' ability to recruit up-and-coming or "star" faculty who desire to engage in entrepreneurial or commercial work; (2) they make the universities less appealing to commercial entities that may wish to engage younger faculty in R&D projects; (3) they limit faculty connections to commercial entities that could present excellent internship and employment opportunities for their graduate students; and (4) they make it likely that only senior, tenured faculty will become engaged with industry, precisely the faculty members who are more firmly rooted in academe and less likely to take risks or pursue commercial opportunities.

Funding constraints within Iowa's state-owned higher education system have caused substantial cut-backs in programs designed to foster commercialization of university R&D.

Historically, state budget cuts have caused a decline in funding to the regent universities. As a result, the universities have had to cut many programs and initiatives that they deemed as not central to their academic research and teaching missions. Unfortunately, economic development, entrepreneurship, and commercialization activities that should be seen as essential contributors to the state's economic future have been subject to these cuts. However, for the state budget beginning July 1, 2005, additional funds have been provided to the state's higher education institutions that can address this problem, not only regarding IT but also advanced manufacturing and the biosciences as well.

Lack of broadband telecommunications service in rural Iowa prevents rural populations from participating in the IT workforce and limits the creation of rural-based IT enterprises.

The participation of Iowa's population in a networked, IT-driven economy is largely restricted to those located in Iowa's major population centers. Iowa does possess an outstanding state-owned fiber backbone reaching every county in the state—however, while this backbone has huge excess bandwidth availability, current state law prevents connectivity and use by commercial non-educational users. The state's fixed distance education network provides opportunities to be opened to industry, and the state's relatively flat terrain has the base to further build capacity through wireless support. Without access to high-bandwidth communications infrastructure, rural Iowans might be unable to take advantage of the opportunities of the digital economy and its entrepreneurial and employment opportunities.

Historically, the lack of access to pre-seed, seed, and venture capital is limiting the formation and growth of IT enterprises within the state.

As identified in *Iowa's Bioscience Pathway for Development,* few very early stage funds have been available for initiating proof-of-concept and basic marketability assessments for new ideas and discoveries. In addition, Iowa has been able to make some critically important state investments in promoting capital availability, including the Fund-of-Funds legislation and now its first closing on funds, insurance premium-based capital funds, and special financing of venture capital deals in the state for California's Acuity venture capital firm. While the venture capital situation is improving, Iowa is still at a considerable competitive disadvantage in this area versus many other states. Similar capital constraints also are seen in IT. This lack of very early funding, coupled with the lack of faculty incentives noted earlier, provide a considerable barrier to university-based researchers moving their ideas toward commercialization. There also are significant financial barriers downstream in the area of venture capital. Iowa lacks a significant volume of indigenous venture capital and has historically failed to attract much attention from the established venture capital firms located out of state.

The qualitative opinions of interviewees in regards to capital difficulties are confirmed by some quantitative studies. The AEA *Cyberstates 2003* report ranked Iowa 44th in venture capital investments (30th in state population), while the Milken Institute's 2004 State Technology and Science Index ranked Iowa 45th on its Risk Capital and Infrastructure Composite Index.

Workforce diversity is lacking.

In modern business, workforce diversity is recognized as having multiple benefits. For companies such as Rockwell Collins that are heavily engaged in federal government contracted projects, it can be a considerable challenge meeting federal diversity mandates in a state as homogeneous in its population as Iowa. Diversity also has been found by social scientists to be a desirable characteristic in terms of engendering outside the box thinking, creativity, and innovation. Within the IT sector, the rise of countries such as India and China in the production of skilled IT and software personnel has opened a channel to a source of scarce technical skills—however, Iowa lacks strong cultural enclaves with connections to these countries. Furthermore, it was noted in multiple interviews that the Immigration and Naturalization Service (INS) branch serving Iowa (located in Nebraska) is known within the immigrant community to be rather conservative in granting work visas and green cards.

The issue of diversity in Iowa is confirmed by quantitative analysis by the U.S. Census.[27] The Census has developed a diversity index and classifies Iowa as a "low diversity" state (in terms of racial and ethnic diversity). Using a six-part scale, all rural counties in Iowa are in the lowest diversity category, while the more urban areas of the state are either in the lowest or next-to-lowest diversity categories. Very few states show such low overall diversity indices.

Opportunities

There is a specific opportunity to move much of Iowa's IT up the value-added chain from basic provision of IT services to the development of branded IT products and services. This opportunity should be built upon the needs and opportunities presented within Iowa's base of large-company IT users, especially those in the insurance and financial service sector. Realizing this opportunity requires a more integrated R&D relationship between these large IT end-user organizations and Iowa's base of smaller IT companies and IT research programs in Iowa's academic institutions. By working together in such a fashion, Iowa can build a more advanced and sophisticated presence in the IT industry.

Most IT subsectors in Iowa are expanding their employment base, and there is considerable room for further growth before Iowa would reach parity with national average employment levels in most IT subsectors.

While IT is not yet a predominant state specialization in Iowa, recent trends show that most IT subsectors are outperforming the national average in terms of growth. Iowa thus has a number of emerging sectors upon which a larger employment base may be built, most notably in communications and network services and software and computer services—these two subsectors account for 53 percent of total Iowa IT employment and appear to be strong and growing. Iowa also has several smaller IT subsectors, on the equipment side, that fall into the emerging category, including computer and peripheral equipment, communications and media equipment, and media recording equipment (however, these three emerging subsectors combined accounted for only 1,502 Iowa jobs in 2003).

[27] http://www.census.gov/population/www/cen2000/atlas.html

Some existing and developing networks and associations form a backbone upon which increased collaboration may be built.

IDED showed considerable presence of mind in helping drive and nurture the formation of the Technology Association of Iowa (TAI). TAI is now a well-regarded organization able to promote the needs and growth of this sector in the state. TAI is still, however, a small organization operating on a $350,000 budget with just a handful of staff; and it receives no support from the state. An opportunity exists to increase the scope of operations of TAI and to form within it subcommittees dedicated to improving specific conditions for IT growth in the state (around factors such as workforce, capital availability, and industry-university partnerships) and fostering subsector-specific initiatives (in areas such as mobile computing, information security, and financial and insurance applications). In addition, as an outgrowth of this strategy development, large IT users and their CIOs have indicated an interest in working together (and with the IT industry, universities, and the state) to build stronger partnerships among firms, educational institutions, and others to address issues and actions recommended later in this report.

The state-owned fiber communications backbone may provide opportunities to rapidly expand broadband access across rural Iowa.

The Iowa Communications Network (ICN) is a state-owned and -operated fiber backbone serving each of Iowa's counties. It currently links government, community colleges, libraries, schools, and higher education systems across the state. In establishing the network, the state recognized and acted on a need for enhanced modern communications connectivity in Iowa's widely spread communities. That said, the system is one-dimensional in serving only the government, higher education, and nonprofit sectors in the state (such as hospital systems). Private industry and commercial organizations have been unable, because of state law, to leverage or piggy-back on this fiber communications backbone despite the fact that less than 10 percent of available bandwidth is being used by all of the intended users combined. It is therefore evident that a significant opportunity exists to leverage the ICN to serve commercial interests across the state—thereby enhancing business communications and connectivity throughout Iowa and providing a source of revenue for the state through the leasing of available bandwidth.

Iowa benefits from a strong capability base in several leading-edge technology areas. Many of these present distinct opportunities for further growth.

Iowa has demonstrated expertise in several IT and information service areas that occupy growing markets including the following:

- Expertise in **RF technology**, particularly in the Cedar Rapids area, is well positioned to take advantage of the growth of mobile and wireless computing and communications systems. This capability is strongest within Iowa industry, with more limited strengths in Iowa academe.
- Iowa has expertise in the production of ruggedized IT components well-suited to application in **mobile computing and communications** environments. The increasing adoption of mobile and wireless systems as central components of an IT infrastructure bring associated needs in embedded software systems, data and systems security, and human-computer interaction and interfacing, each of which have clusters of business and R&D expertise in Iowa. Both Iowa industry and major research universities have strengths in this area.

- A strong base of design expertise also is crucial to a state staying on the leading edge of IT, and Iowa has the opportunity to leverage leading-edge expertise in **VR, modeling, and computer-aided design and prototyping systems** (which resides at both ISU and the University of Iowa).
- The strong base of **financial service and insurance IT expertise** brings with it scalable experience in managing large-scale data networks and in the mining of large-scale information systems for trends and information of strategic business importance. Strengths also reside in both industry and Iowa's leading academic institutions.

Each of the areas of emerging and established IT strength identified above are likely to experience significant growth in demand in an information-driven economy.

Iowa has a small base of experienced IT entrepreneurs whose experience and know-how may be leveraged.

With 240 companies active in TAI, it is not surprising that Iowa now possesses a base of experienced IT entrepreneurs, some of which are engaged in their second or third IT start-up. Companies such as McLeodUSA have generated a cadre of experienced entrepreneurial business people in Iowa who now have the expertise and financial wherewithal to create further IT enterprise. In addition, highly focused technology and R&D companies such as Rockwell Collins have produced a consistent stream of engineers and technical personnel skilled in the development of new technologies; and a number of new business enterprises in Iowa have resulted. There is a history of university spin-offs in the IT area, resulting in an emerging cadre of experienced entrepreneurs and business managers able to create further businesses and mentor a new generation of Iowa start-ups.

Risk capital availability is trending in a positive direction for Iowa. Angel networks have formed in the state, and venture capital is becoming associated with Iowa investments. State actions have reinforced these positive trends.

It appears that access to capital for business ventures with a solid product concept and business plan is becoming less problematic in the state. While pre-seed and early-stage seed capital can be challenging to find, multiple parties noted that such capital is available in the state to people who know where to look. TAI has worked on this situation with the state and cites 10 angel networks now operating across Iowa. Multiple high-net-worth individuals with entrepreneurial experience and investment preferences have been generated by successful enterprises in the state. In addition, Iowa has been able to make some critically important state investments in promoting capital availability, including the Fund-of-Funds legislation and now its first closing on funds, insurance premium-based capital funds, and special financing of venture capital deals in the state for California's Acuity venture capital firm.

Threats

The steady rise of global competition, even within highly skilled IT and technology fields, threatens the market viability of American and Iowa-based IT and information service entities.

Throughout the interviewing process, the specter of overseas competition was consistently on the minds of interviewees. India is clearly viewed as a distinct near-term threat in the software and IT sector, and companies noted that tightening of U.S. immigration post-9/11 has served only to reinforce India's indigenous industry with highly qualified people who may otherwise have come to the United States. Similar strengths are arising in other lower-cost countries, including those in eastern Europe and other

parts of Asia. America's continued dominance of the IT sector cannot be guaranteed, which necessitates Iowa's IT base becoming more value-added in terms of services and products.

Business in Iowa is experiencing a rising cost base, largely driven by dramatic double-digit annual inflation in their benefits costs. These cost increases threaten to negate the bottom-line competitive benefits of increasing productivity achieved through technology investments and skilled personnel.

While cost increases are having the most impact in the manufacturing sector, they also are being felt in the software, IT, and information service sectors. As predominantly human-capital-driven operations—operations selling the skills and know-how of their personnel—software and information service businesses are highly sensitive to the carrying costs of labor. Double-digit health care insurance premium increases are particularly challenging for companies to deal with—yet, companies have to be careful in passing cost increases to employees since Iowa is in competition with many other locations for this skilled labor.

Iowa may be too slow to react to current and emerging opportunities, and too conservative in its funding support, to grow its competitive sectors. Other states and nations, investing more rapidly and aggressively, could overtake Iowa.

Recent setbacks to the Iowa Values Fund legislation were viewed by companies as indicative of an innate conservatism in the Iowa Legislature that could hold back progress in the state. Other states have been far more aggressive in their support for growing their target business sectors—using bond financing and general funds to support and seed the rapid development of a position in fast-growth and emerging business sectors.

Funding constraints within Iowa's state-owned higher education system could reduce the ability of universities to fund key faculty start-up packages and to retain their best and brightest faculty.

In a knowledge-driven economy, it is imperative that leading research universities have the resources they require to hire key faculty. In certain technical fields, this can mean start-up packages of between $500,000 and $1 million to equip state-of-the-art research laboratories for research "stars." Funding restraints at ISU and the University of Iowa make it extremely difficult to create such start-up packages. There is also a challenge in retaining the strongest faculty at these institutions. Faculty salaries have stagnated in recent years as a result of state budget cuts. Faculty and scientists may be attracted to higher-paying jobs and more richly endowed laboratories and facilities in states where investments continue to be made in spite of revenue shortfalls.

Iowa's education and workforce system may fail to provide the types of skilled technology workers required to power growth in the IT and information service space.

Fear over international competition in the IT sector is already impacting enrollments in software, computer science, information systems, and computer engineering programs among domestic students. There is a concern that advisors to high school students (such as guidance counselors) are cautioning midwestern students that the IT sector is moving offshore and good jobs in the field will be scarce in the United States. With Iowa already having difficulty recruiting people, its prospects in the IT, software, and information service sectors could be harmed seriously if the number of students studying these key technical fields at Iowa institutions declines.

Situational and Gap Analysis

The economic, benchmarking, and SWOT analyses provide a reference for Iowa's current position and areas of opportunity in the IT sector. In this section, the specifics of Iowa's IT position are examined, with a focus on current assets, R&D, and commercial infrastructure. In addition, key gaps, problem areas, and development issues are considered that may need to be addressed to optimize IT development potential for the state.

Positioning Iowa for success in IT and information service development requires building upon the existing base and infrastructure for IT R&D and commercialization. Of particular importance in technology infrastructure for IT development are the following:

- The fundamental strengths of the academic and commercial R&D infrastructure in IT and the links between R&D and commercialization vehicles
- The IT industry base, the presence of "clusters" of like commercial enterprise, and the degree to which the industry is engaged in the development process
- The general business environment in the state and its fitness for IT business development and efficient ongoing operations
- The presence of a robust, distributed, and competitive broadband communications network infrastructure
- Efficient and clear processes for technology transfer and for encouraging and supporting entrepreneurship and new enterprise formation
- The ability to secure financing for enterprise development and growth
- The ability to generate, retain, and attract workforce at the various skill levels required for successful R&D through commercial business operations
- The existence of a quality of life and general amenities conducive to the development and retention of businesses and their skilled personnel
- The degree to which government actions, regulations, and policies are supportive of development in the IT sector.

The Battelle team developed this situational analysis based primarily on extensive interviews with industry leaders, economic developers, venture capitalists, workforce providers, foundation officials, and industry service providers. In addition, the project team held three focus group meetings that included representatives from all of these sectors to obtain feedback regarding preliminary findings and conclusions.

Knowledge Infrastructure (Facilities, R&D Centers, and Anchors)

Clusters of knowledge are of critical importance in providing states with a competitive advantage in technology-driven development. In an increasingly innovation-driven economy, the productivity and quality of distinctive expertise in science, engineering, and related technology disciplines are crucial to economic progress.

Iowa is quite well placed, given its size, in regards to its IT knowledge and innovation infrastructure. In particular, some specific areas contain acknowledged clusters of distinctive expertise—both on the academic R&D front and within Iowa's commercial sector. Most notable among these R&D cluster areas are the following:

- In **RF and RFID technologies,** Iowa, particularly in the Cedar Rapids technology corridor, has a very strong base of expertise in wireless applications. Rooted firmly in the high-technology operations and R&D of Rockwell Collins, the Cedar Rapids area has continued to grow multiple companies active in the RF/RFID field (including Intermec, Siemens, Fastek, and Skyworks). Wireless technology and mobile IT solutions are a high-growth field, and Iowa is well placed to take advantage of R&D and engineering skills directly and indirectly related to it. There also are pockets of expertise in Iowa related to other wave frequencies, with a special level of expertise in microwaves. Iowa's major universities are working with Rockwell Collins, and others in the field, through programs such as ISU's Very Large Scale Integration (VLSI) Design Center.
- Centered on the R&D activity of Iowa's two largest universities, a powerful knowledge base has been built in the area of **advanced visualization systems and VR technology**. ISU's Virtual Reality Applications Center (VRAC) is among the recognized national leaders in the development and application of VR technologies and enjoys extensive collaborations with industry both in and outside of Iowa. VRAC and its affiliated researchers also have been instrumental in the growth of several technology companies in Iowa based on VR technologies and applications. This has now expanded to embrace the broader field of "**human-computer interaction,**" providing applied R&D opportunities related not only to visualization and imaging, but also haptics, ergonomics, interface design, and multiple R&D fields. With links to other areas of expertise at ISU in artificial intelligence and computer science and engineering, the University is well placed to advance a human-computer interaction sector for Iowa. Iowa's strengths in this area are further reinforced by resources at the University of Iowa, which is home to intensive VR and simulation research centered upon the National Advanced Driving Simulator. VR work at the University of Iowa also is notable for the R&D activities at the Center for Computer-Aided Design, which contains specialized research work related to the virtual human/soldier project and distinctive expertise in human factors design, multibody dynamics, and simulation. As with ISU, the University of Iowa's work in VR and related disciplines has resulted in the development of local commercial enterprise. Work in visualization and imaging also has a strong link into biomedical imaging and bioscience platform work in Iowa.
- The development and production of **high-reliability, ruggedized IT systems** also represent an Iowa strength. On the corporate side, Intermec is a power player in the development of mobile high-reliability systems, while Crystal Group (also in Cedar Rapids) is a leading producer of high-end ruggedized servers, with particular application to military applications. Similarly, much of Rockwell Collins work relates to product development for avionics and military applications requiring extreme levels of reliability and rugged-duty capabilities. On the academic R&D side, the University of Iowa has focused work on reliability-based design, durability, and optimization in IT systems through the Center for Computer-Aided Design. Related to this technology area would be ISU's Center for Non-Destructive Evaluation and the ISU Information Infrastructure Institute.
- **IT systems security and information assurance** is a fast-growth field where Iowa has some legitimate strengths. On the corporate front, Iowa has high demand for information assurance and security applications for its large financial service and insurance sector. This type of work, for security reasons, cannot be offshored; and much custom application development work occurs

between the major companies and smaller, specialized systems consultancies. On the academic R&D front, security-related R&D is being performed within the ISU Information Assurance Center, which has 40 involved faculty members and is a National Security Agency Center of Excellence. Some local Iowa companies have spun out of this technology area at ISU. It also is important to note that ISU is working to become a National Science Foundation (NSF) cooperative research center (with ISU as the lead institution) for information protection, and the ISEAGE (for Internet-Simulation Event and Attack Generation Environment) total Internet simulator allows ISU researchers to simulate security events such as Internet cyber attacks and associated security issues. The R&D work at ISU is being reinforced by a master's program in information security.

- As noted above, Iowa is home to a substantial base of financial service and insurance corporations. Such operations are, of course, highly IT intensive with large-scale operations in areas such as electronic data interchange, actuarial analysis, data mining, and data warehousing. E-commerce applications are also a growth field within the finance and insurance sector. **Because of the base of finance and insurance operations in Iowa, a considerable number of IT software and systems solutions companies have operations in the state**—these include both locally owned stand-alone companies and branches of international consultancies. The providers of specialized solutions to Iowa's finance and insurance companies have potential to expand their operations both domestically and internationally—taking the skill sets they have learned locally and applying them to greatly expanded markets. In addition, several distinctive areas of academic R&D relate to IT and the finance and insurance sector. At ISU, the Center for Computational Inference, Learning and Discovery has a particular focus on data mining research and applications; and its application to insurance data analysis is assisted by ISU's very strong statistics department. Also, the University of Iowa College of Business has a technology focus and has specific research programs focused on risk management and the insurance sector; researchers in the College of Liberal Arts and Sciences at the University of Iowa are focused on knowledge and information extraction.
- Iowa also demonstrates strengths in **software quality assurance and testing**. Within the University of Iowa College of Liberal Arts and Sciences (home to the Computer Science Department), researchers are engaged in software verification and correctness analysis. This research uses hardcore testing for assurance purposes using specially developed software tools that themselves are able to probe other software for errors. Similar research interests in high-performance software testing and validation exist at the University of Northern Iowa. There also is a cluster of expertise in smaller consulting organizations in and around Des Moines in quality assurance and specification-based systems, with most of these companies serving the finance and insurance industry.
- The Optical Science and Technology Center at the University of Iowa is a cross-disciplinary science center with 20 faculty members. A number of the engaged researchers have international reputations in **optical science and laser technology;** key research programs at the Center are focused on laser spectroscopy and photochemistry, photonics and optoelectronics, ultrafast laser development, condensed matter physics, materials growth techniques, device physics/engineering, surface chemistry, chemical sensors, environmental chemistry, polymer science, plasma physics, and nonlinear optics. Nanotechnology also is a growth area within the Center. Optics, lasers, and associated technology are obviously important component technologies in multiple areas of IT systems and hardware—this extends from consumer applications for lasers, such as compact disc (CD) technology and printing technologies, to ultra high-end military systems using optics and laser sensing in comprehensive missile detection and defense technologies.

- The University of Iowa's work in **quantum electronics and spintronics** also is notable, although commercial application of technology from the research may be long term in relation to IT. Nevertheless, the product potential for work taking place at the University of Iowa, especially in the area of spintronics and its application to reprogrammable transistors based on electron spin and charge, shows great promise. R&D work also is taking place related to quantum-state secure communications and quantum cryptography—very high-end security applications with future IT potential.

The above-cited examples represent the areas of IT and associated applications demonstrating specific strengths in Iowa. However, to realize comprehensive technology-based economic development from these R&D areas, Iowa must have in-place all the key components for commercialization, including university-industry partnerships, intellectual property (IP) licensing, commercialization funding, talent attraction and development, and multiple other requirements. As will be discussed below, gaps exist in the seamless provision of necessary commercialization tools and some front-end gaps limit the efficiency and sustainability of IT R&D in the state.

Key observed gaps or issues facing IT R&D in the State of Iowa include the following:

- ***Relatively limited levels of R&D interaction exist between Iowa's IT companies and Iowa's universities (except in the case of those companies that actually spun out of university-based technologies).*** Many of the IT companies interviewed in both hardware and software solutions in Iowa noted that they have no relationships with Iowa's universities beyond the recruiting of graduates. There is a clear need to raise the profile of Iowa's universities with Iowa industry, which appears to have little knowledge of the true capabilities and faculty research interests in the state.
- ***Iowa universities are not being as proactive as they could be in making industry aware of their capabilities.*** Companies interviewed particularly noted that state universities have not been very active in approaching them with patentable ideas, joint projects, concepts, or presentations of capabilities and interests. The IT commercial sector has low levels of awareness of key ISU-based initiatives including the Center for Industrial Research and Service, the Institute for Physical Research and Technology (IPRT), and the Iowa Manufacturing Extension Partnership. At the University of Iowa, with its more bottom-up environment, industry is challenged in finding an appropriate entry point to initiate discussion regarding potential collaborations. Both large and small IT firms in the state appear interested in scaling up their interaction with higher education in Iowa.
- ***IT industry in Iowa, particularly in the software space, expressed concerns over whether or not universities in the state are able to keep pace with the latest technologies.*** The fast pace of technology change in the IT space requires that universities rapidly restructure their curricula and programs, and industry feels that Iowa's universities may be in danger of slipping a technology generation behind. Similar concerns were expressed by university representatives in terms of budget constraints and an inability to upgrade to the latest generation of equipment to stay competitive.
- ***Faculty engagement in work with industry is somewhat hampered by issues related to tenure and rewards in the academic setting.*** Junior faculty expressed particular concern that engaging in industry and commercial research and entrepreneurial activity wins them few points in terms of their academic careers. Issues related to IP ownership, publication rights, etc., also hamper optimal commercial-academic relationships. Faculty work on intensive R&D projects also would benefit through the creation of "Research Engineer" positions, whereby faculty can concentrate on research

without maintaining a traditional teaching load. At other institutions, such positions favor joint work with industry in a sort of clinical engineering setting.

- ***In some areas of R&D, specific infrastructural investment is needed to sustain leadership or growth.*** R&D at all the state universities is somewhat hampered by lack of very high performance computing resources, but hopes were expressed that a statewide initiative between the three regent universities could gain support for the latest generation of high-performance computing (this is a particular issue in the informatics arena). There are also concerns that the primary VR technologies at ISU are now 5 years old, and considerable investment will be needed in next-generation equipment to maintain a solid leadership position in the field.
- ***Concerns were expressed as to whether Iowa's regent universities can provide the type of start-up packages required to secure additional top-notch talent in core IT R&D disciplines.*** Building and reinforcing centers of excellence in academic science and technology increasingly require the ability to provide start-up packages that attract the very best and brightest research faculty and their research teams. While IT research does not require the size of package typically encountered in the biosciences (where competitive start-up packages can range from $1 million to $2 million), attracting highly promising researchers in high-demand fields can still require packages of $500,000.

INDUSTRY BASE AND VOICE

Key observed gaps or issues facing the IT industry base in the State of Iowa include the following:

- ***Concerns exist over the long-term viability of the smaller-company supply base that feeds into the larger IT and IT-related companies such as Rockwell Collins and Intermec.*** Companies noted that overseas competition, limited capital availability for reinvestment, limited owner succession strategies, etc., are negatively impacting the small-supplier base in the state.
- ***Some of the large buyers of software and IT services in the state note that most of the software and IT consultancies in Iowa are quite small.*** Because of this, large buyers have to use major out-of-state organizations for activities that require large-scale work or that may require rapid scalability in the future. The buyers were, on the whole, complimentary about the good quality and service response of Iowa's small providers; however, working intensively on major mission-critical functions with vendors that may be too small to scale to future demands does pose some risk.
- ***The small size of most of Iowa's IT firms has limited their national and international market penetration.*** Most of these companies in Iowa are serving quite limited state or midwestern regional markets, and they expressed frustration at their inability to gain greater market share outside of this relatively compact market space. In part, the companies noted that they have difficulty being accepted as serious players, by national or international potential clients, because they are based in Iowa. The state has a low technology profile, and an Iowa IT company is hampered by the perceived image of the state outside of the Midwest.
- ***The limited financial resources of TAI places constraints on the organization's activities, programming, and other operations***. TAI operates with an Executive Director and limited staffing, and thus much of its work has to be accomplished through volunteer activity. While this requirement keeps members engaged in the organization, it also limits the time and attention that can be spent on multiple issues.

The companies interviewed noted several trends that they believe may impact the national and Iowa IT environments in the future. These trends include the following:

- **A growing emphasis on products and components moving to a smaller physical scale**. As this move takes place, suppliers and producers will require increasing expertise in small/micro/nano work; this, in turn, may place demands for the development of specialized facilities, such as clean rooms. Associated with this trend would be a need for recruiting or specialized training in the small-scale design, fabrication, and assembly environments.
- Companies predict that basic programming types of operations will continue to move offshore, but there is likely to be **increasing need for U.S. personnel who are skilled in the high-end systems integration work**—able to understand complex systems from end to end. It also is predicted that the IT industry base will increasingly require technical personnel with good communications skills because customization will require close technical working relationships with clients. Translated, this means increasing demand will occur in Iowa IT companies for systems engineers who understand whole systems concepts and are able to develop customized solutions for client needs.
- **Convergence trends** are recognized as having a potential impact on Iowa's IT sector. In particular, multiple Iowa IT companies noted the potential convergence with the biosciences and a rising demand for bio-related IT skills such as bioinformatics. It also was noted that Iowa's burgeoning expertise in biobased materials could provide some of the larger IT hardware companies with the ability to differentiate their products via the use of biobased housings and components.
- **Security for IT systems and software** is predicted to be a fast-growth area. Iowa's major financial service firms, for example, noted that this is an area growing at a double-digit rate in terms of expenditures. Such mission-critical and sensitive work is unlikely to be outsourced offshore, and local providers of security and information assurance solutions are likely to be favored.
- The rapid proliferation of data in all forms of business presents **opportunities for advanced tools in data mining and high-performance computing**. Opportunities for business and academe to work together are anticipated in terms of shared computing resources and joint projects using Iowa's academic strengths in statistics, mathematics, artificial intelligence, and general computer science.
- The value of data, and its rapid accumulation rate, is predicted to place **demands for solutions in low-cost, secure data storage systems and centers**. It is also anticipated that opportunities will arise for company development around information retention solutions and information classification and indexing protocols.
- Iowa's IT companies also note that there will be **primary growth in mobile/wireless devices and solutions and associated technologies**. It is also anticipated that there will be a comprehensive move to communications over Internet protocol, including voice and data integration over Internet protocol.

Overall, the IT company base in Iowa appears bullish on the future of the sector in the state and believes that considerable opportunities are contained in the above trend areas.

General Business Environment

The general business climate (taxes, regulations, operating costs, etc.) varies quite considerably from state to state. Generally, Iowa's business climate is viewed quite favorably. It is seen as not overly regulated and also with levels of state and regional economic development support. Companies generally

characterized the state as a high value business environment given the reasonable comparative costs of operating in the state and the great qualities of the workforce. The fact that IDED and the State of Iowa are highlighting IT as a key economic sector is also viewed as a highly positive development.

Concerns were expressed, however, over several issues seen as negatively impacting the state's business environment. These issues include the following:

- ***Costs of health insurance and other labor-benefit carrying costs are rising rapidly.*** Companies noted, for example, that software is a particularly labor-intensive industry; the smaller companies (those with less than 50 employees) note great difficulty in controlling their cost structure because of large and unpredictable jumps in health care and other costs such as business and liability insurance. Larger electronics companies noted that health care cost increases have been so high that they are effectively negating any financial gains achieved via productivity enhancement investments such as automation or personnel training. Benefit cost increases are, therefore, viewed as a key drag on company competitiveness, especially versus international competitors.
- ***Overall, especially on the IT equipment and hardware side, the industry is seen as so hypercompetitive that companies may have to relocate to lower-cost environments*** (either in the southern U.S. states or, more likely, overseas).
- ***Companies in hardware, software, and IT services noted that the lack of a "technology image" for Iowa harms their sales and growth.*** Being based in Iowa brings challenges in securing customers and financing. It also was noted that Iowa is less than ideally served in terms of air transportation service and flight costs.
- ***Opinions are mixed in terms of the ability of Iowa's base of professional service providers to assist IT companies with IP protection, specialized legal services, business valuation, accounting services, and general business consulting.*** Companies did not consider this to be a major problem, however, because highly experienced help is available in locations adjacent to Iowa, such as Minneapolis, Chicago, and St. Louis. Elsewhere, however, smaller firms have been known to move to where service providers knowledgeable of that industry are concentrated.

COMMUNICATIONS AND BROADBAND INFRASTRUCTURE

Enabling a statewide broadband capacity is critical for Iowa to be at the cutting edge of new advanced communications and IT applications. Broadband infrastructure has become a generic term representing high-speed data services; in fact, different levels of broadband infrastructure reflect different inherent capabilities. According to Gartner, a leading technology advisory firm, one gigabit per second of throughput per home will be required to support the next generation of broadband applications at the consumer level.

Iowa needs to attain such high-bandwidth capacity over the next 10 to 15 years; but, in the immediate period, it is critical to reach increasing levels of broadband access and capability in all communities across the state.

Starting on a positive note, broadband access is showing a steady upward trend in Iowa. Iowa Utilities Board survey data show community-level access rising from 42 percent of Iowa communities in 2000 to 72.6 percent of communities in 2004. It should be noted, however, that community connectivity does not

necessarily translate into household or consumer connectivity; many of the parties interviewed by Battelle noted that Iowa still has serious "last mile of connectivity" issues, particularly in rural areas of the state.

The broadband issue does appear to be primarily a rural one. Companies interviewed that are located in Iowa's major cities, including massive bandwidth consumers such as The Principal in Des Moines, noted that they are well served in terms of primary bandwidth capacity and redundancy. Iowa contains strong fiber "pipes" running through the state, and major communities in the state do have good ties into these. From a data flow perspective, Iowa has more outbound than inbound traffic over these high-bandwidth pipes. It was noted that the high unused "backflow capacity" may present excellent opportunities for Iowa to establish commercial service operations in data backup. Iowa also benefits from having a state-owned, broadband fiber-optic network that provides high-capacity services to education and government entities in all communities across the state.

Nevertheless, rural connectivity to broadband remains a challenge. Federal Communications Commission data show that 17 percent of Iowa zip codes have no high-speed Internet access (versus only 6 percent nationally). Also, where broadband is available, Iowans have fewer choices of providers—24 percent of Iowa zip codes are served by only one broadband supplier versus 14 percent of zip codes nationally. A lack of competition in the telecommunications sector in many parts of Iowa likely lessens motivation for market-driven system upgrades and access provision. Indeed, in one of the group interview sessions conducted, it was noted as follows:

> *Iowa has not attracted significant competition in telecom services. Municipal utilities can play a stronger role, but there is tremendous protection of current telecommunications monopolies. The result is that we're falling well behind in the development and implementation of new telecom capacity, more fiber, etc. . . The issue is that there is no competition in telecommunications in Iowa*.

The ICN has enough unused bandwidth capacity to be a potential partial solution to Iowa's bandwidth connectivity issues. However, the current charter of the ICN does not allow private use of the system. Currently, the capacity of the ICN is limited to "authorized" users such as hospitals, state and federal government, public defense armories, libraries, schools, and higher education.

Additional issues facing communication capabilities in the state include (1) low availability of DSL (digital subscriber line) in communities because of the age of installed systems and (2) consolidation into a few big multistate players likely resulting in more concentration on major urban centers rather than low-margin rural areas. Finally, wireless technology offers new opportunities to integrate agriculture/ biosciences, advanced manufacturing, and IT throughout the state; but, it is currently very underdeveloped in Iowa.

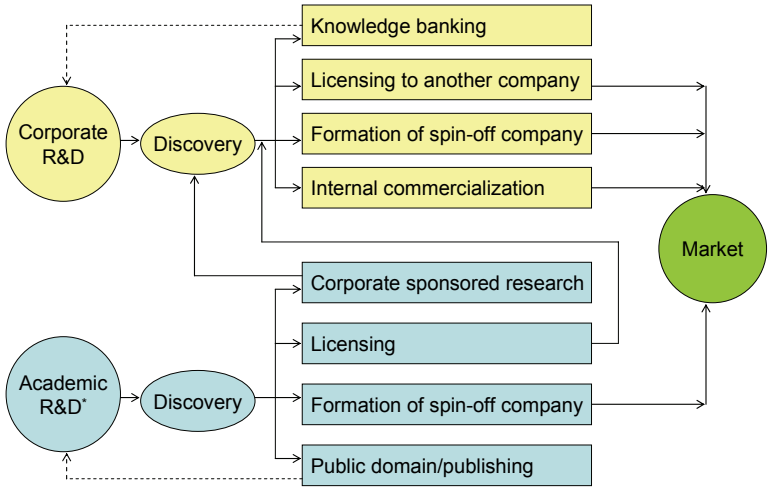
Technology Transfer, Commercialization, and New Enterprise Formation

Iowa-based R&D generates maximum economic impacts when it results in development and commercialization of a product or service that is then produced or delivered from a location in Iowa. Moving IP from discovery to a marketed product or service requires multiple steps, with the most steps required for moving IP from an academic R&D setting into a commercial enterprise.

Figure 11 shows the basic pathways from R&D discovery to commercialization.

Corporate research may be used directly to develop a new or improved product for market or to develop a spin-off or joint venture company to bring the invention to market. In addition, companies will often license IP that they develop that may not be deemed core to their own business. In certain instances, a company may prefer to simply "knowledge bank" their discovery—holding it for further development at a later time or choosing to "sit on" a disruptive new technology that may harm their existing lines of business.

Figure 11: R&D to Commercialization Pathway



* Similar structure for federal labs

In the academic arena, university and college discoveries are almost never directly brought to market by those nonprofit institutions. Instead, academic technology transfer organizations (TTOs) use three principal paths to realize commercial value from their discoveries. The first of these is corporate-sponsored research, whereby a company has sponsored the research that leads to a discovery. In this case, there is a *quid pro quo* in operation—the university gains financial resources to support research while the contracting firm gains research results and access to university scientists and resources. The sponsoring entity (the company) then takes control of the IP and feeds it into their own commercialization processes. The second pathway deployed in academe is to license the university-discovered technology to a corporation to bring to market by whatever path it chooses. The third academic option (and the preferred pathway from a local economic development perspective) is for the university to assist in the transfer of the technology to a newly formed entrepreneurial start-up company that will build a commercial market presence around the discovery.

From an Iowa economic development perspective, some of the paths to market outlined above are clearly preferable to others. Assuming that a solid business case can be made, a market exists for the technology, and financing can be obtained, the formation of a start-up enterprise may be the preferred option. This is because university-based start-ups tend to start and remain in the state in which the university R&D took place. In 1999, the Association of University Technology Managers (AUTM) reported that 82 percent of firms formed around university licenses operated in the same state as the university that provided the license.[28]

[28] *AUTM Licensing Survey: FY 1999.* Association of University Technology Managers, Northbrook, Illinois.

Forming a spin-off company has the additional benefit of forming a local entity around which other entities may spin off at a later date. For example, the University of California, San Diego, spun out Hybritech, which has been responsible for dozens of other spin-out enterprises. This is the type of "home-run" activity hoped for by all university TTOs and local economic development groups.

> *Spin-off firms are a local phenomenon. In general, entrepreneurs who start companies do not relocate but stay close to the source of their perceived competitive advantage, which is typically the referent organization where the founders were previously employed. For university-based spin-offs the university serves as the source of advantage, providing skilled labor, specialized facilities, and expertise. In addition, university personnel who start companies often split their time between the university and the firm, making close location advantageous.*
>
> Feldman, Maryann P. "Entrepreneurship and American Research Universities: Evolution in Technology Transfer." Chapter in *The Emergence of Entrepreneurship Policy*. David M. Hart (Editor), Cambridge University Press, 2003.

Iowa also benefits significantly when either (1) sponsored research is performed for Iowa corporations that then commercialize resulting technologies in the state or (2) universities make discoveries from federally sponsored research that they then license to in-state companies for commercialization purposes. Under these scenarios, the competitiveness of Iowa companies is improved through access to the university-developed technologies, and new markets are opened for Iowa product exports.

When technology is licensed to out-of-state enterprises, the continued benefit to Iowa is the flow of royalty/license revenues returning to the state from the out-of-state licensee. Typically, this will create lower state benefits than in-state commercialization; but, in some instances, it may be logical to license the technology to an out-of-state entity (such as when a dominant market player creates insurmountable barriers to entry or the product resulting from the discovery must be produced close to a required input that is not available in the state). The benefits of pure licensing should not be dismissed—for example, in licensing the Cohen-Bayer patents on recombinant deoxyribonucleic acid technology, Stanford University asked for a one-time license fee of only $10,000, but also required royalty rates ranging from 0.5 percent on sales of end products (such as insulin) to 10 percent on sales of research vectors and enzymes. By the time the patents expired in 1997, Stanford had more than 400 licensees.

Table 9 presents AUTM licensing data for Iowa universities for 2003.

Table 9: AUTM Licensing Data, FY 2003

FY 2003 Metric	University of Iowa	Iowa State University	University of Northern Iowa	AUTM Top Quartile for U.S. Universities	Median for U.S. Universities
Sponsored Research Expenditures	$292,035,000	$224,800,000	N/A	$292,994,000	$133,304,000
Invention Disclosures Received	75	134	1	101	47
U.S. Patent Applications Filed	49	45	1	57	22
U.S. Patents Issued	26	27	3	25	9
Licenses and Options Executed	44	187	N/A	30	9

FY 2003 Metric	University of Iowa	Iowa State University	University of Northern Iowa	AUTM Top Quartile for U.S. Universities	Median for U.S. Universities
Total Active Licenses/Options	239	1,106	N/A	143	48
Licenses and Options Generating Income	144	437	N/A	62	22
License Income	$8,762,838	$5,769,282	N/A	$4,117,369	$899,288
Average Revenue per Active Licenses/Options	$36,665	$5,678	N/A	$37,191	$15,572
Start-Ups Initiated	1	1	N/A	3	1
Disclosures per $10 Million Sponsored R&D	2.57	5.96	N/A	5.58	3.69
Patents Issued per $10 Million Sponsored R&D	0.89	1.20	N/A	1.22	0.82
Licenses Executed per $10 Million Sponsored R&D	1.51	8.32	N/A	1.28	0.84
License Income per $10 Million Sponsored R&D	$300,061	$256,641	N/A	$192,171	$69,214
Start-Ups per $10 Million Sponsored R&D	0.03	0.04	N/A	0.18	0.07
Start-Ups per License Executed	0.02	0.01	N/A	0.18	0.08

In Iowa, the leading academic institutions engaged in IT and associated research are active in each of the commercialization pathways. Research parks in Ames, Iowa City, and Cedar Falls contain IT companies directly formed by university faculty or generated directly by university innovations—so the innovation-to-new-company pathway is operating in the state. ISU has, for example, produced a small cluster of companies particularly around VR technologies. There also has been significant action in software, bioinformatics/ag-informatics, and the VLSI area.

However, the universities also are engaged in active sponsored research programs with industry in which IP ownership may be transferred or shared with the sponsoring organization. For example, a very good commercial research relationship is established at the University of Iowa in the Digital Human Modeling arena with Deere and Caterpillar. Under this relationship, IP ownership for the companies is based on the funding percentage provided by each company. Company sponsors get part ownership of technology, early access to it, and opportunity to invest in spin-off enterprises.

The universities in Iowa also have been proactive in recent years in changing rules, regulations, and policies that presented barriers to technology commercialization and faculty entrepreneurship. There is always room for improvement; but, within the past 24 months, significant strides have been made, such as the University of Iowa changing its royalty policies to provide the first $100,000 in royalties directly to the inventing faculty.

Despite great progress being made, there are still some issues and barriers to having a truly streamlined and optimized innovation-to-commercialization pathway out of Iowa's research universities. Some of the

key issues raised by the qualitative interviews with Iowa companies and university faculty include the following:

- Companies that view the universities/university departments as being rather challenging to work with when negotiating joint R&D deals and IP access.
- Universities being viewed as rather slow and unresponsive during negotiations.
- Challenges in encouraging and rewarding applied commercial research and faculty entrepreneurship and commercialization activities—particularly for younger faculty who believe that such activity will neither gain them recognition nor be taken into account positively in tenure decisions.
- A lack of early-stage pre-seed funds at the universities to progress technology and innovation toward proof of concept or to perform basic market evaluations.
- University entrepreneur assistance programs, incubators, and technology parks being viewed as seriously underfunded and understaffed. Tech transfer and IP protection staffing also is inadequate at the Iowa institutions. Even ISU, which has the largest staff, notes that it now seems to take 3 instead of 2 years to achieve patent protection.
- The ISU research park being out of space (although it is positive that demand has caused all of the space to be occupied).

CAPITAL FOR START-UPS AND EXPANSION

Battelle TPP refers to three primary ingredients necessary for successful technology-based economic development—technology, talent, and capital. It is certainly very encouraging that Iowa has the talented technologists and research scientists to generate new innovations and has access to many state-of-the-art technology resources. But, business generation and resulting economic development will still be only minimally realized if capital is not readily available to fund company start-ups and corporate growth.

On the plus side of the capital question in Iowa, a positive movement in capital availability is observed by interviewees, encouraged by growing angel networks and the state's insurance premium deal. TAI noted that there are now 10 angel groups present in Iowa, and deal syndication is starting to happen. The well-publicized State of Iowa collaboration with Acuity Venture Capital for anchoring venture financed deals in the state has been viewed as a very positive move—one that has already resulted in on-the-ground Iowa IT company formation. Others, such as Wells Fargo Venture Capital, may be interested in a similar type of deal. It also is notable that, with 450 banks and 160 insurance companies, Iowa has a major base of capital and a strong cadre of experienced business finance professionals.

In the Iowa capital arena, there are still, however, capital availability and access issues. At the first stage in the commercialization pipeline, a general lack of funds at the research universities to support very early, pre-seed, proof-of-concept investments presents a major barrier—ideally, the universities would be equipped with a pool of pre-seed investment funds that would be used on a competitive basis to fund early-stage initiatives at the $50,000 level. Small Business Innovation Research and Technology Transfer Program (SBIR and STTR) awards were discussed as early-stage financing options; but, those in the IT technology arena noted that it can take 2 years from application before SBIR/STTR funding arrives, and that is far too slow in the fast-paced IT sector.

At the other end of the financing spectrum, venture capital is viewed as very challenging for Iowa companies to access because the state lacks a strong venture capital community. As such, companies

seeking venture financing are forced to approach out-of-state venture firms (often on the coasts), with the risk that funding from such firms will come with an imperative to relocate to the coasts. In terms of general bank loan financing, it also was noted that, while Iowa has a large number of banks, they tend to be conservative and agriculture oriented and have strict requirements for lending backed by tangible assets (such as property) that technology companies (particularly those in software) do not have. Many interview participants also noted that legislative ups and downs regarding the Iowa Values Fund are sending a very mixed message to investors and entrepreneurs in the state regarding the strength of the state's support and commitment to new venture formation.

WORKFORCE DEVELOPMENT, AVAILABILITY, AND RETENTION

Human capital constitutes the "talent" required for successful technology-based economic development. The root cause of economic progress, and therefore higher wages and higher standards of living in modern western society, can be found in high levels of workforce innovation and productivity—gained in part by technology, but mostly through the education, skills, and ingenuity of the people who use and maintain that technology. Only through increased levels of productivity can standards of living grow; and it is the nations, states, regions, and individual firms that have the highest skilled workforce, other factors held constant, that will be the most productive, produce the best products or services at the lowest costs, earn the highest profits, and dominate markets. The lesson to be learned is a simple but profound one—namely, that industrialized states can no longer compete on the basis of low wages but must, instead, seek to create a high-skills workforce that will enable firms to pay high wages and still be price competitive. The strategy for a state like Iowa must be to make the state's workforce so productive that they will produce more than those in competing states and locations—thereby facilitating the growth of industry in the state and raising the overall standard of living.

The implication for Iowa is critically important for all involved in economic development. In a 21st century economy driven by high productivity and increasingly skilled processes, an unskilled workforce is no resource at all. It is only a potential resource, and that potential can be realized only through high-quality education, workforce education, and skills development.

The need for highly skilled and productive workers extends across all sectors of the economy, the IT sector included. Indeed, in the IT sector high skill and educational attainment are of particular importance. It must also be noted that technology and productive processes are being improved or supplanted at a rapid pace and that, particularly in the IT sector, the speed of technology turnover is extremely fast paced and product life cycles very short. In such a fast-paced, change-oriented working environment, a workforce has to be equipped with the personal learning skills and adaptability traits required to keep pace. Life-long learning is not just a catch phrase, it is becoming a necessity as it is increasingly unrealistic for most workers to expect that their job will continue to be done in the way they currently know it or even will exist at all in a recognizable form a decade from now. In this economic environment, it is absolutely imperative that Iowa produce a human capital output that has high levels of academic literacy, skills attainment, adaptability, and work ethic.

Currently in Iowa, the state is benefiting from generally good IT-sector human-capital capabilities. Companies in the IT space are generally complimentary regarding human capital assets in Iowa, with a typical company quote being that "a major Iowa asset is good people and good universities for recruiting." IT companies generally characterize Iowa's workforce as "excellent" in terms of skills, quality, and work ethic. Iowans are viewed as able to perform complex tasks without a lot of training. The

workforce quality in the state is thought to be giving Iowa IT companies a competitive edge, since pay rates for IT professionals range from average to below-average compared with national pay rates.

In many parts of the nation, especially those coastal regions that have experienced high-technology economic booms, IT labor turnover has become a significant problem. In many software and IT jobs, average employee tenure is now less than 1 year in many of the boom markets. Such high-velocity labor markets are economically beneficial in that a great deal of innovation and knowledge transfer is stimulated, but they are a great challenge to efficient operations in individual firms. IT companies in Iowa noted that they have had very good experiences with staff retention in terms of software personnel, and one of the largest employers of IT engineers in the state said it has only a 4.5 percent attrition rate. It is notable that even call centers (businesses notorious for high workforce turnover) are said to be satisfied with the rate of labor turnover in their Iowa operations. It was noted that attrition is sometimes a problem with foreign national workers who find it more difficult in Iowa to settle and fit in since the state has only minimal levels of cultural diversity.

Iowa's K-12 education system is viewed as generally high quality and more than capable of supplying the volume of well-educated high school graduates required to propel an IT labor pipeline. Some nominal concerns were expressed, however, that the overall performance of Iowa's normally excellent schools may be slipping. Moving up the education chain, Iowa's community college system is viewed very favorably and is notable for its responsiveness and flexibility in developing IT and technology-oriented 2-year programs, such as Indian Hills Community College's 2-year programs for hardware and network technicians. The series of state-supported 260 training programs also are viewed as strong contributors to Iowa's workforce preparation and skills development. At the higher end of the skills chain, Iowa's leading research universities are producing the volume of bachelor's and graduate degree candidates needed to fill positions within Iowa's IT sector—indeed, there is excess capacity in technology degree areas and many Iowa graduates are leaving the state to find technology-based employment.

While the IT workforce situation in Iowa is generally very positive, some issues are still observed by companies operating in the sector in the state. It was noted, for example, that the availability of staff goes with the business cycle; while it is currently sufficient, there were distinct problems accessing enough workers in the IT boom of the latter 1990s. Concerns also were expressed regarding the long-term pipeline of skilled IT personnel in the state. It was noted that enrollment in software/computer science degree programs at Iowa's universities is trending downwards, and the number of women going into computer science has dropped significantly. It was hypothesized that part of the problem may be misinformed high-school guidance counselors advising students to avoid these technology fields because the jobs are moving offshore.

One of the more vexing challenges facing IT operations in Iowa involves access to specialized technical skills or senior management skills that do not currently reside in the state. Recruiting people to Iowa is said to be a challenge, and successful recruiting tends to occur only with personnel who have some degree of prior exposure to the Midwest and its positive lifestyle attributes. The recruitment problem is further exacerbated by the fact that the IT sector is diffused across the state and not heavily concentrated in any one area—as such a geographic critical mass is not evident—and potential recruits worry that they will have to move again if they accept a position at an Iowa firm and it does not work out satisfactorily.

Lack of diversity in Iowa's workforce also presents challenges; some companies felt it is exacerbated by the regional INS, which is said to be very difficult to work with in terms of international students, work permits, and green cards. It also was noted that, for IT companies doing business with major government

entities, it can be challenging to find disadvantaged business enterprises (DBEs) as joint venture partners for meeting government contract requirements.

While companies were generally complimentary regarding the state's series of training initiatives and support, it was noted that one major gap exists in these programs. State funding is not available for support of generalized re-skilling and training—something that is of crucial importance in the very fast moving IT sector.

Given the pace and trajectory of technology change, companies were asked to identify areas of potential workforce need for the future. They believe that Iowa should start directing resources toward the following general categories of skilled personnel:

IT Workforce Need	Details
Systems Architects	Major financial service companies noted a need for senior staff who understand systems and business function architecture distributed across multiple lines of business. This is a "horizon scanning" function. Also need lower-level entrants who have a better understanding of end-to-end system structure and components. Need understanding of integration of legacy systems with modern PC environments.
Systems Security and Assurance	Growing demand for personnel skilled in systems and network security. Also need strong capabilities in software testing and assurance of system functionality and accuracy.
Business/Management Trained in IT Concepts	Need a more technically savvy output of MBA types and finance executives. Want to see a technology/IT core track within these programs.
Project Management	General skills in the management of complex, time-dependent projects.
Information Security Engineers	Said by financial service companies to be very difficult to recruit to Iowa. There is a need to create an education program in the state in this area.
E-Business Experts	Technical personnel with expertise in implementing e-business solutions.

Quality of Life and Other Soft Factors

Skilled technology workers are in demand and thus have the luxury of selecting the place in which they would like to live and work. Therefore, the quality of place and quality of life enjoyed by a location's residents may be an important contributor to technology-based economic development success. Iowa has recognized this trend and has been working throughout the state to provide improved public assets and recreational amenities. Many areas of the state (such as Des Moines and Cedar Rapids) are engaged in active initiatives to improve their urban lifestyle amenities, such as developing downtown housing and attractions.

Overall, companies note that Iowa offers a great quality of life, especially for families where the schools and safe and family-friendly neighborhoods come actively into play. It was certainly noted that Iowa lacks some resources enjoyed in other states (such as mountains or the oceans), but such unique geographic features cannot be replicated. Iowa has to work with the geographic assets it does have (rivers, trails, a central U.S. location, four distinct seasons, lack of traffic congestion, etc.).

Interviewed parties did discuss several aspects of Iowa's quality of life that do need to be addressed to enhance the prospects for IT and technology-based economic development. These include the following:

- Airline service (too infrequent and costly)
- A weak and inaccurate general "image" of Iowa, and a complete lack of a technology image for the state
- Limited recreation and entertainment choices for younger, usually single technology staff
- Relatively high levels of personal taxation—presenting a problem for employees and also for Subchapter S companies
- Lack of major housing developers operating in Iowa who are focused on developing housing complexes that would appeal to younger professionals—and a lack of suitable executive housing in Iowa's more rural communities.

GOVERNMENT AND GOVERNMENT RELATIONS

Government is an important partner in technology-based economic development, as evidenced by the fact that this report is being prepared for the IDED. Government controls important facets of key infra-structure, public schools, higher education, tax policy, finance and incentive packages, etc.—all factors of crucial importance to business success.

On a very positive note, the qualitative interviews showed that IDED is viewed as an active proponent of growth in the IT sector. The state has helped some companies by cosigning on loans to keep loan costs down (something important for software companies that have few tangible assets to use as security), and the state training programs are likewise seen as innovative and on-point. IDED's export promotion activities are seen as helpful, and generally the IT sector is seeing progress in terms of the government recognizing its importance to the state and desiring its growth. The fact that IDED is now aligning to have specialized industry specialists, such as the bioscience specialist position held by Karen Merrick, also is viewed as a positive trend.

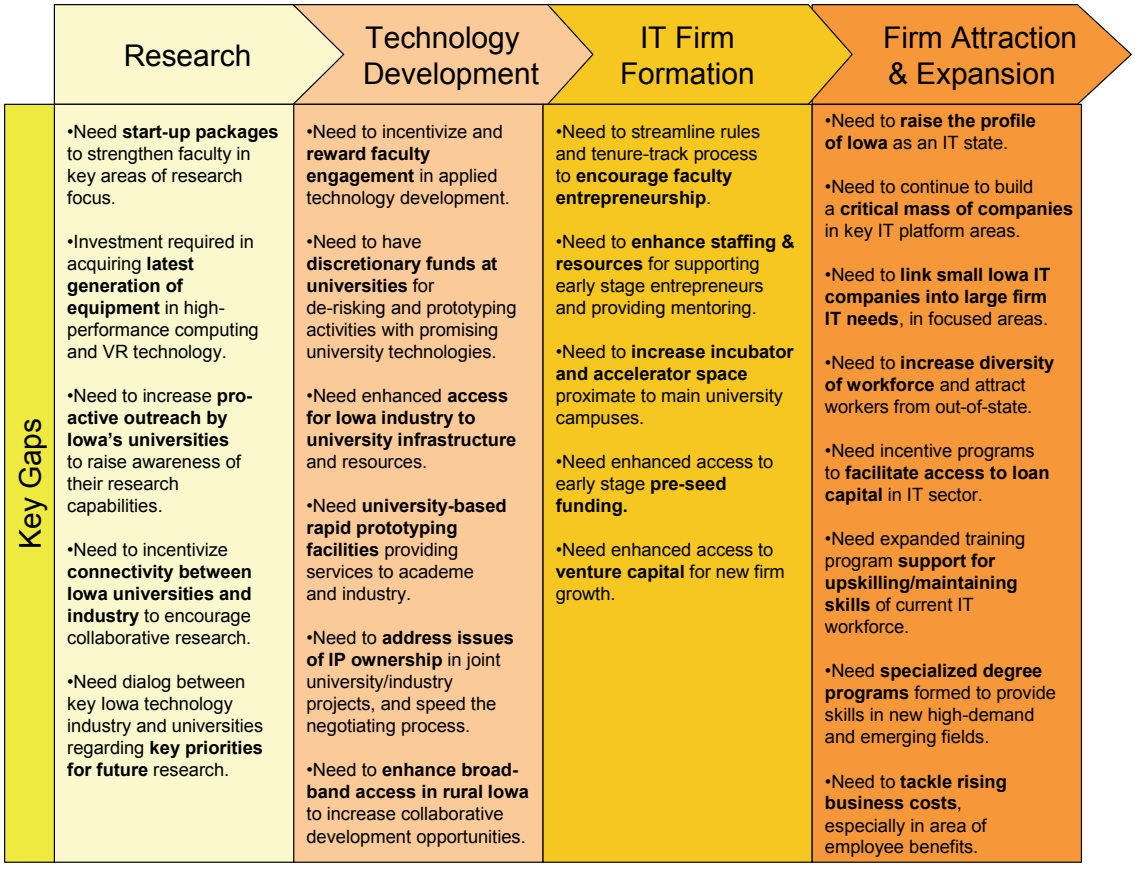
Interviewees did, however, note a number of areas pertaining to government in Iowa that could be improved. Most notable among these were the following:

- Members of the State Legislature, which tends to be dominated by rural representation, do not have an adequate level of appreciation for IT sector opportunities and business sector needs.
- The state is viewed as rather rigid in its purchasing policies and not structured to favor Iowa-based companies in IT bids.
- At the local level, there are so many players in economic development (Cedar Rapids, for example, has four such groups) that there is confusion about which group is appropriate for assistance.
- There is a perception that government in Iowa does not commit to initiatives for the long haul—rather, it changes directions too frequently and is unpredictable.
- Managing sales and use tax in Iowa is considered a challenge given that each of the 99 counties in the state seem to have their own way of doing things. Companies would like to see technology solutions to this through an automation of the process, thereby making compliance easy for smaller firms.

- Companies do not feel that they have a good level of awareness of the various state and local government programs and regent university strengths that may be available to help them.
- Companies noted a need for government incentive programs that are oriented toward wealth creation rather than job creation.
- There is a need to develop training support programs oriented toward skills enhancement and upskilling of existing personnel because of the rapid pace of technological change faced by companies and IT users.

For Iowa to achieve its mission and accomplish an IT-based economic development vision, several key issues will need to be addressed. These issues represent current gaps in creating an integrated wealth-generating continuum of R&D to full-scale and ongoing IT business operations. Figure 12 summarizes the key gaps that need to be addressed to realize Iowa's IT development potential.

Figure 12: Iowa's Key Gaps Along the Information Technology Development Continuum



Strategic Framework for Developing Iowa's Information Technology Economy

VISION

A vision for IT's place in Iowa's economy by the year 2015 would be as follows:

> *Iowa is a state where information technology (IT) industries (producers and users) partner with education institutions to make Iowa a national and international specialized center in several niche areas of IT (e.g., RF technology, finance and insurance IT applications, and advanced visualization systems). Iowa's IT base is differentiated from others b: (l) its customer base in finance and insurance, biosciences, and advanced manufacturing industries; (2) its research university strengths in producing IT graduates and being nationally competitive in IT research; and (3) its strong IT services industry, which offers value-added services as well as design support and solutions.*

RECOMMENDED INFORMATION TECHNOLOGY PLATFORMS FOR DEVELOPMENT

States such as California, Massachusetts, Virginia, and Maryland have very strong established leadership positions in IT that are both broad (covering most aspects of IT) and deep (covering them in detail). It is unrealistic and unnecessary for Iowa to expect to compete at such an across-the-board level in IT; but, it is realistic to develop niche focus areas in Iowa IT that are still large enough to have a significant and substantial impact on Iowa's relatively compact economy and working population. In other words, because Iowa has a relatively small population in comparison to many other states, huge initiatives and economic advancements are not necessary for a substantial beneficial impact on the state. Rather, Iowa has the good fortune to be able to work on focused programs that target specific, high-value, wealth-creating opportunities.

Qualitative and quantitative investigations of Iowa's IT strengths make it clear that the state has good R&D and production-based IT strengths in areas poised for further growth and development. These strengths may form the basis for IT growth and development platforms, leveraging Iowa's unique skills to attain a leadership position in niche, high-value IT subsectors. As noted earlier in this report, Iowa has signature strengths in several technology areas; but, four stand out as near-term[29] technology platform development opportunities, while two stand out as longer-term advanced technology potential opportunity areas.

Ideally, the criteria for selecting near-term areas of opportunity for development should be

- Areas with existing research focus strengths at Iowa institutions
- Areas where some base of commercial activity is already emerging or established within the state

[29] "Near-term" in this context refers to areas of opportunity with a 2-to 5-year time horizon in which not only *research* growth can occur, but also *broader commercialization and economic* growth.

- Areas with a distinct opportunity to leverage Iowa's comparative advantages to create competitive marketplace benefits
- Fields with significant product market potential
- Fields that link to or reinforce other IT and technology strengths in the state—thereby helping to enhance other fields as they expand.

Based on these ideal criteria, the following near-term, high-priority platforms for advanced IT development in Iowa are recommended:

Specialized IT Applications in Finance and Insurance—Leveraging Iowa's base of major finance and insurance "original equipment manufacturers" and the base of specialized IT companies to build a major position in advanced IT applications for finance and insurance around "information security and information assurance," "critical applications testing and quality assurance," and "advanced data mining and database analysis."

RF (Wireless) Technology—Using Iowa's powerhouse corporate R&D and production presence in these technologies and university R&D skills to design and build the next generation of wireless devices for military and civilian applications.

Advanced Visualization and Human-Computer Interaction Systems—Using Iowa's advanced expertise in data visualization, 3-D graphics, VR environments and human-computer interaction to develop innovative applications and technologies for interfacing with and controlling technological systems.

High-Reliability, Ruggedized Systems—Using Iowa's strengths as a center for extremely high-quality and high-tolerance manufacturing and expertise in designing robust military electronic systems to develop a signature presence in IT systems that have extreme levels of reliability and in-service durability.

Longer-term platform development opportunities should be pursued that will leverage early leadership among Iowa institutions in two areas that show great promise for the future. These are largely R&D-based platforms at the present time, with limited Iowa industry presence and include **Optical Electronics and Photonic Systems** and **Quantum Electronics and Spintronics**.

Each of these platforms is discussed in further detail below:

Technology Platform: Specialized IT Applications in Finance and Insurance

Field Definition: This platform will focus on building specialized IT capabilities in Iowa customized to the existing and emerging needs of the large IT user base in the finance and insurance sector. The CIOs of Iowa's leading finance and insurance companies, such as The Principal and Wells Fargo, have expressed support for a concept in which the existing university R&D base and the small to midsize Iowa IT company base is leveraged to develop specialized marketable products and services targeting the large financial service and insurance sector.

Strengths to Build Upon: It is recommended that this platform initiative initially focuses in the following areas (chosen because of demand in Iowa for the services/products among the leading IT-user base and because of established and emerging skills within the university and corporate R&D sector related to IT):

- *Information Security and Information Assurance*—This is an area of critical importance to finance and insurance companies and an area of R&D for Iowa's institutions. ISU is a particularly strong

player in this area, and its Ames location is convenient for collaborative work with the large companies located in Des Moines.

- *Advanced Data Mining and Database Analysis*—The finance and insurance sector generates massive volumes of electronic information from their operations and their customers. Advanced applications and technologies for mining these huge datasets for information and intelligence of commercial value are distinct opportunity areas raised by the industry. Expertise exists within both the University of Iowa and ISU in these areas.
- *Critical Applications Testing and Quality Assurance*—The term "mission critical" very much describes IT and software systems within the finance and insurance industry. The integration of legacy systems with new technologies brings with it substantial challenges in maintaining data integrity and assuring that applications are functioning as intended and providing 100 percent reliable results and output. ISU, the University of Iowa, and the University of Northern Iowa each have capabilities in software engineering and testing, evaluation, and assurance analysis that should be applied to the needs of the finance and insurance sector in the state.

Ideally, R&D consortia should be formed in each of these opportunity areas. The consortia would include the major finance and insurance IT leaders (the customer); leaders of academic research programs in related fields; and, very importantly, existing IT companies that are capable of developing and commercializing applications and technologies in these fields. The goal should be to build the state's future economy on robust new technology platforms with major national and global market potential in the finance and insurance sectors. (Further discussion of Iowa's strengths in this area may be found on page 55.)

Markets: Applications, services, and solutions in the three focus areas for finance and insurance outlined above have very large-scale market potential, and it is likely that products and services that are developed in Iowa would have application to broader market segments as well. The U.S. market for information security is anticipated to grow 19 percent annually through 2008, driven in part by efforts to integrate security on enterprise-wide bases. High-end activities such as consulting/risk assessment and outsourcing are leading gains, followed by encryption hardware, biometric access controls, spam filters, and virtual private network hardware/software. Overall, the U.S. information security industry is estimated to have a market size of $8.7 billion.[30] Data mining, including predictive analytics, is a fast-growing field; and the Aberdeen Group notes that, as of 2004, the market for data mining software and services had reached $4 billion, with a growth rate of 200 percent annually. In terms of information assurance and quality control, the market potential is very large. Software errors have been estimated to cost U.S. industry $60 billion annually, according to the National Institute of Standards and Technology, meaning that there are large-scale opportunities for solutions sold on a savings-realized basis.

Technology Platform: RF (Wireless) Technology

Field Definition: RF technology is used in many applications, such as television, radio, cellular phones, radar, and automatic identification systems. Over recent decades, wireless and RF technologies have grown steadily on a diet of largely military applications, such as electronic warfare, signal intelligence, and electronic countermeasures. Since the 1980s, however, the industry morphed into advanced RF commercial market applications as wireless markets began to open up and show their promise. A growing

[30] www.freedoniagroup.com/Information-Security.html

subset of the RF field is RFID, which describes the use of RF signals to provide automatic identification of items.

Strengths to Build Upon: Corporate leaders interviewed in Iowa note that the state, particularly in the Cedar Rapids area, is home to the largest concentration of RF engineers and design talent in the United States. Rooted in the long-term manufacturing and R&D presence of Rockwell Collins (focused on largely military and avionics applications of RF technology), the Cedar Rapids region has become home to several leading companies engaged in RF/wireless solutions for business applications (including such notable companies as Intermec in wireless data collection and Siemens in wireless data transmissions in terrestrial transportation applications). Iowa's universities also contain defined talent in RF engineering and solutions, although the linkages between the commercial and university strengths are not as robust as they could be. (Further discussion of Iowa's strengths in this area may be found on page 54.)

Markets: BCC Research calculates that, on a broad level, the worldwide wireless infrastructure market reached $177.5 billion in 2004.[31] The market is expected to expand at an average annual growth rate of 2.5 percent, reaching $201.4 billion by 2009. BCC also notes that the total U.S. market for products and processes using RF technologies is projected to rise at an average annual growth rate of 33 percent and reach $100.5 billion in 2008. The Yankee Group estimates that the RFID market opportunity will reach $4.2 billion in 2008. According to *Computer Business Review Online*, citing a Datamonitor study: "Five years from now, the RFID software, hardware and services market is expected to be dominated by North America, with the Europe, Middle East and Africa (EMEA) region forming the next most important region for RFID development. North America is expected to have a market share of $2.7 billion, compared to $2.0 billion for EMEA and a combined share of $1.4 billion from Asia Pacific and the rest of the world making up the remainder of the total RFID market in 2010."

Technology Platform: Advanced Visualization and Human-Computer Interaction Systems

Field Definition: This is a fairly broad field with tremendous growth potential. The proliferation of data, the ubiquitous use of computational systems, and the ever-increasing complexity of tasks that data and computing make possible, are creating demand for advanced methods of data visualization and human-computer interaction and control. Opportunities exist in the design of human-computer interaction hardware, software, and complete systems and in the application of these systems to complex tasks. This platform also has strong ties into the biosciences and advanced manufacturing sectors that Iowa seeks to grow.

Strengths to Build Upon: At the current time, Iowa's principal strengths are rooted in R&D within the regent universities, especially ISU and the University of Iowa. At ISU, work is centered at the VRAC, part of the Institute for Physical Research and Technology (IPRT), where a broad range of applications of VR, visualization, and human-computer interaction is being investigated. At the University of Iowa, advanced work proceeds through the College of Engineering with the Center for Computer-Aided Design with large-scale programs in VR, the virtual human/soldier project, multibody dynamics, and simulation. The University of Iowa is also home to the National Advanced Driving Simulator and its VR/simulation R&D. Iowa's R&D strengths in VR and advanced visualization technologies have started to bear fruit with companies such as Fakespace and CADSci. Advancements in Iowa give the state a strong position to build upon, not only in more traditional VR and 3-D applications, but also in highly advanced aspects of human-computer interaction and interfacing. (Further discussion of Iowa's strengths in this area may be found on page 54.)

[31] http://www.bccresearch.com/editors/RG-246R.html

Markets: Insight Media reports that the visualization and simulation industry was valued at nearly $43 billion in 2003 and is experiencing an annual growth rate of 9.8 percent. Continued growth in the sector is predicted, with a projected market value of almost $78 billion by 2008. Insight notes that one of the fastest-growing parts of the market is related to the war on terrorism. This includes disaster recovery training, hazardous materials handling, counter-terrorism training, and a variety of military training applications. Together, 14 military and civilian applications accounted for more than $8 billion in industry revenue in 2003, up more than 75 percent from 2002. The medical/biotech sector is also a heavy user of VR and advanced visualization and simulation products, and is estimated to have a $8.7 billion demand for these applications. Other top applications of advanced visualization and simulation are in chemical manufacturing, business data visualization, psychotherapy, construction planning and design, energy exploration and production, archeology and paleontology, biotechnology research, medical research, and training for heavy equipment operations. These applications are estimated to account for more than $16 billion in revenue in 2003.

Technology Platform: High-Reliability Ruggedized Systems

Field Definition: This field is composed of the design, development, and engineering of electronic devices and associated components designed for very high levels of reliability, often within extreme operating environments and mobile applications. The military is a high-demand customer for high-reliability ruggedized systems, but so too are many commercial customers who use mobile data collection and computing systems (such as warehouses, package delivery companies, rental car companies, hospitals, and commercial aviation firms). The field is not constrained to mobile systems, however, since certain mission-critical applications require fixed systems with extremely high-reliability and redundancy features (systems such as computer servers, computer-integrated production machinery, and medical imaging devices).

Strengths to Build Upon: On the academic R&D side, the University of Iowa has focused work on reliability-based design, durability, and optimization in IT systems through the Center for Computer-Aided Design. Related to this technology area would be ISU's Center for Non-Destructive Evaluation and the ISU Information Infrastructure Institute. A number of Iowa corporations are engaged in the design and development of specialized high-reliability rugged systems, including Intermec (mobile data collection devices), Crystal Group (high-reliability rugged servers), and Rockwell Collins (avionics systems). (Further discussion of Iowa's strengths in this area may be found on page 54).

Markets: VDC Corporation,[32] in a 2001 report, estimated that demand for rugged mobile computing systems would reach $6 billion by 2005. Clearly, however, the market extends far beyond computers, into a range of mobile and mission-critical devices and applications that must be able to withstand day-to-day use in environments providing multiple stresses.

Longer-Term Technology Platform Opportunities

- **Optical Electronics and Photonic Systems—**The Optical Science and Technology Center at the University of Iowa is a cross-disciplinary science center with 20 faculty members. A number of the engaged researchers have international reputations in optical science and laser technology, and key research programs at the Center are focused on laser spectroscopy and photochemistry, photonics and optoelectronics, ultrafast laser development, condensed matter physics, materials growth techniques, device physics/engineering, surface chemistry, chemical sensors, environmental chemistry, polymer

[32] http://www.mobileinfo.com/Reports/VDC_report.htm

science, plasma physics, and nonlinear optics. Nanotechnology is also a growth area within the Center. Optics, lasers, and associated technology are obviously important component technologies in multiple areas of IT systems and hardware—this extends from consumer applications for lasers, such as CD technology and printing technologies, to ultra high-end military systems using optics and laser sensing in comprehensive missile detection and defense technologies.

- **Quantum Electronics and Spintronics—**University of Iowa work in quantum electronics and spintronics is also notable, although commercial application of technology from the research may be long term in IT terms. Nevertheless, the product potential for work taking place at the University of Iowa, especially in the area of spintronics and its application to reprogrammable transistors based on electron spin and charge, shows great promise. R&D work is also taking place related to quantum-state secure communications and quantum cryptography—very high-end security applications with future IT potential.

Strategies and Actions

While Iowa has existing strengths in IT and information services, and some significant platforms of opportunity to build upon, specific areas of action and assistance are required to realize the state's true IT development potential. As the SWOT and gap analyses identified, Iowa has weaknesses and threats to offset and gaps to fill in order to optimally advance IT as a principal component of its economic future.

For IT and information services to realize their potential as strong components of Iowa's economic engine, the state will need to simultaneously address both the strengthening of research drivers and the efficient emergence and growth of IT enterprise in the state. Five strategies have been identified, incorporating 16 specific actions, to drive Iowa's IT development forward, strengthen its research base, and build a critical mass of specialized IT enterprise in the state. These strategies are as follows:

Strategy One: **Increase R&D and technology relationships between Iowa IT industry and Iowa universities**

Strategy Two: **Increase small IT firm linkages with larger IT-user firms**

Strategy Three: **Address capital gaps and barriers to business development of IT industry**

Strategy Four: **Retain, attract, and develop the IT workforce**

Strategy Five: **Raise the profile of Iowa as a specialized technology state**

These strategies and associated actions are summarized in Table 10, followed by a detailed narrative description and explanation on subsequent pages. Implementation of most of these strategies and actions is anticipated within 5 years. *Immediate* actions should be undertaken in the next 12 to 18 months, *short-term* actions should be undertaken in 18 months to 3 years, and *mid-term* actions should be implemented in the 3- to 5-year time period.

Table 10: Iowa's Information Technology Development—Strategies and Actions

Strategy	Action	Time Frame
STRATEGY ONE: Increase R&D and technology relationships between Iowa IT industry and Iowa universities	Action 1: Convene an" Iowa IT Development Summit" to bring university researchers and company technologists together to profile state capabilities in R&D and applied IT commercial development	Immediate
	Action 2: Form a Strategic Technology Platform Fund to strengthen and accelerate the R&D base, talent pool, and university-industry connectivity around the state's core IT platforms through matching grants and collaborative technology platforms	Short-term
	Action 3: Develop a structure to facilitate joint-venture development of "orphan" IT innovations at Iowa companies and universities	Short-term
STRATEGY TWO: Increase small IT firm linkages with larger IT-user firms	Action 4: Develop an awareness program to raise the profile of smaller Iowa IT firm capabilities	Immediate
	Action 5: Provide incentives for larger user firms to work with Iowa firms, vendors, and educational institutions generally and in targeted platforms	Short-term
STRATEGY THREE: Address capital gaps and barriers to business development of IT industry	Action 6: Enhance access to growth and expansion capital for Iowa IT companies	Short-term
	Action 7: Enhance and facilitate entrepreneurship by university faculty	Short-term
STRATEGY FOUR: Retain, attract, and develop the IT workforce	Action 8: Engage Iowa community colleges in development of 2-year programs in identified IT technology skill areas	Short-term
	Action 9: Develop specialized degree and graduate degree/certification courses in key priority technology areas, including, but not limited to, information security, software testing and quality assurance, high-end systems integration, high-reliability engineering, and advanced data mining	Short-term
	Action 10: Develop and implement a communications program aimed at Iowa K-12 teachers and guidance counselors, keeping them up to date on current and emerging career opportunities in IT	Immediate
	Action 11: Develop a state-funded training program specifically geared to assisting in periodic upskilling of existing IT workers	Short-term
	Action 12: Provide continued support for ongoing initiatives aimed at enhancing workforce diversity in Iowa	Mid-term
	Action 13: Provide financial support for Iowa students enrolling in targeted programs	Mid-term

Strategy	Action	Time Frame
STRATEGY FIVE: Raise the profile of Iowa as a specialized technology state	Action 14: Engage in active promotions and outreach aimed at raising the national profile of Iowa as a technologically advanced state	Mid-term
	Action 15: Use Iowa government as test bed for new government-oriented IT operations and products	Mid-term
	Action 16: Ensure that Iowa's economic development "tool kit" encourages and promotes IT firm development	Immediate

Strategy One: Increase R&D and Technology Relationships between Iowa IT Industry and Iowa Universities

The evaluation of IT strengths and weaknesses in Iowa identified strong capabilities in the corporate IT sector and also within academic R&D at Iowa's regent universities. It was notable, however, that there is considerable room to improve the connectivity and collaboration between the commercial and academic IT-related organizations. While some industry-university joint projects are occurring in IT areas (such as John Deere's work with ISU using VR for manufacturing process and product design), for the most part the companies interviewed noted that they are relatively unaware of university R&D capabilities, areas of research strength in IT, or their willingness to work on sponsored research for commercial entities.

Multiple research studies have found very strong connections between university-based R&D and the generation of large-scale positive economic-development effects. These positive impacts can occur through multiple pathways and include the following:

- Generation of new business enterprises or joint ventures with existing commercial entities
- Transfer of innovative new technologies to existing local industry for commercialization
- Joint development of advanced technologies by university-corporate R&D teams
- R&D based improvements to existing local industries' products, services, and processes.

In the primary technology platform areas identified earlier in this report, Iowa strengths are evident on both the corporate and university sides of the equation. There are, however, relatively limited joint R&D connections between these two sides in all but one of the platforms (Table 11).

Table 11: Iowa's Information Technology Platforms

Platform	Iowa Industry	Iowa Universities	Connectivity
Specialized IT Applications in Finance and Insurance	Major IT user organizations in finance and insurance (e.g., Principal, Wells Fargo, Reliastar) Multiple small software and IT vendor companies providing support services and technology to the sector.	Research programs in data mining, information security and information assurance, software quality control, and other IT systems issues. Research programs in finance and insurance	Very limited levels of observed connectivity. Mostly there is only a recruiting relationship, not joint R&D relationships.
RF (Wireless) Technology	Large cluster of expertise in corporate R&D in RF technology (includes companies such as Rockwell Collins, Intermec, and Siemens)	Electrical and electronic engineering research programs. RF and microwave research programs	Very limited levels of observed R&D connectivity. Mostly there is only a recruiting relationship, not joint R&D relationships.
Advanced Visualization and Human-Computer Interaction	Small base of Iowa companies, largely based on university technology spin-outs	Major R&D presence in this field of technology at both ISU and the University of Iowa.	Strong levels of connectivity because of university technology driving creation of the sector in Iowa. Also use of university VR capabilities by Iowa manufacturing firms.
High Reliability Ruggedized Systems	Company base in very high quality, ruggedized mobile systems (e.g., Intermec, Rockwell Collins) and extreme performance servers (Crystal Systems).	R&D programs related to reliability, systems ruggedization, reliability testing, nondestructive testing, integrated circuit design, software testing, etc.	Very limited levels of observed R&D connectivity.

Iowa is evidently missing an opportunity to connect the corporate sector strengths in these platforms with the university R&D strengths in which the whole would be greater than the sum of its parts. Iowa's universities contain large numbers of academicians with research interests directly related to key platform areas, but for the most part they have limited relationships with Iowa businesses operating within their research fields.

Iowa needs a strategy to help encourage and incentivize formal connectivity between the commercial and academic platform players, thereby leveraging the intellectual capital and resources of both sides to generate economic growth for the state. Multiple specific actions are recommended below to help facilitate connectivity and joint R&D initiatives.

Action 1: Convene an "Iowa IT Development Summit" to bring university researchers and company technologists together to profile state capabilities in R&D and applied IT commercial development.

Rationale: Currently, the level of knowledge in the commercial IT sector in Iowa about the R&D capabilities of the state's leading universities is low. An event is needed to jump-start awareness building and to promote potential collaborations and connections between industry and academic R&D teams.

Action Details: A 2-day summit and R&D showcase should be held in Iowa, with the first day dedicated to each university outlining its overall capabilities, facilities, and research core competencies in IT and related disciplines (such as computer science, software engineering, electrical and electronic engineering, mechanical engineering, industrial design, and physics). A very broad invitation should be extended to companies and stakeholders in Iowa that are in IT and IT-related NAICS codes and to major IT-user enterprises. The second day of the event should focus on each of the four primary platforms, with a separate program for each platform in which both university and industry R&D groups can profile their focus areas, research thrusts, and future goals.

Assuming the event is successful, and given the pace of technological change and advancement in IT, it should be repeated on an annual basis.

Resource Requirements: $50,000 state grant to TAI and the regent universities to organize and host the event.

Time Frame: Immediate

Lead Organization(s): IDED, TAI, CIOs of large IT users, and the regent universities.

Action 2: Form a Strategic Technology Platform Fund to strengthen and accelerate the R&D base, talent pool, and university-industry connectivity around the state's core IT platforms through matching grants and collaborative Technology Platforms.

Rationale:

Two specific subelements are proposed:

1. Investments in the research enterprise for equipment, facilities, faculty, and operating costs of centers of application around identified IT platform areas
2. Matching grant program to ensure connectivity and linkage of these platform investments with industry needs, desires, and innovation demands.

Several platforms have been identified previously that provide niches for industry-university connectivity in Iowa. It is likely that the prioritized R&D initiatives may require making certain investments to reinforce the R&D capabilities of the platforms. For example, in the advanced visualization and VR area, ISU's VR equipment is aging and will need to be updated to the latest generation of equipment. A concerted push in specific platform areas also may require the recruitment of specialized new faculty and research teams, with an associated requirement to fund competitive start-up packages and provide suitable advanced laboratory space.

The lack of strong connections between Iowa industry and its research universities in IT suggests the need to develop ways to increase and encourage collaboration. Experience elsewhere shows

that matching grants are an effective way to encourage connections and collaboration. In addition to holding a summit to learn what is available in the university enterprise, flexible funds need to be available to encourage industry to seek university partners and university partners to seek industry.

Action Details: The proposed Strategic Technology Platform Fund will serve as a vehicle to make strategic state investments in areas that will serve to build research stature, required infrastructure, and connectivity linkages. It is suggested that the Fund have two components:

1. A matching grants program to catalyze key investments required to strengthen and accelerate the IT platforms with industry interests
2. A one-time investment fund for other specialized needs related to one or more platforms.

It is recommended that the Iowa Values Fund administer and manage the Strategic Technology Platform Fund since it is consistent with its current efforts and the Board represents a partnership of several state agencies, including the IDED and the Board of Regents. The Values Fund should initiate a process to secure proposals from research universities and industry through collaboration mechanisms detailed in the implementation section of this report. To assist Iowa's existing IT corporate base, encourage university-industry collaborations, and spur new enterprise development, an IT R&D Matching Challenge Grant Program is proposed. Funds would be awarded on a competitive basis with a 3:1 industry match required, including at least a 1:1 cash match. Project funding would total at least $100,000 to $250,000 per year, with maximum awards limited to two years. This level of funding can provide the scale of impact required to spur high-level, collaborative research. University intellectual property policies would apply; however, the industry participant would have a "first right of refusal" for an exclusive licensing option for a funded project.

Resource Requirements:

The portion of the Fund for investments in infrastructure, programs, and the research enterprise should start at $1 million a year, rising to $3 million by year five to continue through year ten. Funding sources could be the Iowa Values Fund or a separately authorized program. The matching grant program to connect the IT industry and higher education should begin at $500,000 per year, increasing to $2 million a year by year five continuing through year ten. In total, funding would begin at $1.5 million and reach $5 million a year by year five.

Time Frame: Short-term

Lead Organization(s): Iowa Values Fund, IDED

Action 3: Develop a structure to facilitate joint-venture development of "orphan" IT innovations at Iowa companies and universities.

Rationale: It is often the case that inventions and technologies fail to be developed to a state's benefit because the generators of that technology do not wish to further commercialize an innovation themselves. It may be the case, for example, that a company like Rockwell Collins would generate innovations in RF technology that, while having commercial potential, do not pertain to their core business model and thus are not priorities for further development by Rockwell Collins. In such events technologies may simply be shelved (becoming effectively "orphan" technologies), or they may be licensed to companies whose core business is in the

specific technology area (with the odds being that these companies would not be located in Iowa). In rare cases the technology may be significant enough that it warrants the generation of a spin-off company to commercialize the technology (indeed the Siemens operation in Cedar Rapids was generated this way based on Rockwell Collins originated technologies). It would be beneficial for Iowa to have a formal system for identifying these technologies and working with the inventing entities to assure the innovation's commercialization is pursued from a suitable Iowa business base.

Action Details: This concept could apply equally to bioscience or advanced manufacturing innovations, as well as to IT innovations. A commercialization facilitation entity should be established to mine companies and research teams in the platform areas for key innovations and technologies that may have commercial potential. Under a non-disclosure agreement with the owners of the technology, the commercialization entity will evaluate the commercial potential of the technology and work to determine the optimal structure for moving the technology forward from an Iowa commercialization base. The commercialization facilitation entity will negotiate access to the technology and form a joint venture or other suitable entity to advance the technologies development. The feasibility of such an entity would be considerably enhanced if it had its own investment funds for seeding new venture formation and for leverage in reaching joint venture agreements. (The concept of a statewide technology commercialization entity is further discussed in *Iowa's Bioscience Pathway for Development*.[33])

Resource Requirements: To be really effective, a commercialization entity will need to have significant investment funds to leverage. It is proposed that a Prototype Development Fund be created at $3 million capitalized in year two of the financial plan from bond financing, rising to $5 million in year five and continued through year ten.

Time Frame: Short-term

Lead Organization(s): IDED

Strategy Two: Increase Small IT Firm Linkages with Larger IT-User Firms

As noted earlier, Iowa's IT producer base is predominantly composed of small firms in the IT services sector. There is also a large IT-user base in the state, especially concentrated in the large finance and insurance sector, but also across numerous manufacturing OEMs with substantial IT demands. IT-based economic development can, therefore, be further encouraged through increasing the connectivity between the small firm IT producers and the large IT users. The idea is to leverage the IT budgets of the large IT-user companies (both in Iowa and in surrounding states) to help boost the sales, growth, and R&D activity of Iowa's smaller IT producer firms.

Two specific actions are recommended for helping to build these linkages. The first is to develop an awareness campaign and joint marketing program, led by TAI, to raise awareness of the distinctive capabilities of Iowa's IT producer firms—this should be directed both to Iowa IT users and companies in surrounding midwestern states. The second recommendation works to boost the incentives for Iowa IT-user companies to buy services and IT products from Iowa companies and to work on joint R&D programs to develop the next generation of specialized IT products and services.

[33] See *Iowa's Bioscience Pathway for Development*, prepared by Battelle for IDED, July 2004, for further detail.

Action 4: Develop an awareness program to raise the profile of smaller Iowa IT firm capabilities.

Rationale: Iowa is home to a broad variety of small firms operating in the IT services sector. For the most part, these small firms have quite limited market penetration, providing services mostly to customers in and around the Iowa community in which they are located. Like most small firms, the time constraints and pressures of operating a small business limit the amount of marketing and outreach they can do, thereby limiting their growth. One way to enhance IT-based economic development for the State of Iowa is to assist these companies in increasing awareness of their capabilities in a broader market area—especially into surrounding midwestern states and beyond. This will encourage Iowa exports and help promote significant growth in this small IT company base.

Action Details: This task should be led by TAI and should begin with development of a basic categorization system into which each Iowa small IT company is placed. Categories might include, for example, systems security consulting, Web design and e-commerce, custom programming, and network services. A promotional literature package should be developed, together with a Web site, to showcase the broad capabilities of Iowa companies and help raise the profile of Iowa as an IT services hub. Emphasis should be placed on variety of services by category, quality of services and the Iowa workforce, and value-for-money provided by Iowa's IT services. The promotion should target three primary audiences: (1) potential customers in Iowa and surrounding midwestern states, (2) potential customers in high-cost states (California, New York, and Massachusetts to begin with), and (3) a limited number of VC firms operating within the IT sector (to again help raise Iowa's IT profile and showcase small Iowa IT company strengths to potential investors).

Resource Requirements: Funding should be through TAI budget and fundraising, expected to be $50,000 per year.

Time Frame: Immediate

Lead Organization(s): TAI

Action 5: Provide incentives for larger user firms to work with Iowa firms, vendors, and educational institutions generally and in targeted platforms

Rationale: This recommended action is specific to the Specialized IT Applications in Finance and Insurance Platform. Numerous small to midsize (but mostly small) Iowa companies provide IT services to the large financial service and insurance companies in the state. The companies provide a range of services including custom software and applications development, systems integration services, systems maintenance and upgrade services, information security consulting, and other broad applications. Despite the strong base of knowledge in these small companies and the many IT demands and needs of the large IT-user organizations, there have been relatively few breakthrough applications and technologies that would form the basis for midsize or larger commercial entities able to serve the broader national and international financial services and insurance IT market. Interviews with the CIOs and senior management of some of Iowa's largest financial service and insurance companies highlight considerable willingness among these companies to form robust initiatives focused on developing and commercializing technologies and applications in key areas of business, most notably in information assurance and security, quality assurance, software and applications testing, and advanced data mining.

Action Details: Under the administration of the IT Economic Development Taskforce and the Specialized IT Applications in Finance and Insurance Platform Subcommittee, the State of Iowa should fund a matching grant program designed to encourage joint R&D work between Iowa's large finance and insurance IT-user companies and consortia of Iowa's smaller IT services and software companies. Funds should be provided contingent on the resulting technologies being developed as commercial products for export by Iowa companies, rather than just as custom applications for proprietary use by individual financial service or insurance companies. Iowa companies would benefit by being (1) adopters and developers of technologies and applications to meet their needs and (2) potential owners/investors in the resulting consortia companies.

Resource Requirements: An initial fund of $500,000 should be set up by IDED to provide matching funds for seeding up to five R&D joint collaborative initiatives at $100,000 each—to be matched 2:1 by company investments. It is anticipated that this fund would grow to an investment of $1 million a year by year six.

Time Frame: Short-term

Lead Organization(s): TAI and IDED, with Platform Subcommittee

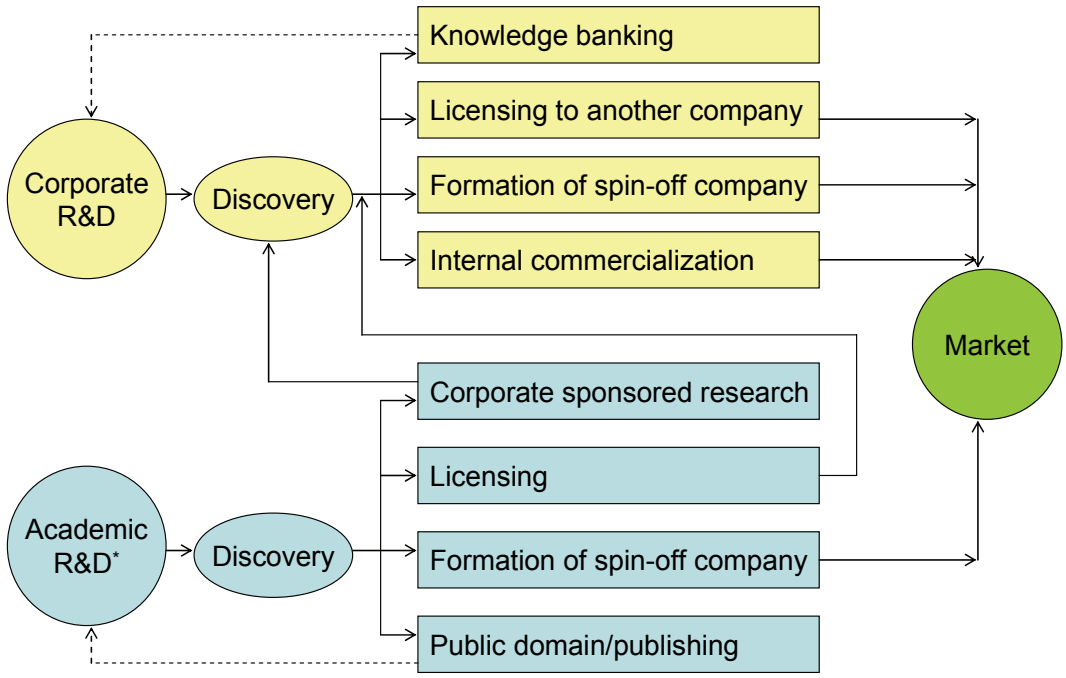
Strategy Three: Address Capital Gaps and Barriers to Business Development of IT Industry

The ultimate goal of a technology-based economic development strategy is to enhance wealth and job creation in an economy through the commercialization of technological innovations and growth of existing technology enterprises. In Strategy One, actions designed to strengthen the IT innovation engine—boosting collaborative R&D to spur enhanced levels of technological innovation in key IT platform opportunity areas—were outlined. Realizing economic benefits from such innovation, however, requires that concerted efforts be made to assure that the pathway from innovation to commercialization is as efficient as possible and that major barriers to commercialization do not exist.

Historically, Iowa is not among the most dynamic of states when it comes to entrepreneurship and new business development. The Progressive Policy Institute's *2002 State New Economy Index* ranks Iowa in the bottom quartile of states for "economic dynamism," a metric defining a state's ability to foster the creation of new firms, support firms that innovate, and cultivate a culture that is epitomized by fast-growing, entrepreneurial companies. The Progressive Policy Institute ranked Iowa 37th in the nation in the number of scientists and engineers in the workforce, 32nd in industry investment in R&D, 42nd in venture capital, and 32nd in innovation capacity—so there is certainly a need to upgrade the state's performance in the innovation-driven economy.

Figure 13 shows the complex process of moving from R&D in either a corporate or academic setting to the launch of successful products in the marketplace. This process must operate as efficiently as possible to maximize economic returns on R&D investments.

Figure 13: Commercialization Pathways for Corporate and Academic R&D



* Similar structure for federal labs

Commercializing technology and building economic value chains involve bridging the gap between innovations and discoveries and development of those discoveries by IT businesses. A state must adequately address three macro-level components to achieve commercialization success:

- The technology transfer functions, including policies, structure, incentives, and approach. Cutting-edge programs actively encourage faculty and student engagement in commercialization initiatives and aggressively pursue faculty disclosures, patenting, and licensing. New business enterprise formations are actively encouraged where justified, as well as the active marketing of university IP to existing business enterprises. In leading universities, such functions are also being expanded to include active technology commercialization.
- Commercialization activities, including assessing the market and commercial viability of intellectual property, finding funding support to assess the value of research discoveries, developing a commercialization plan, and funding proof-of-concept/reduction-to-practice development. Purdue University, for example, has structured funding mechanisms to support this.
- Firm start-up support, whereby the technology transfer and commercialization functions are broadened to provide searches for seed capital, management talent, and marketing assistance. Some universities have created third-party intermediaries to play this role (examples include Baylor, the Mayo Clinic, and Carnegie Mellon University), and some communities have formed stand-alone organizations such as the St. Louis BioGenerator and the Oklahoma Technology Commercialization Center.

The investigations performed by Battelle in the development of the IT Strategy confirmed what was heard during development of *Iowa's Bioscience Pathway for Development*, namely that Iowa is not yet at "high-performance levels" in terms of commercialization encouragement and support and that there are certain roadblocks or barriers to efficient movement of innovations into Iowa-based commercialization—especially the movement of university-generated innovations. Key barriers include the following:

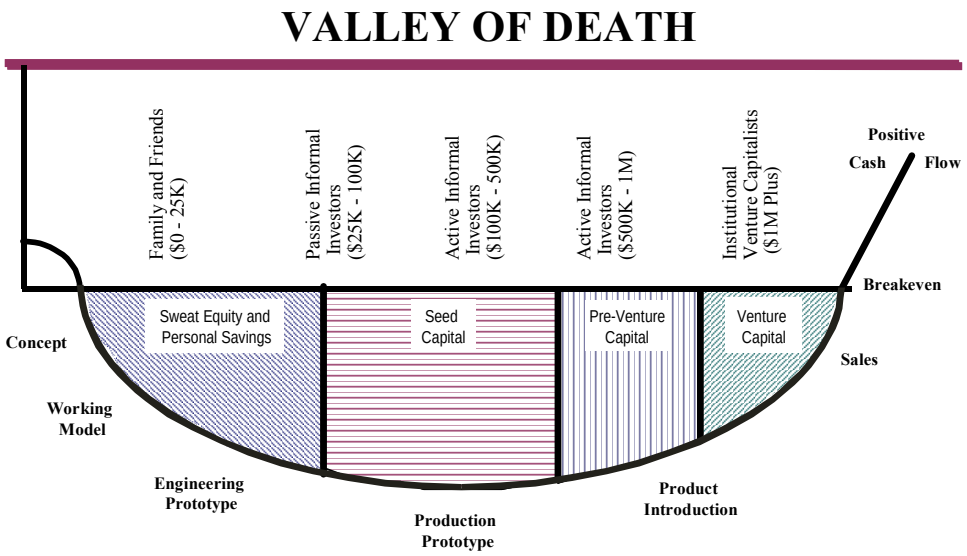
- A comparative lack of capital for pre-seed investigations of the potential commercial viability of an innovation and for the development of working models and engineered prototypes
- A lack of formal recognition or reward procedures for faculty involvement in applied research, patenting, and translational activities leading to innovation commercialization
- Restrictions on faculty involvement and ownership in commercial entities generated by their innovations
- Limited resources for providomg advice and experienced mentorship to would-be entrepreneurs launching IT-related or technology ventures
- Limited space to house new commercial ventures
- Limited university funds for timely patent protection of innovations
- Difficult and slow negotiation processes between universities and companies regarding joint R&D initiatives and intellectual property ownership
- Limited seed and early-stage funding for new company start-up and growth.

Taken together, these barriers present a rather formidable impediment to efficient commercialization of innovations coming out of the platforms or any other area of IT innovation—particularly those with university R&D routes. However formidable these barriers may seem, Battelle did note that, over the year that lapsed between developing the Iowa's Bioscience Pathway for Development and this IT Strategic Roadmap, Iowa's universities made important strides in improving their commercialization processes. At the University of Iowa, for example, policies have changed to encourage enhanced levels of invention disclosures through a guarantee that the first $100,000 in licensing/royalty revenues will be provided to the inventing faculty member(s). Also, university attitudes are changing, for the better, regarding faculty engagement in entrepreneurial endeavors and applied commercial research. Furthermore, the capital availability situation is improving, with concerted efforts by IDED to form angel networks and encourage discretionary funding for university commercialization investigations. Taken together, the positive movements bode well for developing a more efficient pathway to university R&D commercialization in Iowa. To further accelerate and reinforce this progress, the following actions are recommended.

Action 6: Enhance access to growth and expansion capital for Iowa IT companies.

Rationale: Companies interviewed thought that the early investment rounds for companies requiring angel investors have become less problematic in Iowa. Rather, the key financing challenges are in the key growth phases when significant venture capital investments would be required (or, in the case of slower-growth companies, traditional loan capital). In business commercialization circles, the term "the Valley of Death" (Figure 14) is used to describe the seed and pre–venture capital rounds—descriptive of the fact that money is usually particularly challenging to raise at these stages—yet, in Iowa, it appears that key challenges are felt most at the "edges of the valley," in the very early pre-seed phase and then at the venture capital phase.

Figure 14: Financial Capital Life Cycle



Action Details: The State of Iowa has already recognized the venture capital challenge and has been quite innovative in designing programs to encourage further VC investment in Iowa. Most notable among these have been the investments made into Acuity Ventures projects that are located in Iowa. The Acuity deal has already resulted in the formation of three Iowa IT companies. More of the same type of financial arrangements made with venture firms active particularly in technology areas within and supportive of the targeted IT platforms would be a good move for Iowa.

It also should be noted that software companies have low levels of tangible assets to use as collateral in business loan finance applications. This is proving to be problematic in a state with traditionally conservative banks—institutions that are used to holding farmland and other tangible property as loan collateral. Loan guarantee backing provided by the State of Iowa for high-priority software companies would be beneficial in opening up traditional loan finance avenues for these organizations.

Resource Requirements: The Acuity Ventures agreement called for $2 million in state investment to leverage $10 million in Acuity investment. Given that this level of investment leverage has worked with Acuity, it is likely to appeal to other VC firms. A further $2 million should be allocated by Iowa Values Fund, targeted at leveraging investment deals with VC firms in the focused platform areas around IT.

Time Frame: Short-term

Lead Organization(s): IDED

Action 7: Enhance and facilitate entrepreneurship by university faculty.

Rationale: Iowa can grow its IT-based economy by supporting and nurturing the growth of its existing commercial base of IT companies, but it also must be actively working to develop the

next generation of companies focused in new and innovative IT R&D-based discoveries. For Iowa to succeed as a future IT-focused state, its R&D-generating institutions must be places that celebrate and facilitate the commercialization of discoveries and innovations. Doing university-based commercialization well requires a complex chain of support and encouragement services at the universities, including incentives to encourage faculty involvement, facilitating conflict-of-interest policies, access to commercialization space, provision of advice and professional assistance, efficient technology transfer, and timely IP protection and incubation services. Faculty need to be shown that commercializing their innovations is actively encouraged, well-supported, and "doable." Those states and regions of the country that are performing well as technology growth poles tend to share one factor—they are home to universities that have embraced the commercialization mission and put in place policies, procedures, and proactive services to facilitate it.

Action Details: Iowa's regent universities should be encouraged to establish a culture and policies that provide clear rewards and incentives for faculty engagement in commercialization, translational research, and industry collaborations. This requires that the highest levels of university administration set this as a high priority and that a clear message be sent that technology commercialization is viewed as equal in importance to research and education. A review should be undertaken of all regent university procedures and policies related to entrepreneurship and commercialization against national best practices, and then changes should be made to bring policies and procedures in line with these best practices. Once changes and facilitating procedures are in place, the university must then actively promote commercialization internally and be seen as being on the side of the entrepreneurial faculty members, working with them to find ways to make necessary actions happen.

Resource Requirements: No costs

Time Frame: Short-term

Lead Organization(s): Iowa Board of Regents and the individual regent universities.

Strategy Four: Retain, Attract, and Develop the IT Workforce

In the 21st century economy, economists such as Lester Thurow[34] are predicting that human capital will be the key differentiator between winning regions and losing ones. Without skilled people, technology innovation cannot occur and advanced technologies cannot be deployed. Without skilled technical and managerial personnel, capital also is extremely difficult if not impossible to secure.

Gray and Herr note[35] that

> *Among all the riches a nation may possess, its people—its human resources, its human capital—are the most important. The value of this human resource depends not on size, however, but on the occupational and intellectual skills its members possess. At least in this regard history is clear: a large "unskilled" population is a detriment to national economic growth and to a high standard of living.*

[34] Thurow, L. *Head to Head: The Coming Economic Battle Among Japan, Europe and America.* New York: Morrow and Company. 1992.
[35] Gray, Kenneth C., and Herr, Edwin L. *Workforce Education*. Massachusetts: Allyn and Bacon. 1998.

The root cause of economic progress, higher wages and higher standards of living in modern western society, can be found in high levels of workforce productivity—gained in part by technology, but mostly through the skills and ingenuity of the people who use and maintain that technology. Only through increasing levels of productivity can standards of living grow; and it is the nations, regions, communities, and individual firms that have the highest skilled workforce, other factors held constant, that will be the most productive, produce the best products or services at the lowest costs, earn the highest profits, and dominate markets.

The lesson to be learned is simple but profound—developed nations, states, and regions cannot compete on the basis of low wages but must, instead, seek to create a high-skills workforce that will enable firms to be innovative, efficient, pay high wages, and still be price competitive. The strategy for a state like Iowa must be to make members of the state's workforce so productive that they can produce more than those in competing locations—thereby increasing the growth of industry in the state and raising the overall standard of living. This must be accomplished for the IT sector, as it must in all focus sectors of the Iowa economy.

A great deal has been written about knowledge as the driver of the U.S. economy, but there is much misunderstanding about those who possess this knowledge. Some have interpreted this to mean that an elite with 4-year college-degrees, but the fact is that skills and knowledge are increasingly required across the total workforce. The creative elite (scientists, engineers, software developers, etc.) may be a critically important driver of invention and new products and services, but they constitute only a small proportion of a state's labor force. The rest of the workforce must produce new products and services in volume and at a higher level of productivity than can be achieved elsewhere. As Gray and Herr[36] note

> *If the route to success is inventing new products, the education of the smartest 25 percent of the labor force is critical. If the route to success is being the cheapest and best producer of products, new or old, the education of the bottom 50 percent of the population moves to center stage. This part of the population must staff those new processes. If the bottom 50 percent cannot learn what must be learned, new high-tech processes cannot be employed. If the education of the bottom half moves to center stage, so too must workforce education, which we have defined as education and training below the baccalaureate level.*

The implication for Iowa is critically important for all involved in economic development to grasp. In a 21st century economy driven by high productivity and increasingly skilled processes, an unskilled workforce is no resource at all. It is only a potential resource, and that potential can be realized only through workforce education and skills development.

It also must be noted that technology and productive processes are being improved or supplanted at a rapid pace—and this is particularly the case in the rapidly churning IT arena. In such a fast-paced, change-oriented working environment, a workforce has to be equipped with the personal learning skills and adaptability traits required to keep pace. Lifelong learning is becoming a necessity because it is completely unrealistic for most workers to expect that their jobs will continue to be done in the way they currently are, or even that they will exist in a recognizable form a decade from now. In this economic environment, Iowa cannot afford a workforce that has low levels of academic literacy, skills attainment, and adaptability.

[36] Gray, Kenneth C., and Herr, Edwin L. *Workforce Education*. Massachusetts: Allyn and Bacon. 1998.

Skilled people drive the knowledge economy; ergo skilled people drive the IT economy. Iowa is blessed with a comparatively high-performance K-12 education system, a large and well-resourced network of community colleges, and a series of regent universities with a distinct track record of innovation and talent development in key science and engineering disciplines. The fundamental building blocks for high-performance talent development are in place, but refinement is necessary to fully meet the challenges of an IT-based knowledge economy. In addition, Iowa has been experiencing a talent drain, as its talented graduates are recruited to out-of-state employment centers by the promise of higher wages, a quality of life perceived to be more dynamic or exciting, or a broader cadre of technology businesses in which to build and advance their careers. Retaining and attracting talent are as important to Iowa's future as home growing talent.

As noted above, IT is an extremely fast-moving technological area. Products may often have less than an 18-month market window before the next generation of products must be fully developed and ready for distribution. In such an environment, purely reactive demand-driven education and training courses are likely to place Iowa behind the technology curve, since, by the time they are established, staffed, have their curricula developed, and enroll participants, the technology targets may be moving on. What Iowa needs are predictive education and training programs built on the generally agreed-upon future needs of the Iowa IT industry and key IT-user industries—particularly in those areas related to platform development. The following actions are specifically recommended for Iowa.

Action 8: Engage Iowa community colleges in development of 2-year programs in identified IT technology skill areas.

Rationale: While much IT R&D and advanced development will be driven by personnel with 4-year and advanced graduate degree credentials, having a broader production and service-based IT employment system will dictate pursuing skills development at the 2-year and certification levels. Iowa's first-rate community college system is an important resource to be deployed in generating the technical workforce required for IT growth.

Action Details: As other efforts in this Roadmap move forward, the Board of Regents and its member institutions, the community colleges, and the vocational technical leaders should develop a program that is administered through the state workforce investment board to develop and launch new IT programs and curricula that come out of the work of the state's trade association. This IT Innovation Workforce Fund is designed to provide funds to initiate cutting-edge IT curriculum in the state as well as to be used to offer multi-institutional offerings.

Resource Requirements: $250,000 per year for 10 years to initiate new programs, with tuition and fees recouping future costs.

Time Frame: Short-term

Lead Organization(s): IDED, Iowa Workforce Commission Board, community colleges.

Action 9: Develop specialized degree and graduate degree/certification courses in key priority technology areas, including, but not limited to, information security, software testing and quality assurance, high-end systems integration, high-reliability engineering, and advanced data mining.

Rationale: To be competitive, Iowa has to be in the high-technology, high-value end of the IT spectrum with specialized products of high quality. Developing and producing products and

services in this specialized end of the market require highly educated and skilled personnel. Certain degree programs will need to be made more robust or developed more fully to meet potential IT and platform demands in Iowa.

Action Details: The key areas in which Iowa has an opportunity to develop leading-edge programs fall into two fields: (1) computer science/management information systems (MIS) and (2) engineering (electrical and electronic engineering, mechanical engineering, software engineering, and production engineering/manufacturing engineering). For the most part, the required programs and capabilities already exist at the one or more of the three regent universities, and what will be needed is refining and customizing the curriculum to meet the prospective needs of the platforms. Key specialized program areas are likely to include emphasis in the following areas:

- Engineering for high reliability and durability in electronic products
- Testing and evaluation
- RF and wireless technology design and engineering
- VR and advanced human-computer interaction
- Information security and information assurance
- Software and systems testing and quality assurance
- Advanced data mining and database technology
- Legacy and complex system integration and design.

For the most part, the types of degree being discussed would be taught at the master's level and above, with perhaps specialized post-graduate certificate programs in the mix.

Resource Requirements: The universities should be able to refine their existing curricula to meet most of the potential demand areas outlined above. Still, it is likely that some faculty hires and specialized equipment and research resources may be required to support these initiatives. Funding for this program would come out of the Strategic Technology Platform Fund, and no additional dollars are proposed herein.

Time Frame: Short-term

Lead Organization(s): IDED, Board of Regents, Taskforce Subcommittees.

Action 10: Develop and implement a communications program aimed at Iowa K-12 teachers and guidance counselors, keeping them up to date on current and emerging career opportunities in IT

Rationale: Concerns were expressed to the Battelle project team (by both university and corporate representatives) that Iowa student enrollments in computer science, MIS, software engineering, and associated disciplines are declining. It is believed that high school counselors and other advisors to high school students erroneously believe that software and IT employment opportunities in the United States are declining.

Action Details: Quantitative statistics to back up the premise that there will continue to be large-scale employment opportunities in the computer science, software, and IT sectors will need to be compiled. A communications strategy and campaign should then be developed, with the assistance of the Iowa Department of Education, to reeducate counselors and other student advisors regarding the opportunities in IT. After rolling the communications program out within

Iowa, consideration should be given to extending the information program into surrounding states that have historically been a source of students for Iowa's university-based IT degree programs.

Resource Requirements: $100,000 annually for 10 years for campaign development and implementation.

Time Frame: Immediate

Lead Organization(s): IDED, Iowa Department of Education, Taskforce.

Action 11: Develop a state-funded training program specifically geared to assisting in periodic upskilling of existing IT workers.

Rationale: IT is such a fast-moving field, with rapid advancements occurring in technology platforms, software systems, and markets, that a major cost for companies in the sector revolves around upskilling and skills maintenance of the existing workforce. Currently, training support programs in the State of Iowa are geared toward reskilling displaced workers and training people in new fields, as opposed to upskilling and maintaining the skills of existing Iowa workers.

Action Details: An additional program in the260 series (the series of very innovative state workforce training programs) should be studied for feasibility. The program would provide a 1:2 match ($1 from the state for every $2 from a company) in terms of training dollars for IT company worker skills maintenance and skills development courses.

Resource Requirements: Ceiling of $200,000 in year one, rising to $500,000 in years five through ten.

Time Frame: Short-term

Lead Organization(s): IDED

Action 12: Provide continued support for ongoing initiatives aimed at enhancing workforce diversity in Iowa.

Rationale: Companies in the IT sector, particularly the larger companies, expressed concerns regarding the diversity (or lack thereof) of the available IT workforce in Iowa. For some companies, such as those engaged in government contracting work, a lack of diversity makes it challenging to meet workforce diversity requirements. More generally, a lack of workforce diversity is felt to be a potentially limiting factor in the creativity of the workforce (the provision of varied cultural and educational perspectives) and problematic for attracting workers who may be ethnically, racially, or culturally diverse to the state.

Action Details: The state has identified diversity as a problem and has attempted to address the issue with Iowa's communities in the past. These prior efforts met with quite considerable resistance at the community level. Iowa's leadership is aware of the issue, and we raise this as an action because we agree with senior state government officials that diversity enhancement needs to be a priority for the state.

Resource Requirements: To be determined

Time Frame: Mid-term

Lead Organization(s): IDED

Action 13: Provide financial support for Iowa students enrolling in targeted programs.

Rationale: Between 1998 and 2002, the number of science and engineering doctoral degrees awarded to U.S. citizens at U.S. institutions fell 11.9 percent to 14,313, according to the Commission on Professionals in Science and Technology, a nonprofit research group. As a result, the United States has become more dependent on non-Americans for its most-educated positions in science and engineering. Between 1990 and 2000, the proportion of foreign-born people with Ph.D.s in the science and engineering labor force rose from 24 percent to 38 percent, according to the National Science Foundation. However, the pipeline of foreign talent has been shrinking. The U.S. State Department issued 20 percent fewer visas for foreign students in 2001 than in 2000, and the rate fell further between 2001 and 2002, according to the National Science Board.[37] As countries such as India and China rapidly develop their own economies, they are providing jobs at home for their best and brightest (people who previously would have strived to come to and remain in the United States). It is, therefore, imperative that young Iowans be actively encouraged to enter higher-education in science, computer science, and engineering disciplines if growth and innovation in the IT sector are to continue. Financial incentives should be put in place to help support and encourage enrollment in key targeted programs at Iowa's regent universities.

Action Details: Encouragement and financial support programs should focus on graduate degrees for Iowa residents in key IT and disciplines related to the priority IT platforms. A scholarship fund should be established, providing between $1 million and $3 million annually to help cover tuition and fees for Iowans entering these high-priority programs. A long-term Iowa commitment should be made to sustaining this program, and it should be communicated aggressively to high school students and their advisors, as well as students enrolled in suitable undergraduate disciplines.

Resource Requirements: Beginning in year three, an investment of $1 million, rising to $5 million in years five through ten.

Time Frame: Mid-term

Lead Organization(s): Iowa Board of Regents, state government/IDED

Strategy Five: Raise the Profile of Iowa as a Specialized Technology State

In some regards, perception and knowledge of Iowa IT approach the importance of the actual development of IT services and products within the state. Multiple parties interviewed in the corporate IT sector noted that they have a very difficult time selling their products and services outside of Iowa and the Midwest because Iowa simply has no visibility or credibility as a technology-driven state. Iowa has some leading-edge companies in IT and electronics, has notable research and education programs in its universities, and an extremely capable workforce for high-quality IT work—but these capabilities and strengths are quite unknown outside the state, and not particularly well recognized even within Iowa. In some regards, the same problem holds true in manufacturing and human medical biosciences as well.

Iowa is known and recognized for its agriculture, a heritage of which the state is justifiably proud. It has not, however, successfully moved beyond its agricultural heritage. Other states have been more successful in altering their image and achieving a more well-rounded technological reputation. Examples include the following:

[37] http://techrepublic.com.com/5100-22_11-5299911.html

- *North Carolina*—long known as a southern state steeped in the traditions of tobacco farming, textile manufacturing, and furniture manufacturing. Now North Carolina is recognized for its high-technology skills in the biosciences and advanced technology because of the investment in, and promotion of, the Research Triangle.
- *Georgia*—once seen as a sleepy southern state known for fruit farming (especially peaches). Now Georgia is successfully diversified in its technology reputation in areas such as advanced communications and media, with considerable growth in an around Atlanta and highly successful programs reinforced by the Georgia Research Alliance.
- *Texas*—long regarded for energy production (oil and gas) and as home to a major cattle ranching industry. Now Texas is noted as one of the high-technology hubs of America, with cities such as Austin lauded as key destinations for skilled technology workers.
- *Wisconsin*—certainly known for cheese and dairy production. Now Wisconsin is quite well recognized for its advanced technology in the biosciences and technology, especially centered around the University of Wisconsin–Madison.

Having low awareness levels and a lack of a positive image in technology brings tangible penalties to Iowa. As noted above, Iowa IT companies find it difficult to raise awareness, sell their products, and gain exports for the state. Also, Iowa IT companies find it challenging to recruit senior talents and specialized technologists to the state since people with these in-demand skills believe they may be coming to an agricultural backwater, with few opportunities for IT career advancement.

This is not to say or imply that the state has not tried to raise its profile in areas outside of agriculture—it has. Rather, there is clearly a need for a more concerted, long-term, committed effort to generate a high-technology signature for Iowa. To help accomplish this, the following actions are recommended.

Action 14: Engage in active promotions and outreach aimed at raising the national profile of Iowa as a technologically advanced state.

Rationale: Iowa needs to raise its profile and move beyond the narrow perception of its being an agricultural state. A broader recognition of Iowa as a state active in research and corporate activity in various high-technology areas must be built. This will assist technology sectors in achieving broader sales outside the state and in their attractiveness to skilled human capital.

Action Details: IDED should review its current promotional awareness-building programs to assure that they are appropriately promoting capabilities in the key technology focus areas of the state (IT, the biosciences, and advanced manufacturing). A communications firm with proven experience in producing and managing successful awareness-building campaigns for other states should be brought in to conduct a review of current and planned Iowa communications initiatives and to make recommendations regarding refinements or even redirection. Whatever the final campaign and strategies, Iowa needs to commit to a specific technology branding and follow through with active communications and promotional activity sustained over the long haul (i.e., more than a decade).

Resource Requirements: Beginning in year three, an investment of $2 million, rising to $5 million in years six through ten.

Time Frame: Mid-term

Lead Organization(s): IDED

Action 15: Use Iowa government as test bed for new government- oriented IT operations and products.

Rationale: Iowa can help grow and reinforce its IT industry by being a more active/proactive customer for the state's IT companies. In terms of applications in information security, advanced communications, mobile systems, etc., the state can be an important customer and test-site for new technologies.

Action Details: State government must obviously work in the public interest to achieve value-for-money in the expenditure of its citizens' tax dollars. This does not, however, mean that it should always contract with low bidders; if low bidders for products and services are located outside of the state, the economic leakage of payments fails to engender positive multiplier effects within the state. A broader view of contracting should be taken, whereby in technologies and services related to key priority development sectors in Iowa, the state makes proactive efforts to secure services from Iowa companies. In effect, this becomes a "buy in the circle program" extended on a statewide basis. Multiple technology companies in the state, such as the Siemens transportation operation in Cedar Rapids, count government as a key customer base—by serving as an anchor customer and test-bed site for key strategic technologies, Iowa can help support the growth of its IT company base. To begin with, Iowa should consider setting aside a certain percentage of the state technology purchasing budget that will be earmarked for expenditure only with Iowa-based companies and operations in strategic platform areas.

In addition, the State of Iowa should help support local efforts to expand and enhance its IT infrastructure, particularly in rural Iowa, which often lacks competitive commercial services. For example, one recent success story involves Marshalltown, Iowa, a small rural community that significantly expanded its IT infrastructure in June 2005. The community has substantially leveraged a $35,000 investment in wireless fidelity (WiFi) over 20 blocks in downtown Marshalltown by attracting a large broadband cable provider, Mediacom, to the region. Mediacom will provide 10-megabit cable service to households in Marshalltown at $19.95 per month (versus $40 per month currently). In essence, Marshalltown's small WiFi investment has enabled the community to contract for the fastest download speeds in Iowa for the price of a dial-up connection. Mediacom also has agreed to help widen the wireless hot zone considerably. In addition, as a direct result of the WiFi zone, the community has helped create a climate for entrepreneurial success. Within the first 60 days of the WiFi service being available, three companies located within the hot zone, in part because of the high-speed Internet access.

The Marshall Economic Development Impact Committee (MEDIC) now plans to extend the WiFi concept across all 17 communities in the county. State support of such efforts will help rural Iowa to become more distinctive when it comes to entrepreneurial growth and the ability to enable businesses to compete.

Resource Requirements: No costs, use existing resources

Time Frame: Mid-term

Lead Organization(s): IDED

Action 16: Ensure that Iowa's economic development "tool kit" encourages and promotes IT firm development.

Rationale: The attraction and growth of IT business enterprises is a highly competitive field. As other states and regions have come to recognize the preeminent importance of the innovation economy and its key constituent components such as computer science and engineering, they have focused efforts to ensure that their incentive programs, tax codes, legal codes, and other government-controlled factors are supportive of technology and IT sector growth. For Iowa to be a competitive location for the attraction and retention of the IT industry, it must ensure that its government policies, regulations, and codes are encouraging rather than discouraging Iowa investment. Furthermore, incentives, policies, procedures, and laws should be evaluated to assess their positive or negative impact on entrepreneurship, the start-up of businesses, and the spinning-out of technologies from the state's universities.

Action Specifics: IDED should initiate a review of its programs to ensure IT start-ups and young, growing firms can take advantage of its various programs.

Resource Requirements: No costs, use existing resources

Time Frame: Immediate

Lead Organization(s): IDED, Taskforce

Implementation Plan

The previous sections of this report evaluated Iowa's position in IT and information services by outlining Iowa's current IT base (in terms of both industry and research bases); assessing the state's competitive position and its IT development strengths, weaknesses, opportunities and threats; outlining a vision and mission for Iowa's IT development; identifying gaps to be addressed; and proposing a five-strategy, 16-action program to address gaps, build upon IT platform opportunities, and significantly improve Iowa's standing in IT development for the next 10 years. This section lays out the major actions critical to success, the immediate action priorities, the resources required, the organization and structure for moving this IT development roadmap forward, and the measures of success and accountability.

This Implementation Plan for Iowa's IT development roadmap is designed to catalyze public and private sector collaboration and public sector investment, focused on filling "market gaps" that the private sector cannot or will not undertake on its own. But addressing gaps, while necessary, is not sufficient. The State of Iowa will need a set of public and private sector leaders and champions committed to working to raise funds and secure support for the specific strategies and actions outlined herein. This commitment will need to be sustained over the course of the next decade to ensure that the necessary changes are made, gaps filled, and actions taken.

Wherever possible, existing entities' roles and responsibilities should be expanded to implement the recommended strategies and actions. The preference should be to reconstitute or use existing organizations and programs wherever possible in the implementation of this Roadmap. Stakeholders should be encouraged to use this approach in terms of efficiencies and, equally important, in terms of achieving results.

Critical Actions

Realizing the full IT economic development potential outlined by this Roadmap will require that certain critical actions are successfully implemented. Specifically, the ultimate success of the strategy hinges on the forward movement of three activities, forming the fundamentals of Iowa's IT critical path. These three critical actions, quite similar to those recommended as critical actions in the *Iowa's Bioscience Pathway for Development*,[38] will ultimately determine whether Iowa will become a leading state in IT-based economic development. These critical actions are as follows:

- Convene an **"Iowa IT Development Summit"** to bring university researchers and company technologists together to profile state capabilities in R&D and applied IT commercial development.
- **Form a Strategic Technology Platform Fund** to strengthen and accelerate the R&D base, talent pool, and university-industry connectivity around the state's core IT platforms through matching grants and collaborative technology platforms.
- Develop a structure to **facilitate joint-venture development of "orphan" IT innovations at Iowa companies and universities.**

The above actions will ensure that the strengths of Iowa in IT are leveraged and further built; industry and academe work together on joint R&D initiatives to develop commercial innovations from IT research and

[38] See *Iowa's Bioscience Pathway for Development*, prepared by Battelle for IDED, July 2004, for further detail.

specific IT platforms; funding and support are available to develop IT entrepreneurs and their business ventures; and the regent universities are actively engaged and encouraging IT development and commercialization in the state.

Immediate Priorities

Immediate work plan priorities are those steps that should be undertaken in the first 12 months of strategy implementation regardless of how critical they are to the overall strategy. Several immediate priorities can be implemented right away, while others will need to be planned and allocated funds before they can become fully operational. The following actions should be undertaken in the first year:

- Convene an "Iowa IT Development Summit" to bring university researchers and company technologists together to profile state capabilities in R&D and applied IT commercial development.
- Develop an awareness program to raise the profile of smaller Iowa IT firm capabilities.
- Develop and implement a communications program aimed at Iowa K-12 teachers and guidance counselors, keeping them up to date on current and emerging career opportunities in IT.
- Ensure that Iowa's economic development tool kit encourages and promotes IT firm development.

Resource Requirements

For each action, Table 12 indicates the time frame of the action, breaks out state funding needs into two 5-year phases, provides the estimated one-time costs, and indicates the anticipated external leverage. Overall, costs to the state government from general fund appropriations would require total investments of $172.125 million over 10 years, broken out as $62.875 million in the first 5 years and $109.250 million in the second 5 years. In addition to these investments, private sector resources, both direct and matching funds, will amount to $198.850 million over 10 years, broken out as $83.600 million in the first 5 years and $115.250 million in the second 5 years. These funds could additionally leverage federal and philanthropic dollars; but, the precise amount cannot be determined. Table 13 lays out the State of Iowa's annual investments by each year over a 10-year period to implement these strategies and actions.

Table 12: Iowa's Information Technology Financial Plan

Action	Time Frame	Annual Funding by Year: Years 1–10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds	Comments
1-Convene an Iowa IT Development Summit	Immediate	None	$50,000	$100,000 match or 2:1	Matching funds from private sector
2-Form a Strategic Technology Platform Fund	Short-term	Two elements: Infrastructure Year 1: $1 million; Years 5–10: $3 million Matching: Year 1: $500,000; Years 5–10: $2 million annually		3:1 match on matching program	
3-Develop a structure to facilitate joint-venture development of "orphan" IT innovations	Short-term	Year 2: $ 3 million; Year 5: $5 million; Year 10: $5 million		Leverage other private investments of 3:1 state funds	

Action	Time Frame	Annual Funding by Year: Years 1–10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds	Comments
4-Develop an awareness program to raise the profile of smaller Iowa IT firm capabilities	Immediate	Private funds of $50,000 per year		All private	
5-Provide incentives for larger user firms to work with Iowa firms	Short-term	Year 1: $500,000 Year 6: $1 million a year		2:1 industry match	
6-Enhance access to financial capital	Short-term		$ 2 million in additional venture fund	3:1 to 5:1 industry match	
7-Enhance and facilitate faculty entrepreneurship	Short-term	Use existing programs and give priority to IT. No additional costs			
8-Engage Iowa community colleges in development of IT programs	Short-term	$250,000 per year for 10 years		Tuition and fees will leverage funds over time	
9-Develop specialized degree and graduate degree/certification courses	Short-term	No additional funds—this program would be funded through the Investment Portion of Action 2			
10-Develop communications program for K-12 teachers and guidance counselors	Immediate	$100,000 per year for 10 years			
11-Develop training program geared to periodic upskilling of existing IT workers	Short-term	$200,000 in Year 1, rising to $500,000 in Years 5–10			
12-Provide continued support for workforce diversity in Iowa	Mid-term	To be determined			
13-Provide financial support for Iowa students enrolling in targeted programs	Mid-term	Year 3: $1 million rising to $5 million by Years 5–10			
14-Raise the national profile of Iowa as a technologically advanced state	Mid-term	Year 3: $2 million rising to $5 million by Years 6–10			

Action	Time Frame	Annual Funding by Year: Years 1–10	Estimated One-Time Costs	Leverage Ratio of Private and Federal Funds	Comments
15-Use Iowa government as test bed for new government-oriented IT operations and products	Mid-term	Use existing resources and budgets. No additional costs			
16-Ensure that Iowa's economic development "tool kit" encourages IT firm development	Immediate	Use existing resources and budgets. No additional costs			

Table 13: State of Iowa's Annual Information Technology Investments/Resource Allocations ($ millions)

Actions		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total 10-Year Investment
1-Convene an Iowa IT Development Summit		0.050										0.050
2-Create a Strategic Technology Platform Fund	Infrastructure	1.000	1.500	2.000	2.500	3.000	3.000	3.000	3.000	3.000	3.000	25.000
	Matching Grants	0.500	0.750	1.000	1.500	2.000	2.000	2.000	2.000	2.000	2.000	15.750
3-Develop a structure to facilitate joint-venture development of "orphan" IT innovations		-	3.000	4.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	42.000
4-Develop awareness program to raise profile of smaller Iowa IT firm capabilities												
5-Provide incentives for larger user firms to work with Iowa IT firms		0.500	0.500	0.500	0.500	0.500	1.000	1.000	1.000	1.000	1.000	7.500
6-Enhance access to financial capital		1.000	1.000									2.000
7-Enhance and facilitate faculty entrepreneurship												
8-Engage community colleges in development of two-year IT programs		0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	2.500
9-Develop specialized degree/certification courses in key priority technology areas												-
10-Develop a communications program for Iowa K-12 teachers and guidance counselors		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	1.000
11-Develop training program geared to periodic upskilling of existing IT workers		0.200	0.275	0.350	4.000	0.500	0.500	0.500	0.500	0.500	0.500	7.825
12-Provide continued support for enhancing workforce diversity		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	-
13-Provide Financial Support for Iowa students enrolling in targeted programs				1.000	3.500	5.000	5.000	5.000	5.000	5.000	5.000	34.500
14-Raise the national profile of Iowa as a technologically advanced state		-	-	2.000	3.000	4.000	5.000	5.000	5.000	5.000	5.000	34.000
15- Use Iowa government as test bed for new government oriented IT operations and products												
16-Ensure that Iowa's Development "Tool-Kit" encourages and promotes IT firm development												-
Annual Total		3.600	7.375	11.200	20.350	20.350	21.850	21.850	21.850	21.850	21.850	172.125

ORGANIZATION AND STRUCTURE

An Iowa IT Development Taskforce should be formed focused on steering and advising implementation of the IT development strategy. The Taskforce should confirm support for, and prioritization of, key development platforms.

Rationale: Given the imperative for creating a collaborative IT development environment in Iowa, a joint government, industry, and academic taskforce should be established to steer and direct implementation of this IT Strategic Roadmap. Having representatives of each group of stakeholders involved in the Taskforce will help seed collaborations and avoid drawing the strategy too far in any single direction or driving it by any single group's agenda.

Action Details: Ideally, the Taskforce should contain senior representatives from the following stakeholder groups:

- Iowa IT industry in both software and hardware systems, both general and platform-specific representatives
- CIOs of largest IT-user companies in Iowa (especially those within the financial service/insurance sector)
- Senior research administrative leadership of Iowa's regent universities and deans of key departments engaged in leading IT-platform–related research
- Representatives of the entrepreneurial and business capitalization/investment community
- Senior IDED and Board of Regents leadership.

The Taskforce should be convened immediately to receive a formal presentation of the Iowa IT Strategic Roadmap. The Taskforce will then be responsible for approving key strategy elements and actions and steering their implementation.

Resource Requirements: IDED should assign a staff person to the Taskforce, as should the Iowa Board of Regents and the IT industry through its statewide association, TAI.

As part of the Taskforce work, a subcommittee should be formed among industry, higher education, IDED, and Board of Regents representatives to focus on the IT platforms identified in this report. For each platform, a shared agreement should be developed on research priorities for basic research, applied/translational research, and contract research (product enhancement, refinement, and problem-solving services). This group should structure an agreed working plan for R&D contributions and collaborations

Rationale: Once the Taskforce has reached agreement on platforms for Iowa IT development, it will then need to bring the leading R&D parties together from commercial and academic entities to discuss collaborative opportunities in basic and applied R&D. Discussions also should be held regarding priorities for sponsored research initiatives designed to specifically improve the current products and solve business problems for Iowa companies in the target sectors.

Action Details: Assuming the Taskforce accepts the recommendation for four platforms, four Platform Research Subcommittees should be formed comprising the senior R&D and product planning personnel from industry and the leaders of key R&D teams associated with the

platforms at Iowa's regent universities. The Subcommittees will undertake a review of research agendas and capabilities at the universities and work to identify potential matches to the needs and interests of Iowa industry in the sector. Furthermore, industry representatives will be able to profile their needs and opportunity areas for joint R&D initiatives. The Subcommittees will work toward achieving a consensus on high-priority R&D initiatives likely to have the greatest commercialization and economic benefit for Iowa.

The Iowa IT Strategic Roadmap proposes a set of strategies and actions that involve multiple public and private organizations and entities. These strategies and actions have been designed to build on the base of organizational capabilities that currently exist in Iowa and to provide resources and structure for redirecting the efforts of these organizations and forming new organizations to plug critical gaps.

Direction and administration of the implementation of the Iowa IT Strategic Roadmap are critically important functions. Given the important role that industry, academia, and government each must play, it is imperative that an organization be structured that will engage each of these groups in the process. The Iowa IT Development Taskforce would be the logical convening entity, created as a formal collaboration between industry and academia with specific state support, including staffing and funding support. As mentioned above, the Taskforce would oversee industry and academic subcommittees, one for each IT platform and one for IT workforce development.

The IT Development Taskforce should serve as an informal, not a legal, entity, at least initially. Its Board representation should include key public and private representatives including the following:

- Iowa Regents Economic Development Director
- Director of the IDED
- Provosts for research from each of the regent universities and deans of key colleges engaged in platform-focused research
- A legislative representative from each caucus of the Iowa House and Iowa Senate
- Industry representatives from
    - The largest IT-user companies in finance and insurance, and other key industries
    - Software products and services
    - Computer and computer hardware manufacturing
    - Electrical and electronic systems and components manufacturers
    - IT consulting services
    - Communications and networking technology providers
    - Product design companies
    - Any company active in one of the four primary platform technologies.

Measures of Success and Accountability

The following represent key measures and performance goals, with actual monitoring undertaken on an ongoing basis through the Iowa IT Development Taskforce to determine to what degree performance objectives are being accomplished. Key measures that could be used include the following:

- Increasing IT business start-up rate in Iowa by 100 percent by 2010.
- Doubling R&D funding (primarily from federal sources) for IT-related research by 2010.
- Leveraging federal and other dollars at least three times for every dollar of state support.
- Accomplishing implementation progress on the actions outlined in this Roadmap—at least 70 percent with substantial action after 3 years and 90 percent within 5 years.

Economic Impact Potential of Iowa Information Technology Roadmap

The 10-year potential economic impact of this Roadmap on the IT industry in Iowa is focused on the efforts to (1) grow new firms through the commercialization of university-based IT R&D and (2) enhance the prospects of existing IT firms to ensure their competitiveness, retain (and, if possible, expand) their Iowa-based employment, and maximize their ability to reach their economic potential. The potential impact of the Roadmap's strategies and actions can be captured in the following ways.

Potential New IT Start-Ups

Impact Parameters and Methodology

In terms of IT-related, research-derived economic development, an important impact comes from firms that are started based upon the technologies developed within the universities. To provide some understanding of this potential, Battelle has developed an estimate of the numbers of new start-ups that are possible from the Roadmap's enabled (and existing) research and the potential employment of these new firms.

Baseline IT R&D—Battelle has forecast that baseline university IT-related R&D will continue in the future at the existing compound annual growth rate from 1990 to 2002 (most recently available data) of 3.0 percent in nominal dollars.[39]

Start-up efficiency—To estimate the formation of new start-up companies based on university IT-related research, the model uses a fairly low R&D expenditures/start-up figure of $10 million per start-up to account for the relative ease (compared with more laboratory or manufacturing-based start-ups) of launching an IT/software company.[40]

Start-up sales progression—Start-up firms' sales are projected from a conservative sales growth model that reaches $2 million by year five and $20 million by year ten. To understand the conservative nature of the model's sales forecast, it can be compared to the rough rule of thumb of the venture capital community, with successful firms reaching $10 million in sales by year five and $100 million by year ten.

[39] For the purposes of this effort, R&D expenditures in computer sciences and electrical engineering are used.
[40] If the two largest Iowa universities' R&D expenditures per start-up data from AUTM were used, nearly $260 million of R&D per start-up would be required.

Start-up employment—Start-up firms' employment is based on a conservative firm average of $275,000 in "sales" per employee. For comparison, manufacturing as a whole typically operates successfully at sales of $250,000 per employee. As sales increase for the start-ups, employment also is forecast to increase at this rate.

Employment multiplier effects—The proposed research and programmatic investments and their direct employment impacts will generate additional spending throughout the Iowa economy and hence generate additional regional employment impacts. In a straightforward yet conservative approach, this potential impacts model attempts to account for some of these "multipliers" by assigning a 2.6 employment multiplier on new private sector employment generated by the new IT start-ups. Rule of thumb multipliers are wide ranging within the IT realm, with the software/service multipliers typically around 1.2 new indirect/induced jobs per new job and computers/hardware multipliers typically around 3.5 or higher per new job. In the case of this model, these multipliers add the indirect and induced employment to the stated direct employment impacts.[41]

Summary

This potential impact analysis is based on recent comparable data of the performance of Iowa's universities in IT-related R&D and the launching of research-based start-ups, in the context of the research and programmatic investments stemming from this Roadmap. Battelle's analysis of potential impacts indicates that the investments recommended in this Roadmap can result in the following firm and employment impacts.

Increase in Firms, Jobs, and Sales

Table 14 details the potential impacts of the Roadmap by new start-up firms, private sector employment, and generated sales.

In total, the IT Roadmap's potential impacts on the Iowa economy include the following:

- The Iowa IT industry can conservatively grow by an additional 45 firms over the next 10 years.
- Employment in the state's IT industry can grow, through the employment in these new start-up firms, by more than 900 jobs over the next decade. In turn, this direct IT employment will have a multiplier effect, accounting for nearly 2,400 additional jobs in all sectors of the state's economy.
- These new IT start-up firms will conservatively generate, over only a 10-year period, annual sales that reach more than $16 million by year five, more than $240 million in year ten, with a cumulative total of more than $620 million over 10 years.

Potential Retention and Expansion of Existing Firms and Jobs

A number of Roadmap efforts are designed to increase the value-added capabilities and competitiveness of existing IT firms through collaborative efforts and training. Given the nature of these actions, the specific impacts will vary considerably based on the size and types of firms involved and the specific scope of services delivered. However, some measure of the potential (and necessity) for impact can be developed by examining some comparative trends.

[41] Some usage of the term "multiplier" includes the direct employment impact within the multiplier. Since this model develops the direct employment from the Roadmap's investments, this use of a multiplier creates "additional" indirect/induced employment impacts. Therefore, the 2.6 multiplier used in this analysis would correspond to a similar 3.6 multiplier in other studies.

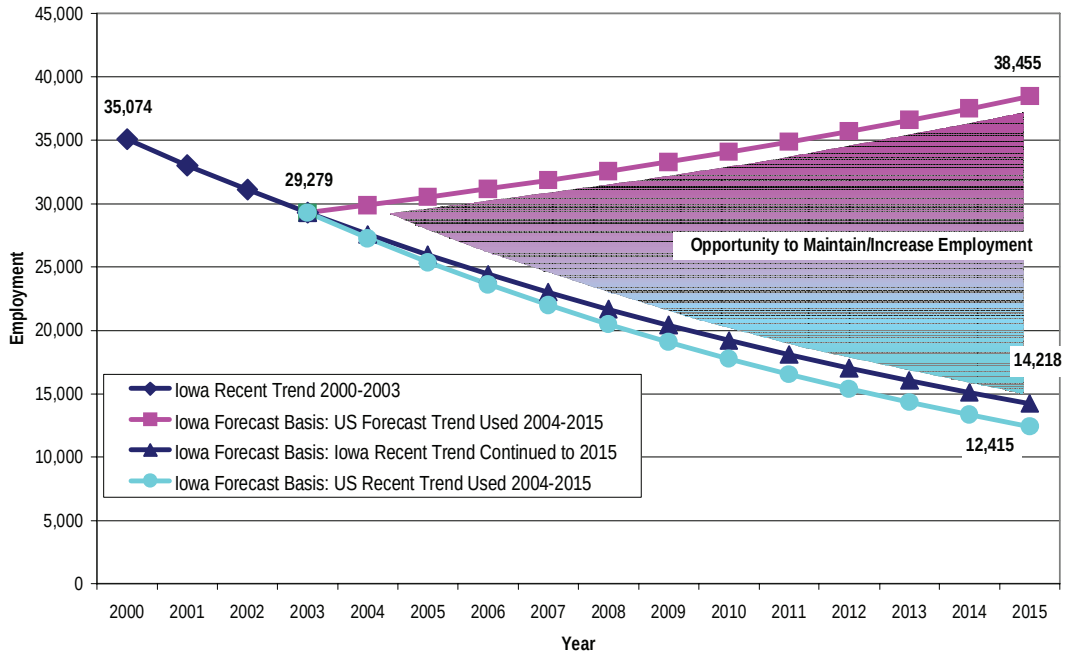
Table 14: Potential Impacts from Iowa Information Technology Roadmap

Iowa Information Technology -- Potential Impacts Model											
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	10 Year Total
Baseline Iowa Information Technology Institutional Research Funding ($ millions, Battelle projection based on 1990-2002 CAGR of EE & Comp. Sci. R&D Expenditures - from NSF)											
Regional Research Institutions Information Technology R&D	15.982	16.462	16.956	17.464	17.988	18.528	19.084	19.656	20.246	20.853	183.218
Total Public and Private Investments in Iowa IT Roadmap Efforts ($ millions)											
Annual Investments in $M	11.250	24.675	27.250	40.900	42.400	44.900	44.900	44.900	44.900	44.900	370.975
Total IT-Related Investments and Expenditures in Iowa Region ($ millions)											
Total Information Technology Research Investments	27.232	41.137	44.206	58.364	60.388	63.428	63.984	64.556	65.146	65.753	554.193
Total IT-Related Research Investments and Expenditures in Iowa Region ($ millions)											
Total Information Technology Research Investments	17.982	31.462	36.956	43.464	45.988	46.528	47.084	47.656	48.246	48.853	414.218
Research-based start-up efficiency ($ millions of R&D expenditures per Start-up)	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	
Direct Employment - Results of IT Investments and Roadmap Impacts											
Start-up Firms											
From base-level Iowa research funds	2	2	2	2	2	2	2	2	2	2	
From additional & leveraged research funds	0	2	2	3	3	3	3	3	3	3	
Annual Totals	2	4	4	5	5	5	5	5	5	5	
Cumulative Start-ups	**2**	**6**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	
Start-ups Sales Progression Forecast	*0.200*	*0.400*	*0.800*	*1.400*	*2.000*	*5.000*	*8.000*	*12.000*	*16.000*	*20.000*	
Projected Sales from Start-ups	0.400	1.600	4.000	8.600	15.800	30.600	58.000	100.000	161.000	241.000	621.000
Total Direct Employment Impacts											
Start-up-based New Employment	**3**	**12**	**25**	**46**	**77**	**136**	**241**	**399**	**625**	**921**	
Cumulative In-direct "Multiplier-Effect" Impacts											
Multiplier of Increased Information Technology Employment (2.6) (Cumulative In-Direct/Induced)	**8**	**31**	**65**	**120**	**200**	**354**	**627**	**1,037**	**1,625**	**2,395**	
Total Cumulative New Employment											
Roadmap-Related New Private Sector Employment	**11**	**43**	**90**	**166**	**277**	**490**	**868**	**1,436**	**2,250**	**3,316**	

The U.S. Bureau of Labor Statistics (BLS) has developed an Industry Employment Forecasts to 2012, which provides industry-level (at a four-digit NAICS code level) compound annual growth rates to 2012. These growth rates can be used to calculate a potential estimate of Iowa's IT industry baseline employment growth—from the 2003 data used to quantify the industry and subsector size in this Roadmap to 2015 (the 10-year time frame for the proposed Roadmap). Given the diverse industry mix within the IT industry (including both manufacturing and services) and the recent negative trend (though less negative than the national trend) in Iowa IT employment totals, using these national industry growth forecasts provides for a potential employment trend for Iowa to strive for (e.g., getting at least its fair share of national employment "growth"). This forecast can be compared with one where Iowa's recent negative trends continue and with one where Iowa's industry slips further, taking on the recent more negative trend of the overall U.S. IT industry. These comparisons, in effect, provide an understanding of the "opportunity" for Iowa to retain and maintain (and even increase) its IT industry employment over the 2003 level. This potential opportunity is shown by the gap between the topmost and bottommost forecast lines in Figure 15. These forecasts provide a variety of insights.

- Baseline employment in 2003 (per the economic analysis) is 29,279. If the recent decline from 2000 to 2003 was continued (using a compound annual rate), by 2015 the state's IT employment level would be cut in half to a level of 14,218.
- Based on the U.S. BLS forecast, which forecasts that the IT industry will have somewhat of an overall rebound by 2012, Iowa's IT employment could increase by approximately 30 percent over 2003 levels to nearly 38,500 workers by 2015.
- The retention opportunity, or the employment loss risk, could be more than 26,000 jobs over this period.
- This opportunity area consists of some industries that are forecast to decline at the national level as well as some that are forecast to rebound and/or increase over the next decade.

Figure 15: Potential Iowa Information Technology Retention and Expansion Opportunity



Conclusion

Currently, Iowa has a relatively small IT economy, largely centered on providing IT services to Iowa customers. However, Iowa's IT sector shows significant promise for growth and has proven itself to be more robust than the national IT sector in weathering IT downturns and challenges.

IT is an important sector to grow for Iowa's economic future. It provides good-paying jobs and the fundamental technological underpinning for advancement in a broad range of other sectors, from finance and insurance to manufacturing and the biosciences. Given the relative size of the Iowa economy, the state does not need to be a leader in all facets of IT; rather, it can afford to concentrate on specialized niches of IT activity where it already has established and emerging strengths based in R&D and business operations. For niche development, Iowa shows distinct promise for further developing its IT economy around (1) specialized IT services for finance and insurance companies; (2) RF/wireless technology; (3) advanced visualization and human-computer interaction systems; and (4) high-reliability, ruggedized systems and devices.

Distinct strategic actions are needed to achieve the promise of IT development for Iowa. Key stakeholders in private industry and public and academic sectors in Iowa will need to come together in a collaborative environment to drive progress and mitigate barriers. In particular, action is needed in five key strategic areas: increasing R&D and technology relationships between Iowa IT industry and academe; increasing small IT firm linkages with larger IT-user firms in the state, addressing capital gaps and barriers to IT business development, retaining and enhancing the IT workforce, and raising the profile of Iowa as a specialized technology state. This Iowa IT Strategic Roadmap details the actions required to make these strategies work, providing a pathway for achieving the true promise of IT-based economic development in Iowa.

Appendix A: List of NAICS Codes Included in Information Technology Sector

Subsector	NAICS	Industry
Communications & Media Equipment	334210	Telephone Apparatus Manufacturing
	334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing
	334290	Other Communications Equipment Manufacturing
	335921	Fiber Optic Cable Manufacturing
	335929	Other Communication and Energy Wire Manufacturing
Communications Network Services	517110	Wired Telecommunications Carriers
	517211	Paging
	517212	Cellular and Other Wireless Telecommunications
	517310	Telecommunications Resellers
	517410	Satellite Telecommunications
	517510	Cable and Other Program Distribution
	517910	Other Telecommunications
Computer & Peripheral Equipment	334111	Electronic Computer Manufacturing
	334112	Computer Storage Device Manufacturing
	334113	Computer Terminal Manufacturing
	334119	Other Computer Peripheral Equipment Manufacturing
Internet & Data Services	516110	Internet Publishing and Broadcasting
	518111	Internet Service Providers
	518112	Web Search Portals
	518210	Data Processing, Hosting, and Related Services
Media Recording Equipment	334310	Audio and Video Equipment Manufacturing
	334611	Software Reproducing
	334612	Prerecorded Compact Disc (except Software), Tape, and Record Reproducing
	334613	Magnetic and Optical Recording Media Manufacturing
Media Services	515111	Radio Networks
	515112	Radio Stations
	515120	Television Broadcasting
	515210	Cable and Other Subscription Programming
Semiconductor & Electronic Components	333295	Semiconductor Machinery Manufacturing
	334411	Electron Tube Manufacturing
	334412	Bare Printed Circuit Board Manufacturing
	334413	Semiconductor and Related Device Manufacturing
	334414	Electronic Capacitor Manufacturing
	334415	Electronic Resistor Manufacturing
	334416	Electronic Coil, Transformer, and Other Inductor Manufacturing
	334417	Electronic Connector Manufacturing
	334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing
	334419	Other Electronic Component Manufacturing
Software & Computer Services	511210	Software Publishers
	541511	Custom Computer Programming Services
	541512	Computer Systems Design Services
	541513	Computer Facilities Management Services
	541519	Other Computer Related Services

Appendix B: Analysis of Information Technology Sector: Data and Methodology

This economic analysis report examined the economic situation of the information industry and associated subsectors for the years 2000 and 2003. The Quarterly Census of Employment and Wages (QCEW) data series was used by Battelle to examine employment, establishment, and wages information. [42]

The QCEW data, or ES-202 as it is referred to, is a cooperative program involving the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor and State Employment Security Agencies. The QCEW program produces a comprehensive tabulation of employment and wage information for workers covered by state Unemployment Insurance laws and federal workers covered by the Unemployment Compensation for Federal Employees program. Publicly available files include data on the number of establishments, monthly employment, and quarterly wages, by NAICS industry, by county, and by ownership sector, for the entire United States. These data are aggregated to annual levels, to higher industry levels (NAICS industry groups, sectors, and supersectors), and to higher geographic levels (national, state, and metropolitan statistical area).[43]

Battelle worked with the Iowa Employment Statistics Bureau to obtain the most accurate and up-to-date data for the State of Iowa. The Iowa Employment Statistics Bureau provided Battelle detailed data at the full six-digit NAICS code level that are typically withheld from public by the federal government for confidentiality reasons. In order to comply with federal and state mandates, Battelle followed strict guidelines in order to protect confidentiality. The unsuppressed data provided enabled Battelle to better understand industry trends

[42] Reported monthly employment data represent the number of covered workers who worked during, or received pay for, the pay period which included the 12th day of the month. Reported annual average employment is an average of the corresponding monthly employment levels. Reported number of establishments represents the number of establishments whose activities were reported to the Unemployment Insurance system for the quarter. An establishment is an economic unit, such as a farm, mine, factory, or store, which produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Reported annual average number of establishments is an average of the corresponding quarterly number of establishment levels. Reported quarterly total wages are the wages paid by Unemployment Insurance covered employers during the calendar quarter, regardless of when the services were performed. Reported total annual wages are the sum of the total wages reported for the corresponding quarters. Total wage values reported in this database have been rounded and are reported in thousands of dollars.

[43] Major exclusions from Unemployment Insurance coverage include self-employed workers, most agricultural workers on small-arms, all members of the Armed Forces, elected officials in most states, most employees of railroads, some domestic workers, most student workers at schools, and employees of certain small nonprofit organizations.

The location quotient measure was used in addition to examining establishment and employment trends. The location quotient is used to measure the level of employment concentration within an economic region.[44] When the location is significantly above average, a location quotient above 1.20, the region is said to possess a specialization in the industry. Figure B-1 demonstrates the formula used to indicate regional specializations in the advanced manufacturing base in Iowa.

Figure B-1: Location Quotient Formula

$$LQ_{it} = (M_i / M_t) / (US_I / US_T)$$

Where:

M_i = industry *i* employment for the region

M_t = total employment for the region

US_I = industry *I* employment for the nation

US_T = total employment for the nation

[44] Location quotients (LQs) are a common measure of the concentration of a particular industry in a region relative to the nation (reference area). The LQ consists of the ratio of the share of total regional employment that is in the particular industry and the share of total employment in the nation (reference area) that is in the particular industry. A LQ greater than 1.0 for a particular industry indicates that the region is relatively concentrated, whereas an LQ less than 1.0 signifies a relative under-representation. A location quotient above 1.20 denotes employment concentration well above the national average. Throughout this report, LQs are used to report regional industry concentrations relative to the United States as a whole. The minimum concentration threshold for declaring a regional specialization is a matter of judgment and varies somewhat in the relevant literature. In this analysis, regional specializations are defined by LQs of 1.2 or greater.