Colorado Institute of Technology

Global Telecommunications Planning Study

Final Report

Project Team

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September 30, 2002
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Executive Summary

Introduction

The state of Colorado is known as a center for the telecommunications industry, an industry that is vital to the global economy. Although recent changes in the industry and the economy are reducing the present size of Colorado’s workforce engaged in the business, Colorado telecommunications companies currently generate $30 billion in global revenues and employ more than 40,000 workers in the state.1 This report, the product of a study funded by the Colorado Institute of Technology (CIT), identifies the knowledge requirements of this important Colorado industry and opportunities for educational initiatives. The ultimate objective is improved economic health of the Colorado telecommunications sector.

The research represented in this report was conducted using qualitative methods; it was focused on determining the workforce attributes most needed by the telecommunications industry and on identifying the educational assets to meet these requirements. The project had five major steps:

- Assess knowledge and skills for the global telecommunications industry
- Assess capabilities and capacity of Colorado educational institutions to deliver and implement recommended solutions
- Identify best practices in exemplars of educational programs that prepare graduates for work in telecommunications companies
- Assess student and employee perceptions of demand and professional education
- Provide recommendations for action to CIT

The project team consisted of experienced industry and academic experts: Barbara Bauer, project director; Andrew Eiseman, telecommunications consultant; Michele Jackson, research director; and Lucy Sanders, principal investigator. Ellen Grady, a graduate student, assisted with the industry and academic program research effort. Level 3 Communications and Qwest Communications were CIT board sponsors. Rob Hagens, senior vice president of Level 3, and Theresa Taylor, senior vice president of Qwest, were the specific project contacts from those companies, respectively. An academic advisory board, led by Dr. Michael Martin and Dr. Robert Schnabel, provided input to the project team.

The project spanned four months, from mid-May to mid-September 2002. Thirty-three industry and thirty-one academic leaders were interviewed. Industry leaders included executives from service providers, infrastructure manufacturers, Internet service providers (ISPs), and consulting and venture capital firms, such as Qwest, Level 3, and Avaya. Academic leaders interviewed included chancellors, deans, and chairs of continuing education, business schools, engineering, and computer science. The academic institutions included the University of Colorado, Colorado State University, the University of Denver and the Colorado School of Mines. Commercial providers included Colorado Technical University (CTU) and Accenture’s Avaya University.

The project was funded by a grant from the Colorado Institute of Technology (CIT) to the University of Colorado.

Telecommunications Industry Profile and Required Workforce Attributes

An important part of the research focused on the definition and makeup of the telecommunications industry itself. Based on interviews, we developed the following definition:

*Global telecommunications is the ability to exchange information around the world, independent of underlying technology or the specific nature of the message.*

A telecommunications industry provides the network and services that support this core global telecommunications capability. A detailed industry definition is provided in Appendix A.

All respondents agreed that economic pressure, financial chaos, and uncertainty characterize the global telecommunications industry. Nationally, the workforce is down by over 165,000 workers for the first half of 2002, 27% lower than the first half of 2001. This reduction represents one in every four job cuts in all U.S. industries through this June.2 By June 2002, total market capitalization for the industry was down 87.5% from the peak in 2000, with an overall loss of $306.7 billion.3

However, respondents in our study expected economic recovery to begin within 18–24 months.

The single most defining characteristic of the industry itself is its increasing complexity. Global partnerships, multicompany solutions, matrixed organizational structures, and varied financial, customer, and supplier alliances all contribute to intricate business and workforce dynamics. The complex forces of the industry create a need for employees with specific, key skills: excellent core technology competence, broad industry and business knowledge, and strong communication and collaboration expertise. The integration of these skills enables employees to solve problems and execute solutions quickly in complicated technical and organizational situations. Respondents emphasized that the “ideal” preparation for an employee was a “relevant” degree (computer science, computer engineering, math, business/IT, management information systems, etc.) plus a full complement of additional communication and collaboration skills and basic business knowledge.

Of the more than 40,000 telecommunications workers in Colorado, roughly half are what we term “professionals” and typically have at least four-year degrees. The other 20,000 employees are what we term “practitioners” and typically have no more than a two-year degree from a community college. We found that both groups need similar skills for successful job performance, although they differ in the level of skills needed and the educational resources used to acquire the expertise.

**Academic Assets**

In addition to researching an industry profile and required workforce attributes, we assessed existing educational resources, relevant to telecommunications, in the state and in the nation. Colorado has many educational assets, particularly degree programs that can support some subset of the stated skills and capabilities required by the telecommunications industry. However, there is no obvious single package of these assets that supports all the knowledge sets needed. Hence, no “exemplar” program was found in the state that provides the ideal mix of technical, business, and critical-thinking skills. A national research scan of academic institutions, however, revealed educational programs that appear to support both the relevant undergraduate degrees and the additional skills. Such programs were found at technical schools that have added or included substantial liberal arts schools to complement their technical expertise. Examples include Georgia Institute of Technology and Virginia Tech.

Finally, we found that industry interviewees were consistently unaware of state educational assets and had very limited partnerships or activities in collaboration with the Colorado academic community. However, both industry leaders and employees expressed interest in forming active partnerships with academia to improve curriculum and to motivate research in key technology areas, leading to expedited growth of the telecommunications industry in Colorado.

**Recommendations**

Key recommendations are:

- **Current Workers**: Develop educational initiatives that address the need for existing telecommunications employees in Colorado to improve or add skills in business, communication, and collaboration. University continuing education divisions and commercial providers have substantial assets available to address this need, and they should be encouraged to partner with each other and industry to increase their reach and effectiveness.

- **Future Workers**: Develop educational programs that combine core technology understanding, broad industry and business knowledge, and strong communication and collaboration skills to ensure that professional and practitioner employees can think critically and execute solutions effectively. For the professional segment, solutions should use existing relevant higher-education degree programs with added key skills education. For the practitioner employees, solutions should leverage existing community college and commercial provider assets to create the requisite specific skill needs and capabilities.

- **Industry Development**: Develop a Telecommunications Industry Council to create and sustain the communication and partnership between industry, academia, and government leaders. This council should champion efforts to improve the economic health of the Colorado telecommunications industry, as well as support educational initiatives and research as appropriate.
Detailed Results

This document describes the detailed research, results, and recommendations for the Colorado Institute of Technology (CIT) Global Telecommunications Planning Study project. The results of interviews and secondary research are presented first, followed by analysis and recommendations.

Project Goals

Technology is changing the global landscape in clear and compelling ways. Underlying these changes are phenomenal advances in telecommunications networks and solutions. Colorado is a hub of the global telecommunications industry. People working in this industry require a strong foundation in technology, applications, and human factors (sociological and economic), as well as a global outlook that includes key understandings in law and public policy. Through a collaborative effort of industry and academia, this project is intended to propose a pragmatic, research-based model and recommend initiatives for the education of Colorado telecommunications industry workers, both current and future, leading to continued economic growth in the state.

Research Approach

The research represented in this report was obtained using qualitative methods. Interviews were conducted to deduce an industry profile, determine industry skill needs, and identify educational programs that could support developing needed skills. More than sixty industry and academic leaders from a variety of companies and academic institutions were interviewed. The majority of industry leaders were executives, although hiring managers and human resources professionals were also interviewed to determine if different management levels and functions noted different workforce skill requirements. Academic leaders included chancellors, deans, and chairs of continuing education, business schools, engineering, and computer science. For convenience, the specific academic institutions included in the interviews were all located close to Denver, but care was taken to allow the results and recommendations to be applied to any academic institution in the state, and perhaps nationally. Appendix A provides a list of companies and schools interviewed. In addition to traditional higher education institutions, commercial providers such as Colorado Technical University (CTU) and Accenture’s Avaya University were included. Surveys of students and focus groups of employees were used to determine their perspective on necessary skills and educational solutions. The project research included investigating recommended academic programs to seek exemplar initiatives. Additional research efforts included literature and Web research scans, direct educational requests, and the use of Colorado State labor data.

The interviews with industry and academic leaders followed a standardized protocol to determine:

- Telecommunications industry segments and definitions
- Future drivers of industry change
- Required workforce skills and attributes
- National curriculum possibilities
- Partnership insights and possibilities between industry and academia

Many respondents provided information beyond the strict scope of the above areas; those insights were factored into this report as appropriate.

Research Findings

A very important part of this research focused on the definition and makeup of the telecommunications industry itself. All respondents agreed that economic pressure, financial chaos, and uncertainty characterize the global telecommunications industry of today. As noted in the Executive Summary, severe workforce cuts and large capital losses continue to depress this industry. More layoffs and retirements loom with continuing financial pressure, industry consolidation, and the “graying” of the large, unionized workforce. In addition, Colorado’s claim to be the hub of cable and telecommunications prominence is eroding due to the merger, migration, downsizing, or closing of several companies with headquarters in Colorado. Companies such as MediaOne, TCI, US WEST, UGC, Jones, ICG, and others have reduced or closed Colorado offices due to such changes. Colorado now has nearly 42,000 telecommunications employees, down from 50,000-plus in 2001. This reduction in jobs is 25% of the total jobs lost in Colorado during the past year.

Although the current situation is challenging, all respondents interviewed for this study were optimistic about the longer-term (three- to five-year) growth and development of the industry. In fact, respondents expected economic recovery to begin within 18–24 months. They spoke emphatically about how this industry is fundamental to society, vital to global business, and important to the Colorado economy. Although the telecommunications industry may presently be in difficult circumstances, they told us, its role is essential in the information economy and knowledge-driven industries that dominate growth in the world financial system. Industry respondents predicted that the industry will show signs of renewed economic strength within 18–24 months.

Industry Definition

Based on our interviews, we developed the following definition of the industry:

*Global telecommunications is the ability to exchange information around the world, independent of underlying technology or the specific nature of the message.*

The telecommunications industry exists to provide the network and services that support global communications. We define the telecommunications industry to consist of two major segments (hardware and software suppliers and service providers) and two partial segments (system integrators and consultants and government and public policy bodies that support the larger segments). See Figure 1 below.

**Infrastructure Suppliers:** Most respondents included manufacturers of hardware and software whose products form the networks and operation centers of the service providers. These companies include traditional telecommunications suppliers, such as Nortel, Lucent, and Avaya, as well as more general technology suppliers, such as Microsoft, HP, Intel, Cisco, and others.

**Communication Services Providers:** All respondents included traditional service providers in the industry space, usually naming prominent long distance and local access companies, such as Qwest, Level 3, AT&T, and well-known international providers, such as British Telecom, Deutsche Telekom, Singapore Telecom, etc. This segment also includes companies that run their own networks, frequently larger than some public access companies, such as Bank of America, national governments, American Express, etc. All technologies, regardless of whether they transmit voice or other traffic, were included: wireline, wireless, cable, and satellite.

**Content Providers:** About 20% of respondents included content providers in the industry. Of the 80% who did not include content providers within the industry itself, many described the content companies as having a significant impact on the economic health and growth of the telecommunications industry, and felt that technology innovations will be made to meet content provider needs.

> “Entertainment companies are more aware than the telecommunications or the computing companies of the convergence of their industries. It is unwise for the telecommunications and computing industries to ignore the entertainment industry.”

7. All quotes, unless otherwise noted, are from industry or academic interviewees.
requirements. Nearly everyone stated that this impact would increase in the next few years. Some respondents felt that telecommunications industry leaders need to be more informed about the direction and priorities of the powerful content industry. In fact, several academic leaders strongly suggested that the academic preparation of future telecommunications workers should include information on the content industry.

As a quick verification of our industry model and research, we correlated it against the Colorado Technology Alliance database (see Figure 2).

The CTA data show that more than 220 Colorado companies have identified themselves as “telecommunications industry” firms. These companies represent a subset of the 1,097 companies included in the Colorado State NAICS 2001 data. Thirty-one percent of the CTA-listed companies are telecommunications infrastructure suppliers, 38% are service providers (Qwest is the largest with 15,000 employees in the state), 28% include consulting firms that support telecommunications companies and the regulatory and government agencies, and 3% are content providers. This breakdown of the CTA companies generally supports the telecommunications industry model boundaries.

Drivers of Change

The driver of change (see Figure 3) for the future telecommunications industry most often mentioned by interviewees was Finance/Money/Economy, including both the short-term economic pressure and the longer-term economic recovery and growth. Growth will occur as industry segments consolidate and improve their efficiency, and as demand for capacity and services increases. The second most significant driver is the Market: the set of needs and opportunities represented by business and residential customers. Lower in priority are New Technology, Security, and Regulatory issues. New Technology as a driver represents the introduction of technology independent of financial or market pressure. Security represents the increased emphasis on both national security and personal privacy. Finally, the Regulatory driver indicated that public policy and regulation will continue to have an impact, albeit less than the first four drivers.

Several respondents noted that the current “apparent overcapacity” of bandwidth could be quickly consumed as overall economic recovery occurs. Market opportunities either for additional customers or for additional needs from existing customers will drive the recovery, as well as more innovative packaging of existing services.

Figure 2. Colorado Telecommunications Companies

Figure 3. Drivers of Industry Change

Almost all respondents emphasized that technology initiatives without compelling market or financial drivers would not be implemented. Some industry respondents noted that this is the most important change from the late 1990s, when technology innovation frequently overrode financial concerns. Important market opportunities mentioned were entertainment, health, education, and security. While technology itself will not drive the recovery, there was general acknowledgment that there are significant opportunities to serve current customers’ needs with emerging technologies, particularly in wireless and satellite technology and in new security applications. Also emerging is a focus on solving incompatible global interconnection standards that would enable less convoluted and more quickly deployed customer solutions.

Respondents offered different models of the future industry structure. In the most frequently described structure, the boundary between content providers and service providers will become less distinct, and some revision to the definitions of content and service providers will occur. Regardless of industry structure, content was still viewed as a major driver of both telecommunications technology choices and market development.

**Colorado Telecommunications Industry Business Status**

Colorado is a powerful leader in the global telecommunications sector, generating more than $28 billion in global revenue and employing more than 40,000 workers in the state. These employees earn more than $3 billion in total wages and populate more than a thousand different companies. In the second quarter of 2002, $66.8 million in new venture capital was invested in Colorado telecommunications companies. In addition, Colorado has the highest concentration of technology workers in the private sector of any state in the United States.

The existing 40,000-plus Colorado-based telecommunications employees work primarily in the service provider industry segment (see Figure 4). For the seven telecommunications companies in the *Denver Post* Top 100 Companies, six are service providers with just over 37,000 employees—slightly over 90% of the total workforce. Thus, the industry in the state is dominated (when one looks at employee numbers) by the service provider companies. The number of employees in infrastructure manufacturing is much smaller: less than 5,000.

In the process of gathering data for this project, we discovered that Colorado telecommunications data could not be easily correlated across different state data sources. There does not appear to be a single set of standards, telecommunications-specific state reporting codes used consistently across all government agencies or by the media. Improving the quality of industry data is necessary to properly assess the contribution of this industry to the overall state economy, and to determine the policies and programs that can accelerate economic recovery in the state.

### Research Findings: Workforce Attributes

The complexity of the industry is increasing each year with global partnerships, multicompany solutions, and matrixed organizational structures; the resulting customer and supplier alliances are intricate and interdependent. Such intricacy creates a need for employees with greater flexibility, creativity, collaboration skills, and the ability to solve problems quickly in complex technical and organizational situations. Products and technologies that span continents with widely different standards, regulatory environments, and cultures create new challenges for marketing, finance, technical, installation, and support teams. Different market expectations and priorities now drive technology deployments. Network and technology changes are increasing, adding new software.

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10. This figure (40,000 employees) does not appear to include telecommunications workers in nontelecommunications businesses, such as the communications support person for a suite of offices or the voice and data network system administrators in hospitals and other large businesses. This segment of telecommunications employees will grow when any industry segment in the overall Colorado economy grows.


and hardware, while not eliminating older deployed technologies. Competition for customers is accelerating, requiring all employees to have improved customer interface, negotiation, and business skills. This increasing industry complexity requires more productivity from a workforce already pressured to do more with fewer people. To support the additional stress from the economic recession, educational institutions and providers need to respond with innovative solutions to support both students entering the telecommunications workforce and those existing employees continuing to work in the industry.

**Employee Attributes**

As part of our research, we asked respondents to identify skills and attributes that employees must have in order to succeed in the global telecommunications industry. These characteristics (see Figure 5) cover all aspects of functional, personal, and business acumen.

Following are definitions of the key skills identified in our research:

- **Critical Thinking/Problem Solving:** Judgment in problem situations, identifying what is most important, dealing with situations in which there is no “right answer,” dealing with complexity and new situations, ability to apply analytic and reasoning skills

- **Deep Core/Good Breadth of Knowledge:** Combination of expertise in a functional area, especially technology, and sufficient supporting knowledge and capabilities in broader industry and business, including basics in marketing, accounting, finance, etc.

- **Ability to Communicate:** Combination of (1) formal presentation, writing, and speaking skills; (2) ability to communicate well in interpersonal contexts, including interacting with coworkers and with customers; and (3) ability to articulate ideas effectively

- **Collaboration Capabilities:** Working with others, both in an employee’s own work group and across an enterprise, or with those outside the enterprise

- **Ability to Learn:** Excited by new ideas or knowledge to be acquired, rises to challenges, ability to self-teach and develop competencies in new domains of knowledge on the job

- **Handle Change/Multitask:** Ability to move quickly; be flexible and adaptable; handle ambiguity, change, and complexity; and perform multiple tasks simultaneously without reduced effectiveness

- **Intelligent:** Innate ability; responding to situations expertly; ability to understand, apply, and integrate knowledge to solve problems

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Figure 5. Attributes and Key Skills Needed for Telecommunications Employees
Section 2

“Critical thinking and reflective judgment can be taught and can be measured.”

“Technology skills are basic, but interpersonal skills are more important.”

- Real-World Capabilities: Real work and workplace experiences; ability to apply functional knowledge to real problems
- Ethical Grounding: Foundation in values, responsibility, accountability, ability to operate from a personal moral framework
- Global Perspective: Working internationally with people who have different cultures and languages; knowledge of relevant foreign regulations and policies
- Personal Drive: Initiative, persistence, creativity, enthusiasm
- Leadership: Ability to exert influence on individuals or groups to achieve a desired objective
- Management Skills: Ability to determine company positions or directions and to supervise employees to achieve a corporate objective

While the two respondent groups, telecommunications industry and academia, identified different priorities for many skills, there was strong correlation on the most frequently named skills as illustrated in Figure 5. In particular, there were close parallels across all respondents on the four most-often named attributes. While many industry participants acknowledged global perspective was important, most did not define specifically what the attribute means for employees. Both industry and academia emphasized math and the appropriate liberal arts courses as good ways to develop critical thinking and problem-solving skills.

Note that critical thinking can be developed as a skill itself, or as an integral component of developing other skills. Both employers and academic institutions must be able to ensure the development of critical thinking and problem solving. Some schools in the state are applying instruments to determine successful development in this attribute, especially at the undergraduate level.

Professionals and Practitioners

Based on what respondents told us, and for the purposes of further work, we divided the industry workforce into two major groups: "professionals" and "practitioners." Professionals are employees who have college degrees or equivalent job experience. Practitioners are skilled labor employees, frequently unionized, with either a high school degree or a community college degree.

Respondents estimated that, of the more than 40,000 telecommunications employees in the state, roughly half are professionals and half are practitioners. These terms are project nomenclature choices and, especially for the practitioner employees, do not imply any lack of "professionalism" in their work skills or job accomplishments.

Professionals include management employees with roles in information technology, network planning and engineering, product design and development, sales, marketing, strategy, planning, and finance. This group usually includes the management and leadership roles in the companies. This segment in Colorado has been decreasing steadily due to layoffs, headquarters movement, and the recent closing of several telecommunications companies. Without aggressive economic development of the telecommunications industry in the state, this population will continue to decline. However, offsetting the reductions from the financial pressures, the rapid changes and complexity of the industry and a lack of key skills in existing employees still offer a substantial opportunity for either state colleges and universities or commercial providers to offer new, better programs to address their needs, hence improving the overall productivity of the industry. Even if the professional population were to be reduced by 50%, there still would be an opportunity to provide up to 20,000 hours per year of continuing education.

Typical jobs for practitioner employees include field support, call center, and operations jobs, where they support the customer care, installation, maintenance, and order processing of the business. Several respondents identified a strong need for better education and training in this group, both in the specific task requirements and broader skills, such as customer and work group collaboration.

One aspect of the recent “downsizing” in this set of unionized employees is that the remaining group has many workers eligible for retirement. Replacement of this retiring workforce offers one of the larger employment and education opportunities for new employees in the state over the next three to five years. Respondents from companies with a large practitioner workforce have estimated about 40% of existing practitioners, or 8,000 workers, could retire in the next five to ten years. These numbers are typical nationally, so many job opportunities will occur nationwide for trained and skilled practitioners.
Lifelong Skill Development

Industry interviewees believe that employees get adequate preparation in their chosen technical or functional area, although curricula can always be improved with specific courses that target telecommunications technologies. The biggest area of missing capabilities identified was the set of collaboration, communication, and broader business skills noted earlier. Respondents want employees to learn the fundamentals of these skills in their initial education programs and to continue enhancing these skills throughout their entire career.

To describe the development of skills throughout a worker’s career, we developed the attribute model shown in Figure 6. The three-dimensional nature of the model can illustrate how employees’ skills change over time. First and foremost, employers want to hire employees with expertise in a particular functional area (computer science, engineering, marketing, etc.). Since telecommunications is an industry that relies on technology, each position in the industry requires a certain minimum level of technical competence. Employees are expected to demonstrate acceptable expertise on the x-axis (technology foundations) before they are hired. New hires in sales and marketing will require a different minimum level than new hires in network engineering or information technology. Over time, employees are expected to acquire more business acumen and more expertise about the industry (moving along the y-axis). Likewise, they also need to either acquire or further develop their collaboration and communication skills (movement on the z-axis). Embedded in this development is progress in critical thinking and problem solving, either as part of the three study areas or acquired separately. Movement on the y-axis and z-axis is especially important for R&D developers; respondents emphasized that these employees usually lack business and collaboration skills when they graduate with technical degrees.

Respondents were consistent in their recommended academic approach to realize this attribute model. They want academic institutions to improve and extend existing degree programs to include teaching the broader skills. In addition, existing degrees in technical or functional majors should review the required courses to ensure support of relevant telecommunications technology. For example, a B.S. in computer science should include courses in software engineering, networking, and discrete mathematics, as well as courses or other pedagogical approaches to develop communication, collaboration, and basic business skills. Future employees can start acquiring the key skills as part of an improved undergraduate program, and employees on the job can continue developing these skills through improved continuing education opportunities. In particular, the need to develop an understanding of the industry and to continually refine business acumen should be supported by a flexible and focused portfolio of educational resources.

Research Findings: Academic Resources

Academic Asset Inventory

In addition to researching the industry profile and required workforce attributes, we assessed existing relevant educational resources in Colorado and the U.S. The state has many educational assets germane to telecommunications (see Figure 7 and the list in Appendix A), particularly four-year degree programs like computer science, electrical engineering, computer engineering, computer information systems, math, and business/IT, that can support some subset of the stated skills and capabilities required by the industry. However, there is no obvious single package of these assets that supports all knowledge sets needed for critical thinking, business acumen, communication, and collaboration. Hence, no undergraduate “exemplar” program was found in the state that provides the ideal mix of technical, business, and critical thinking skills. A research scan of academic institutions nationally, however, revealed educational programs that appear to support both the relevant degrees and the additional skills. Such programs were found at technical institutions that have added liberal arts schools to complement their technical expertise.

Workers need to “see...their careers as a continuum, so we’re not just specializing anymore, but we’re learning to move across various disciplines within the telecommunications space.”
Examples of universities following this model are the Georgia Institute of Technology, Virginia Tech, and the Worcester Polytechnic Institute.

“Exemplars” of lifelong learning programs need to meet three criteria: a mix of educational resources (courses, seminars, e-learning, etc.); resources relevant to the telecommunications skill areas identified above; and options to participate without requiring a degree program. Three programs that fit these criteria are: University of Washington Business School Executive Programs,16 Rutgers University Telecommunications Specialist program,17 and Penn State Management Development.18 The new program offered by the CU system on the Interlocken Level 3 campus also holds potential for meeting these criteria.

Industry and Academic Partnerships and Research

Industry interviewees were consistently unaware of Colorado educational assets relevant to telecommunications. The recommendations of programs preferred by industry interviewees, such as MIT or Stanford, were usually acknowledged to be based on perception, rather than on actual information about the school or program. Hence, we concluded that Colorado schools don’t market their programs effectively to the telecommunications industry or to students who might be interested in telecommunications careers. The marketing that exists is usually to “brand” a school, not to distinguish a program relevant to a specific industry.

Industry respondents described few partnerships or activities in collaboration with the academic community. Although several advisory boards were noted, telecommunications industry participants were generally lacking or, if listed on a board, did not seem to have created any significant engagement. However, industry leaders frequently expressed great interest in forming active partnerships with academia to improve curricula and to motivate research in key technology areas, leading to expedited growth of the telecommunications industry in the state. Academic leaders expressed the same desire, mentioning that joint research with the industry would better prepare their students, as well as better focus their work.

Telecommunications Degrees

At the outset of our research, an initial literature scan of more than 50 undergraduate named telecommunications programs across the country revealed a wide diversity of program models and curricula. These programs mapped into one of five model types, based on the discipline of origin, such as computer science, engineering, or communications, as well as a multidisciplinary program. We found that none of these programs was characterized by a proper blend of the key skills and attributes described above.

Industry leader interviewees did not request a general “telecommunications” degree at the undergraduate level.

In fact, the requirement was strongly for employees with specific, relevant degrees, such as computer science, electrical engineering, math, marketing, etc., as well as the critical thinking, communication, and collaboration skills noted above. Telecommunications minors in undergraduate degree programs viewed as relevant were considered to be helpful but not necessary. Hence, we discontinued our search to find the best telecommunications undergraduate program in the nation.

We should note, however, that we believe a graduate telecommunications degree is useful in developing employees’ business and industry knowledge as they advance through their career.

17. Rutgers University Telecommunications Specialist program Web site: http://rutgers.ce.com/myce/careersummary.html?C=10022/ap=811a01BqzkV4KZ01FwZDa34Z3mFpmHPP-i7s1AWU2g8.
18. Penn State Management Development Web site: http://mdev.outreach.psu.edu/welcome.asp.
Colorado Economic Development

Industry and academia emphasized that technology research and the broader telecommunications community have important roles in attracting new companies to Colorado and more funding for business. Both groups of respondents referred to known centers of industry and academic collaboration and economic growth, such as Silicon Valley, Research Triangle, and the Boston Route 128 Corridor. Both observed that Colorado has yet to capitalize on telecommunications expertise in the state (e.g., broadband, satellite, and wireless) in order to create similar economic synergies. Most respondents suggested that an improved “telecommunications community” was needed to realize the necessary quality of intellectual exchange.

Research Findings: Student and Employee Perceptions

Employee focus groups confirmed the list of attributes identified by interview respondents, though the emphasis depended on whether the workers held business or technical positions. These participants expressed interest in pursuing additional educational opportunities and in building relationships with higher education institutions (for example, through internships or guest lectures).

The results of student surveys were more ambiguous. Approximately half of the graduate students, already enrolled in a telecommunications program, were interested in working in technical positions in network or wireless areas. The remainder were interested in management or consulting in the telecommunications sector. None of the undergraduates in computer science degree programs indicated a desire to work in telecommunications. An interesting finding was that, for almost all respondents at undergraduate and graduate levels, electives were seen as a way to increase technical depth, rather than as a means for obtaining breadth or “well-roundedness.” None took electives to improve their abilities to communicate or collaborate. A few took electives to gain some industry or business skills and knowledge.

Summary

To summarize the research findings:

- Economic pressure, financial chaos, and uncertainty characterize the telecommunications industry today. However, respondents spoke optimistically about its future and the need to prepare for its recovery.
- Respondents placed a strong focus on nontechnical skills and expertise, saying that employees in the telecommunications industry need a relevant technical or business degree that includes the key skills and attributes: critical thinking/problem solving, deep core/good breadth of knowledge, communication, and collaboration. A specialized telecommunications undergraduate degree is not necessary.
- Current employees need ongoing skills enhancement in collaboration, communication, general business, and critical thinking in addition to their core expertise; they should never stop learning.
- Respondents want active engagement between industry and academia to further mutual educational and economic development goals.

Our findings are consistent with what others have found. A January 2002 study, “Help Wanted: Workforce Development & the New Economy,” confirms this conclusion, stating that critical thinking, problem solving, and interpersonal relations are the most attractive job skills.

A study conducted by Anne Heinz, dean of University of Colorado at Boulder Continuing Education, found the same necessity to form strong relationships between industry and academia as noted in this report.

Recommendations

Section 3

Based on research, and despite recent setbacks in the telecommunications industry in Colorado, there will be both job and educational opportunities for practitioner and professional groups of telecommunications employees. New employees and current workers need core technology and business skills, as well as proficiency in critical thinking, communication, and collaboration. In addition, no recommended educational initiative can succeed without the active support and interaction of industry leaders, educators, and public agencies. Their collaboration on educational initiatives, as well as the roles they play in ensuring the successful economic recovery of the industry, is essential.

The interview and research results indicate three initiatives are required to support the telecommunications industry:

• Professionals: Development of four-year programs for future employees and “lifelong” learning programs for current professional employees that include skill development in critical thinking, communication, collaboration, and general business

• Practitioners: Development of two-year programs for future employees and “lifelong” learning programs for current employees that include skill development in critical thinking, communication, collaboration, and general business

• Development of a Telecommunications Industry Council to foster active communication and engagement among industry, education, and government, and to promote economic recovery and additional development of educational ideas

Future Professional Employees

Since a telecommunications industry recovery is 18 to 24 months away, Colorado has time to define and implement new programs to educate future employees. Academics who “own” relevant undergraduate degree programs must critically assess how well their programs support the key skills and attributes (critical thinking, communication, collaboration, and business acumen) and redesign the degree programs accordingly. Steps should include:

• Determining how best to involve industry partners in the assessment and redesign of curricula

• Reviewing existing exemplar programs (e.g., Georgia Institute of Technology)

• Reviewing existing relevant degree programs and resources for alignment in teaching key skills of critical thinking, communication, and collaboration

• Reviewing opportunities for faculty to learn instructional methods supporting critical thinking, communication, collaboration, and general business knowledge

• Designing curricula or other learning experiences to address gaps

The focus should be on teaching to integrate skill development in existing courses without the necessity of adding required hours to already full degree programs. In addition to the traditional “for-credit” courses, there are other creative ways to address any missing components, including using on-line, commercially available “short courses” (already widely used in several telecommunications companies in Colorado); continuing education opportunities with site-based instruction, such as the University of Colorado Interlocken initiative; and tailored “one-off” initiatives, such as the First Data program at Daniels College of Business at the University of Denver. Also available are innovative faculty initiatives to introduce the key skills into technical degree programs. For example, a professor in the UCB communications department currently works with the UCB computer science faculty to train students in collaboration skills.

Important goals of the curricular review are to ensure that:

• Relevant degrees provide the best possible support for the telecommunications industry, by including both solid foundations and current developments in networking (especially data networks), discrete mathematics, software engineering, and project management

• Critical thinking, problem solving, business knowledge, collaboration, and communication are supported by the appropriate required courses or recommended electives in mathematics, science, liberal arts, and other pedagogical resources

• Industry insight and priorities are actively and thoughtfully integrated into the curriculum and extracurricular aspects of the program

For additional benefit, academia should create more aggressive engagements with industry, including use of industry mentors, commitments to student internships, and an industry opportunity for summer jobs and career positions. For optimal success, one or more faculty members should be involved in a “faculty internship” to develop and solidify the understanding of the business and technology challenges for the program’s industry partners. Another type of creative response would be to develop and deepen an undergraduate’s understanding of the industry and business issues through speaker forums and seminar series.

An exciting and aggressive package of four-year degree programs with the core technology degrees and additional training and education in key skills will retain Colorado students and attract out-of-state students to Colorado schools. These students will be completing their undergraduate degrees at the time the telecommunications industry will be growing. Key to success in both attracting students and finding jobs for them upon graduation is early, active, and continuing direct involvement by company leaders and employees in educational initiatives.

This recommendation is not without its challenges. The key skills of communication and collaboration are not usually emphasized in undergraduate programs for technical degrees, especially in computer science and engineering. Respondents in the interviews were emphatic about the need for technologists to be excellent communicators and collaborators, but the traditional curriculum has little support for this requirement, and faculty members in these departments are rarely asked to support these skills. Possible responses include faculty training, creation of topical materials by experts for faculty use, guest lecturers, addition of team projects and critical thinking assignments to curriculum, use of commercial material, etc.

**Current Professional Employees**

The largest educational opportunity in both number of students and impact on the telecommunications industry is the need for existing professional employees to develop or improve their key skills. This is the biggest opportunity as there are 20,000 possible students. It is also the most difficult, because there are three stakeholders: the company, the employee on the job, and the education provider, either academic or commercial.

The size of this opportunity can be estimated by a “norm” used in many telecommunications and technology companies to support one to two weeks per year of continuing education for professional employees. This yields a total of 20,000 to 40,000 weeks per year of training, or upwards of 300 person years of training, for the 20,000 current professional employees in Colorado. In times of economic stress, companies are unlikely to meet this standard, but even a substantially reduced figure is a large prospect. This level of opportunity has the attention of commercial providers and continuing education divisions at Colorado universities, as well as the embedded internal company training departments.

Commercial providers (such as Colorado Technical University or Accenture) emphasize a business- and performance-based approach to learning, which is becoming very attractive to the larger telecommunications companies. For example, Accenture now runs an organization called Avaya University that provides all training for Avaya’s internal employees and external customers.

We recommend partnerships between industry, commercial providers, and university continuing education divisions as the ideal way to approach this educational market. Each of these stakeholders has unique assets to contribute. Academia brings the brand recognition of a major educator, the potential for sharing academic credentials, and community access through continuing education courses and marketing. Commercial providers bring scale, profitable business models, sales, marketing, distribution capabilities, and a large customer base of professional employees. Industry brings motivation, resources, and the employees. We recommend a pilot that includes all three stakeholder groups because of their unique roles and strengths. At a minimum the pilot should focus on creating curriculum and learning opportunities to address the key skills and attributes. The pilot should be a one-year program with a formal evaluation component to assess the satisfaction of employees and stakeholders. If possible, the pilot should be attractive to a range of companies in the industry.

“Universities need to help industry minimize the learning curve for new employees.”
Figure 8 summarizes our recommendation as it relates to professional telecommunications employees and their pursuit of four-year degrees, graduate degrees, and lifelong learning. In all cases, educational providers need to address the attribute gaps in critical thinking, collaboration, communication, and general business.

**Future Practitioner Employees**

Although the practitioner workforce was not the original focus of this project, many respondents noted both the size of the employee population and the lack of programs that successfully address the development of both specific job training and key skills. In addition, actual job openings in the practitioner group may be even larger than the professional group due to the retirement-eligible demographics of the current practitioner population (estimated to be as high as 40% over the next five years), and due to the need to keep a large number of workers in the state to service local customers. While productivity improvements will continue to reduce the total number of practitioner employees, industry respondents still predict the need to hire thousands of new skilled laborers over the next several years.

Students interested in practitioner jobs will need the equivalent of a two-year degree, specific job skills like Cisco certification or DSL installation skills, and key skills of critical thinking, communication, and collaboration. In the recent past, these skills have been developed in programs like the certificate in network engineering that Qwest created in partnership with the community college system. Since job openings for practitioners will begin to occur in more volume in the next three to five years, state community colleges should leverage current assets, including distance learning, to package programs and certificates for future telecommunications practitioners. Minimally, the next steps should be:

- Sponsoring a study to analyze specific, required job skills needed by practitioners in the next few years (e.g., network management, database, customer service, etc.), including skills in the key attribute areas of collaboration, communication, and critical thinking
- Identifying the mapping of existing community college assets and commercial resources to these priorities
- Leading an effort to assess and update programs to support the skills identified in the study
- Engaging industry—the practitioner employee needs the same level of strong industry participa-
tion and sustained support given to the professional employee, including internship and co-op program possibilities.

However, more should be done. The state could begin to prepare future workers with a coordinated series of “2+2+2” programs, starting with vocational programs in high school, continuing with two-year certificates, and ending with four-year degrees for employees interested in moving from practitioner to professional careers. Additionally, we heard from respondents that the diversity profile for the telecommunications industry needs to be improved, especially in the practitioner workforce. Coupling the program recommendations above with existing high school and community college outreach to underrepresented populations can improve this situation.

Numerous local educational assets offer resources and ideas for this recommendation: the existing Computer Magnet high school educates students who may be motivated to seek telecommunications practitioner jobs. Community colleges have a work-skills-based approach, existing assets, and close connections with the high schools across the state. Currently there are 459 programs at 21 community colleges supporting 1,759 students in computer science/IT, math, telecommunications service, and other “relevant” programs. However, the sheer quantity of different programs is a hurdle to industry involvement. A “packaged” approach, with marketing and communication about the program, will be necessary for reaching the students and the industry companies. Although many industry interviewees expressed interest, no telecommunications co-op or work-study programs were found in the community college system.

**Current Practitioner Employees**

Many industry interviewees told us that the 20,000-plus current practitioners in Colorado have serious gaps in essential skills. This is an important issue since these employees are frequently the “face” of the company to the customer, and they often lack important customer support and communication skills. Even if the estimate of retirees in this group is correctly projected at 40% (or 8,000 employees) in the next five to ten years, the remaining practitioner workers still need ongoing key

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24. Also available are assets developed by commercial providers, such as Accenture, working with the Leeds School of Business, University of Colorado at Boulder to develop new simulation technology for network technician training.
We recommend the creation of a Telecommunications Industry Council to support active and sustained communication and partnerships, to develop common policy objectives, and to help attract new business and investment to the state. The objectives of such a consortium, led by a group of educators, industry, and government participants, should include:

- Development of a self-sustaining, self-funded organization that hosts events, facilitates communication, provokes dialogue, and coordinates partnerships in the telecommunications industry
- Facilitation of joint industry-academic research, especially in high-priority technologies like security, satellite, and wireless
- Strengthening state educational resources—building the brand of the assets and developing marketing approaches, as well as providing academia with industry input
- Attracting industry and educational partners and investors
- Research and publication of accurate directories of people, resources, etc.
- Coordination with government agencies, especially state offices of technology and innovation and the state economic development council
- Communication with state legislature and other public policy bodies about issues related to telecommunications
- Creation of goals for the state telecommunications industry and, along with the government agencies, measurement of progress
- Development of an industry retention and growth strategy

We believe that CIT should lead the effort to create this council, drawing on the participants in this study and other involved telecommunications leaders in the state.

There are clear precedents for this recommendation, both within the state and nationally, such as the Colorado Space Council, the Colorado Biotech Council, and the community and academic coalitions in visible...
national centers like Chapel Hill and Silicon Valley. Resources such as the Silicon Flatirons Telecommunications Program seminar series in the School of Law at the University of Colorado at Boulder have national visibility and bring prominent telecommunications experts to Colorado for seminars and events. Other examples in the state include the collaboration between the University of Colorado at Colorado Springs and the Colorado Springs Economic Development Council, the partnership between Colorado State University and HP in Fort Collins, and the CU-Boulder College of Engineering and Applied Science and the companies near Boulder that developed media storage technology.
Conclusions

The recommendations contained in this report point to a much brighter future for telecommunications employees and companies and the state of Colorado itself. The following is a scenario for this brighter future. Imagining such an outcome is exciting: it is definitely within reach!

Future Vision: 2005 Colorado Telecommunications Scenario

Both Wired and Fortune magazines hit newsstands this week with the story of Colorado's telecommunications renaissance. In the past few years, the state has seen an increase in industry profitability. Researchers in the state have also recently invented key wireless technologies that solve global telecommunications network interoperability problems. Key to this economic and innovation revival are the widely touted Colorado educational programs that have created the most attractive telecommunications workforce in the country. Graduates from these programs and faculty members are engaged in active partnerships with Colorado telecommunications companies, providing both technology and business innovation. Other communities seeking to invigorate moribund economies in their state frequently review Colorado's academic initiatives and programs.

Everyone involved in Colorado credits an aggressive initiative from the Colorado Institute of Technology to create a Colorado Telecommunications Industry Council in 2002, in the midst of the national recession and the telecommunications financial meltdown. As part of this council, industry leaders, the academic community, and state agencies organized the support necessary to build the highest-performing telecommunications workforce in the nation, and to attract over 30 new businesses to the state. Divisions of several Fortune 500 telecommunications suppliers have located in clusters around Colorado Springs, Fort Collins, and Durango, where a combination of skilled workers, academic resources, and leading-edge research are supporting new product development in satellite and wireless products and services. Several of these new businesses have connections with global telecommunications companies, helping return Colorado to prominence as a major center for the global economy.

As this effort took shape, several specific education programs emerged. All have been extremely successful at retaining Colorado's brightest students and attracting students from around the nation to Colorado's schools and businesses:

- A program called “The Colorado Telecommunications Challenge Scholar” is now operating on many Colorado higher education campuses, and about 200 students graduate each year. These graduates are the first choice of the local telecommunications businesses, including large service providers and smaller, innovative product companies. The undergraduate program, using as a foundation four-year degrees in computer science, math, electrical engineering, and business, is noted for its emphasis on in-depth preparation in technology, as well as on collaboration, communication, and critical thinking. Industry leaders say these students “hit the ground running” and are well positioned to drive future development of the business.

- Another exciting program highlighted in the media is the “Telecommunications Learner for Life” program, an integrated, on-the-job training curriculum. This program is offered across the state, is hosted by industry companies and educational suppliers, and provides both professional and practitioner employees with access to a wide array of continuing development in areas vital to telecommunications. The hallmark of this series is the packaging of the educational modules into certificate programs that are constantly refreshed to support changes in the industry. This program is a collaborative effort between traditional community colleges and the commercial providers in the state.
A new "2+2+2" program for field and call center employees, built by a partnership between state high schools, commercial education providers, and several community colleges, is graduating several hundred students each year. This curriculum takes advantage of the excellent industry training facilities in the state. These graduates are contributing to better customer service and satisfaction, as well as increased efficiency for the businesses in which they work.

The driving force behind these educational projects and many others is the Colorado Telecommunications Industry Council, whose membership now includes over 300 companies and 200 academic leaders. Each year, the council hosts the international "Colorado Telecommunications Summit," which draws telecommunications, government, and financial leaders from around the world.

Council leaders recently concluded the 2005 summit, with exciting results:

- New international standards were passed that will help accelerate the adoption of wireless and broadband services for both consumers and business customers,
- International collaboration was funded to support telecommunications infrastructure in developing countries, and
- New approaches were approved for national, state, and local regulations to encourage faster introduction of new products and service packages to customers nationwide.

The governor of Colorado, delivering the keynote at the summit, thanked the participants for their efforts in restoring health to the industry, both in Colorado and worldwide.
## Appendix A: Industry Data

### List of Companies and Schools Interviewed

#### Telecommunications Companies
- Accenture
- AT&T Broadband
- Avaya
- Bank of America
- CableLabs
- Callahan Associates
- Deloitte and Touche
- EDS
- Greater Colorado Springs Economic Development Corporation
- Level 3 Communications
- Lucent Technologies
- Morgenthaler Ventures
- Qwest Communications
- Time Warner Cable
- US Bank
- ViaWest
- Other unaffiliated industry experts

#### Educational Institutions (Public)
- Colorado Community Colleges
- Colorado School of Mines
- Colorado State University
- Regis University
- University of Colorado at Boulder
- University of Colorado at Colorado Springs
- University of Colorado at Denver
- University of Denver

#### Educational Institutions (Commercial)
- Accenture Avaya University
- Colorado Technical University
Industry Definition

Global Telecommunications Definitions:

Global telecommunications itself is the ability to exchange information anywhere with ease, regardless of content and underlying technology. Based on the respondent definitions and current Colorado telecommunications business data, the global telecommunications industry includes two major segments, the hardware and software suppliers and the service providers, and two partial segments, the system integrators and consultants and the government and public policy bodies that support the larger segments.

Infrastructure Suppliers: Most respondents included the manufacturers of hardware and software whose products form the networks and operations centers of the service providers. These companies include the traditional telecommunications suppliers, such as Nortel, Lucent, and Avaya, as well as more general technology suppliers, such as Microsoft, HP, Intel, and others.

Communication Services Providers: All respondents included the traditional service providers in the industry space, usually naming the prominent long distance and local access companies, such as Qwest, Level 3, AT&T, and the well-known international providers: British Telecom, Deutsche Telekom, Singapore Telecom, etc. This segment also includes companies that run their own networks, frequently larger than some public access companies, such as Bank of America, governments, American Express, etc. All technologies that support communications were included: wireline, wireless, cable, and satellite. Satellite transmission and supplier companies also overlap some definitions of the “space” industry.

Content Providers: About 20% of respondents included the content providers in the industry. Of the 80% who did not include them within the industry, nearly everyone described the content companies as the most powerful in impact on the economic health and growth of the telecommunications industry. Nearly everyone stated that this impact will increase in the next few years. Some respondents feel that the telecommunications industry leaders need to be more informed about the direction and priorities of this powerful adjacent industry. Some of the academic leaders interviewed strongly suggested that the academic preparation of future telecommunications workers include information on this adjacent industry as part of the educational curriculum and preparation.

Future Industry Structure: Today, some companies such as AOL-Time Warner and Liberty Media have business units that participate in all three segments: supplier, service provider, and content provider. This structure was not strongly supported by the respondents as a model for the evolution of the industry or for a trend for consolidation in the industry. Instead, several of the respondents predicted that the industry could disaggregate into more discrete, efficient components, rather than continue a transition toward strong vertical integration. The major consulting companies, such as Accenture and Deloitte and Touche, include all three segments in their industry verticals but support their customers with strong expertise in each unique segment: supplier, service provider, and content provider.

Attached are Diagrams 1 and 2, which describe the current and future telecommunications industry, respectively.
Most (but not all) respondents defined the telecommunications industry to include supplier and connectivity provider segments. Content providers form a separate business viewed as a major driver of the telecommunications industry.

Distinctions between industry segment boundaries will blur in the future. Regardless of industry structure, content is still viewed as a major driver of both telecommunications technology and market development.
Colorado Academic Asset List

Higher Education Asset List by Campus

(September 9, 2002)

Methodology:
Compiled from interview transcripts and notes, responses to e-mail queries, and Web scans of Internet sites. Information related to relevant degrees/disciplines and desired attributes.

Categories:
1. Industry Alignment
2. Degrees and Certificates
3. Continuing Education
4. Curriculum Enrichment
5. Other Supporting Assets

If category is missing, no assets were collected for that campus from these sources. Degree program details provided in a separate document.

Interinstitutional
1. Industry Alignment
   • Front Range Gigapop (consortium sharing of WAN services) CSU, UCB, UCD
2. Degrees and Certificates
   • Executive Education MBA program, held physically in Denver, taught by all three CU campuses
   • Joint on-line certificate program in computer science between Mines and CU-Denver (in development, funded by CIT)
5. Other Supporting Assets
   • Internet2 involvement

Colorado School of Mines
1. Industry
   • With Lucent, including an ongoing program working with American Indians

   • Advisory boards: Engineering
2. Degrees and Certificates
   • BS in Math and CS, approximately 50–60 students per year. About 80% of these are CS specialists.
   • EE (B)
   • ES (M)
   • McBride program in public policy with seminar courses on economics and political systems
3. Continuing Education
   • With DU, on-line certificate program
4. Curriculum Enrichment
   • Encourage part-time jobs and internships
   • “Field session” between the junior and senior year where students work in teams on real industry projects. Typical companies include IBM, SUN, etc.
   • Department of Economics and Business has a seminar series

Colorado State University
1. Industry
   • CASI—collaboration with industry, e.g., 10 years’ collaboration with Storage Tek
   • Advisory council/boards
     – One at the university level
     – One at the department level (Business, Engineering):
       • ECE board has 30–45 members and meets twice a year
     – ECE also has alumni board focusing on fund raising
   • Linux hub project with IBM
   • Consulting:
     – Advanced Energy: Semiconductor processing (Collins)
     – Avaya: Computer networks (Jayasumana)
     – DSM and Tensor Comm, Data Fusion: imaging and signal processing (Scharf)
     – HP: VLSI design (Chen)
     – Idris Communication: multicarrier technologies for wireless (Nassar)
Section 5

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– Seagate and Advanced Energy: Controls (Young)

• Industrial Fellowships with HP and Agilent Technologies

• Strong research relationships with a number of companies, including HP, Agilent, Seagate, Maxtor, and Advanced Energy

• Active Industrial Associates Board consisting of over 40 members representing approximately 35 companies. Meets twice a year.

2. Degrees and Certificates

• Masters in CIS. “Professional retooling” approach. 50% liberal arts, 25% business, 25% technology. Admit 40 students per year

• Distance MBA program. 24th year. Uses FirstClass system, infrastructure outsourced to a company in Toronto (Embanet). Videotapes for lectures, interaction through chat room. 1:45 Adjunct: Student ratio.

• Electrical Engineering (B, M, D)

• CS (700 students, with about 100 grads per year. There are 17 faculty, and 4 full-time instructors.) (B, M, D), including an on-line degree

• Math (B, M, D)

• Business (B, M)

• Industrial Technical Management (B)

• EMgt (B)

• Ebusiness certificate. Industry oriented. Two years old. Customers have been Cisco and IBM.

• On-line Master of Engineering in Communications in the Electrical & Computer Engineering Department.

• Certificate in Telecommunications in E&CE Department

• Communications concentration under development within EE

• Interdisciplinary Studies Program in Information Science & Technology, under development.

3. Continuing Education

• Educational Extension—Corporate and Custom Training packages

• On-line CS and Telecommunications classes (telecommunications certificate)

• Distance learning—MBA, Engineering Management

• Fall 2003—on-line version of the Interdisciplinary Studies Program in Information Science & Technology

4. Curriculum Enrichment

• Internships and co-op programs (e.g., with HP) (CS)

• 50% of CS students take internships

• Freshman seminar (CS), which includes industry leaders and involves emphasis on technical journalism and group project skills

• Electrical and computer Engineering senior design team projects

5. Research

• DARPA (including TRW): “Cameron project,” improving the programmability of field-programmable gate arrays (FPGAs)

• AFOSR: Using AI to schedule satellite usage

• NSF: Face image recognition

• Telecommunications

• Active, distributed databases

• Signal processing (Chandra, Louis Scharf, and Mahmood Azimi)

• Optoelectronics including VCSELs (Carl Wilmsen, Jorge Rocca, Kevin Lear, Carmen Menoni, and Randy Bartels)

• Fiber optics (Carmen Menoni and Kevin Lear)

• Networking performance (Anura Jayasumana, Chandra, and HJ Siegel)

• Optoelectronics center (Carl Wilmsen)

• Class 1000 clean room (Electrical & Computer Engineering)

• Software engineering

• Space-time and frequency-time communications (Louis Scharf)

• Access to the next-generation Internet2 network
**University of Colorado at Boulder**

1. Industry
   - Use of industry-active adjuncts (ITD)
   - Donation of industry equipment (ITD)
   - Advisory Board (ITD)
   - Advisory Board (Engineering)
   - Advisory Board (Women in Engineering)
   - Advisory Board (ATLAS)
   - Advisory Board (Leeds School of Business)
   - Business Incubator
   - Research on speech technology (CSLR and Avaya)

2. Degrees and Certificates
   - CS (B, M, D)
   - ECE (B)
   - ITD (M)
   - EE (B, M, D)
   - IS (B, M)
   - Math (B, M, D)
   - Applied Math (B)
   - Business (B, M, D)
   - Five-year program: Business undergrad and one year of grad in ITD to earn M.S.
   - ATLAS Certificates
     - Technology, Arts, and Media
     - MAT/TechTAM
   - CEDIR, in Leeds School of Business. A three-year, two-weeks-per-year, on-campus program, supported by companies such as Level 3, IBM, SUN, etc. 60 students

3. Continuing Education
   - CATECS (ITD, CS, ECE, Engineering Management courses)
   - Leeds School of Business Executive Education Program
   - Professional, noncredit courses
   - Professional certification
   - Interlocken initiative
   - On-line Distance Learning courses

4. Curriculum Enrichment
   - Educational Technology House (CS)
   - Senior design projects (CS)
   - Internships (but no formal internship program) CS, ITD
   - Seminar program (industry speakers) ITD
   - Remote telecommunications lab (ITD) (in development, funded by CIT)

5. Other Supporting Assets
   - Leeds School of Business, Deming Center for Entrepreneurship
   - Silicon Flatirons (speaker series)
   - Department of Communication (College of Arts & Sciences). Undergraduate courses in communication competencies. Masters program with course emphasis in organizational communication in high-tech industries
   - Herbst Program for the Humanities (College of Engineering)

**University of Colorado at Colorado Springs**

1. Industry
   - Relationship with Jones International Cable
   - Relationships with Peterson, Schriever, AFA, AF Space Command, Fort Carson, etc.
   - Small business technology incubator
   - Center for Institutional Technology Transfer
   - RDC (Research Development Center) in College of Engineering/Applied Sciences

2. Degrees and Certificates
   - MBA distance education program
   - Business (B, M)
   - Math (B)
   - Applied Math (M)
   - CS (B, M, D)
   - Computer Engineering (B)
   - Engineering Management (M)
   - Electrical Engineering (B, M, D)
   - ECE (B)
3. Continuing Education
• Web site under development but mentions business/finance classes. Computer certificate has been discontinued.

4. Curriculum Enrichment
• College of engineering: internships, co-ops

5. Other Supporting Assets
• Communication Department (course in technology and society)
• Network, Information, Space, Security Center (NISSC). Will offer targeted instruction (degrees and certificates) in the area of network security and information assurance. This is a campus-wide initiative but is mostly aligned with Business and Engineering.
• Faculty support
  – Strong technology infrastructure (70% of courses have tech experience)
  – Faculty-led technology teaching and learning laboratory
  – Faculty mentorship program for technology use

University of Colorado at Denver
1. Industry
• Summer faculty traineeships (faculty go into industry)
• Advisory Boards
  – IS/IT board: policy and curriculum setting
  – Health Admin MBA; industry leaders engaged in the program

2. Degrees and Certificates
• CS/IS (B, M, D)
• EE (B, M)
• Business (B, M)
• CSE (B, M)
• EMgt (M)
• Applied Math (M, D)
• College of Arts and Media (B, M)
• On-line certificates (in conjunction with Colorado School of Mines) in systems engineering, network engineering, Internet SW engineering, Database Engineering, and OO software engineering

3. Continuing Education
• Courses offered in business, IT, CS, and engineering

University of Denver
1. Industry
• Institute for Executive Education in Daniels Business School. Company-tailored “one-off” semi-custom programs.
• Advisory boards: Women’s College Applied Computing/WICS

2. Degrees and Certificates
• Math (B, M)
• Math/CS (D)
• Engineering/CS (M)
• Emgt (M)
• Applied Computing (B)
• Electrical Engineering (B, M)
• Business (B, M)
• Information/Electronic Commerce (B)
• Computer Science (B, M)
• Computer Engineering (B, M)
• School of Communication (media courses)
• Joint degree at DU between CS and Digital Media Studies (B)
• Cable/Telecommunications Management (M)
  (25% of students do on-line degree)

3. Continuing Education
• Women’s college/WICS, Applied Computing
• Applied Software
• Daniels School of Business—executive/professional
development (MBA), leadership program, corporate programs and services, on-line certificates

4. Curriculum Enrichment

• College requirements form institutional vision for all graduates
  – Math
  – English/writing portfolios
  – Study abroad
  – Senior independent study

• MA in International and Intercultural communication

• MPP in Public Policy

• Classes in conflict resolution

5. Other Supporting Assets

• Cable Center
Solution Criteria

The following criteria should be used to evaluate the potential effectiveness and desirability of proposed tactical programs to address this report’s recommendations.

Character of Solution
1. Generative (creates more and more)
2. Sustainable
3. Scalable
4. Adaptable

Makes a Difference (Positive Impact)
5. High-quality student output (number of people with improved skills in all major gap areas/through programs)
6. Fish and loaves (Synergistic)
7. Measurable outcomes (e.g., number of people/activities involved in collaboration efforts)
8. Near-term results (Time to results)
9. Applicable to other industries (Extensibility)

Implementation
10. Identifiable champion/accountable roles
11. Incremental, builds on current assets
12. Cost effective

Acceptance
13. Stakeholder appeal, including benefactors
14. Makes current players want to play
15. Easy to explain

Three Recommendations with the Criteria Addressed:

Consortium
2, 1, 4, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

Existing Workforce Skills Improvement
2, 3, 4, 5, 8 (partial), 9, 11, 12, 13, 14, 15

Future Workforce Skills Improvement
2, 3, 4, 5, 6, 9, 11, 12, 15
Biographies

Barbara T. Bauer
Barbara T. Bauer currently runs her own consulting business, BTB Consulting Services, which provides executive consulting services to the telecommunications and information technology industry. Typical consulting projects include the program management of an enterprise solution framework for a major system integrator and the Global Telecommunications project for the Colorado Institute of Technology, an industry-funded and government-supported initiative to improve the technology workforce supporting Colorado industry.

Prior to starting her own business, Bauer was an executive at U S WEST responsible for a large software development organization that provided U S WEST development and integration services for a wide range of business processes, including all electronic commerce and Internet initiatives. Her responsibilities also included the systems design and development for all finance and human resource systems and the development of solutions to support the Telecommunications Reform Act.

Bauer was the vice president, general manager of the Rides business unit, a subsidiary of Raynet, Inc., a manufacturer of fiber-optic transmission technology in California. She started her career as a systems engineer and software developer at Bell Laboratories. Her academic credentials include a B.S. and M.S. in physics and the Stanford Executive Program.

Andrew Eiseman
Andrew Eiseman is an independent consultant in the field of broadband communication and digital and interactive television. He has assisted cable and telephone companies in Europe, Asia, and the United States in development and deployment of advanced broadband, digital television, and interactive television services. Prior to his current work, Eiseman was with U S WEST and U S WEST Advanced Technologies, where he worked with Bellcore on some of the fundamental technologies used in today’s digital television and DSL industries.

Eiseman has a bachelor’s degree in performing arts management from the University of Rochester and an M.B.A. Beta Gamma Sigma, Sigma Iota Epilon from the University of Denver.

Michele H. Jackson
Michele H. Jackson is assistant professor in the Department of Communication at the University of Colorado, Boulder. She teaches, consults, and advises about the organizational implications of new communication technologies. Her interests are in new communication technologies, organizational culture and change, and small group communication and collaboration. A general theme in her work is the contribution of communication to technical areas, including the development of collaboration skills in engineering professions and the design and use of technologies to support group work.

Jackson is a past Charles Babbage Institute Tomash Fellow for the History of Information Processing and a past Research Fellow with the Poynter Institute for Media Studies. Prior to joining the faculty at CU, she held an appointment at Florida State University. She also served previously as a faculty member in the Interdisciplinary Telecommunications Department at UCB. Her research appears in places such as the Journal of Computer-Mediated Communication; Information, Communication and Society; the New Media Handbook; and the ACM Special Interest Group in Computer Science Education Conference Proceedings.

Jackson holds graduate degrees in communication granted by the University of Minnesota (Ph.D., M.A.) and an undergraduate degree (cum laude) granted by Macalester College, St. Paul, Minn. She grew up in Fargo, North Dakota, and currently lives east of Boulder with her husband and two children. http://stripe.colorado.edu/~jackson

Lucy Sanders
Lucy Sanders received her B.S. and M.S. in computer science from Louisiana State University and the University of Colorado, respectively. She worked at AT&T Bell Labs, Lucent Bell Labs, and Avaya Labs for over 20 years, where she specialized in systems-level software (operating systems, database systems, etc.) and solutions (multimedia communication and customer relationship management). In 1996, she was awarded the Bell Labs Fellow Award, the highest technical accomplishment bestowed by Bell Labs. Sanders retired from Avaya as vice president of R&D and CTO for customer relationship management in 2001 and began a new career at the University of Colorado. At CU, she
holds the position of executive in residence for ATLAS (Alliance for Technology, Learning and Society). ATLAS is preparing all students at the CU-Boulder campus for lives and leadership careers in the networked information age and is placing a special focus on those issues that impede women and minorities from successfully embracing technology.

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The project team would like to thank The Garrigan Lyman Group (www.glg.com) for its assistance in the design and layout of this report.
Appendix C: Recommended Reading

State of the Industry


State of the Workforce


Colorado Demography Section of the Colorado Department of Local Affairs:
Economy Forecasts:
http://www.dola.state.co.us/demog/Economy/Forecasts/CBEFHandout.pdf

Labor Force:
http://www.dola.state.co.us/demog/LaborForce.htm

Census Data:
http://www.dola.state.co.us/demog/Census2k.htm


Science, Math, and Engineering Education

“As We Lose Engineers, Who Will Take Us Into the Future?” Wall Street Journal, June 7, 2002, B01. (Efforts at top engineering schools to make engineering degrees more attractive and curb anticipated shortage)


Resources for Considering Report Recommendations


