Colorado's Economic Opportunities:

Today, Tomorrow, and the Future

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INTRODUCTION AND OVERVIEW

This report is the culmination of an intensive eight month study of the Colorado economy. The genesis of this research was a desire on the part of several entities to develop an economic development report that would look at Colorado today and posit possibilities for tomorrow and the longer run future. The study was commissioned as a collaborative effort between the State of Colorado (through the Economic Development Commission) and the Economic Developers Council of Colorado. The purpose was not only to research potential target and emerging industries for the state, but also to perform a detailed economic base analysis of the 64 counties. This combined approach gives an industry perspective that can be used as an economic tool.

The research results are reported in two sections. The first section begins with this introduction and is followed by a review of methodology for the entire project. A summary of the industry section findings is presented in the next part. The first section concludes with detailed reports for the industries studied. The second section begins with a more detailed methodology and definition section for the county part of the report. This is followed by the 64 county profiles presented in groupings based on the 14 planning regions. The second section concludes with a list of acknowledgements.

We believe the timing of this project is perfect in light of the recent economic downturn and the more competitive economic development environment that both the state and the nation face. This slowdown has had a differential impact around the state. In some cases, this impact has caused a reexamination of the current economic base and has given impetus to the notion of restructuring the local economy. Obviously, the citizens of each county will react differently in terms of how they approach their economic future. This report will be one of many tools that local leaders can use to help move their county and regional economies, and ultimately the state economy, forward.

Based on our experience working with economic development leaders, we know that they have an excellent understanding of their local economy. This tool should help them and their constituencies better understand the challenges and opportunities they face. Economic development means something different to each county. For some counties it may mean balancing growth with quality of life, while for others it may mean diversifying the economic base. Local leadership and interest will always be the most important part of the process. This tool is designed to help all counties, no matter how they define their economic development future.

We feel privileged to have worked on this project and believe the results will help guide future economic development efforts throughout the state. We appreciate the tremendous support we received from the business and government communities in assisting with this research. All errors and omissions remain ours.

METHODOLOGY

This project was conducted using a multifaceted approach. This was driven by the realization that there was more than one objective to the study. We clearly needed to determine the short- and long-term potential for growth in various industry sectors. However, we also needed to categorize and understand the economic base of the individual counties. Ultimately, we would use both pieces of information to develop economic development possibilities for the counties and regions of the state.

The industry sector part of the report began with a process of identifying a list of potential target and emerging industries for the state. This list is not meant to be exhaustive and tends to exclude many industries that would not be considered "primary" job generators. The lack of discussion of these industries does not mean that they are not essential or important to the state economy. Simply stated, industries that are more primary in nature lead to greater overall employment growth and greater economic diversity.

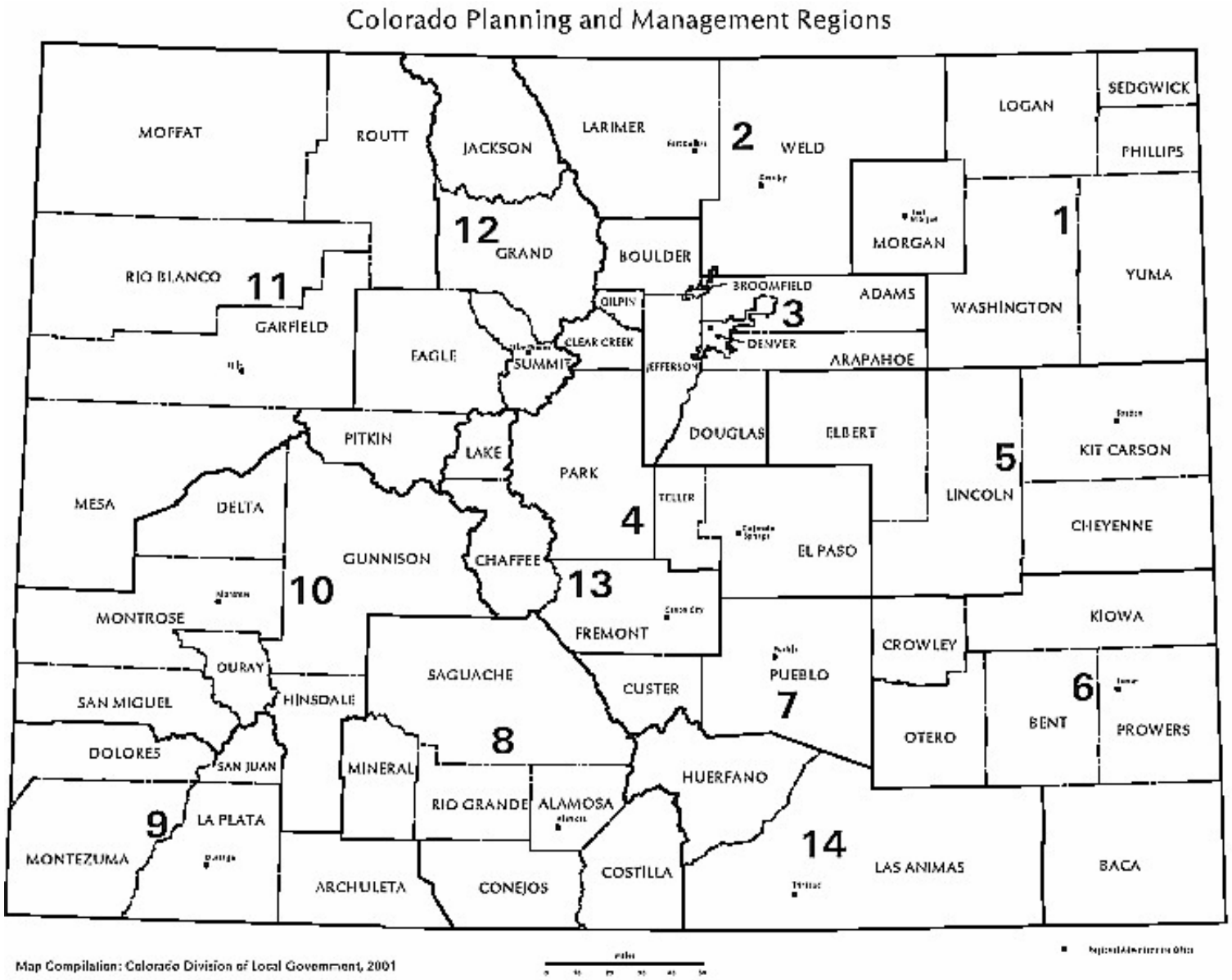
Our industry studies began with extensive background research. This information was augmented by surveys and focus group discussions and put together into a preliminary examination of the trends, strengths, weaknesses, opportunities, challenges, and location requirements for the industry. These preliminary reports were reviewed by several industry experts for completeness. The reports were then edited and finally crafted into the final industry reports.

The county level analysis was driven by primary source research. The most current demographic, infrastructure, geographic, and resource data were collected. In addition, extensive economic data were extracted and analyzed, including ES202 firm level data and IMPLAN county level data. This resulted in a five-page county profile. These county economic and demographic base analyses were sent out for review to economic development professionals and local leaders throughout the state. The end result was a more thorough and accurate set of county profiles.

The material developed in the first two parts of the study was combined to produce a county by county economic overlay page. This page represents our best effort at identifying the existing, target, and emerging industry opportunities for each of the counties. This page was constructed using the specifications of the industry sectors studied and comparing them with the county specific attributes. The entire six-page county section was then sent out for review and comment to the economic development community. The comments returned were reviewed on a case by case basis and, where appropriate, were included.

The findings of the economic base analysis and the county overlay are presented in the second part of this report. They are listed on a county by county basis, and grouped by the 14 state planning regions. There is a separate methodology section for that part of the report that describes the data, definitions, and issues specifically related to that analysis.

The map on the following page shows the state's 14 planning regions.


Colorado Planning and Management Regions
MOFFAT
ROUTT
JACKSON
LARIMER
2
WELD
LOGAN
SEDGWICK
PHILLIPS
MORGAN
1
YUMA
12
GRAND
BOULDER
RIO BLANCO
11
GARFIELD
BROOMFIELD
ADAMS
WASHINGTON
OILPIN
3
CLEAR CREEK
DENVER
EAGLE
SUMMIT
JEFFERSON
ARAPAHOE
PITKIN
LAKE
DOUGLAS
ELBERT
KIT CARSON
5
PARK
LINCOLN
MESA
DELTA
TELLER
4
CHEYENNE
GUNNISON
CHAFFEE
EL PASO
10
13
MONTROSE
FREMONT
KIOWA
CROWLEY
OURAY
SAGUACHE
CUSTER
PUEBLO
SAN MIGUEL
HINSDALE
7
6
OTERO
BENT
PROWERS
DOLORES
SAN JUAN
8
MINERAL
HUERFANO
RIO GRANDE
ALAMOSA
9
LA PLATA
14
MONTEZUMA
ARCHULETA
CONEJOS
COSTILLA
LAS ANIMAS
BACA
Map Compilation: Colorado Division of Local Government, 2001

SUMMARY OF INDUSTRY ANALYSIS

The following paragraphs are a brief synopsis of the individual industry analyses using the following format. First we examine the international and national trends for that industry. Then we explore the location requirements. Finally we discuss Colorado's competitive position and growth opportunities. For an even more succinct version we have included a one-page summary table at the end of this section.

Food and Agriculture

International and National Industry Trends. Productivity gains have been driven by scientific discoveries in plant and animal genetics, animal nutrition, and livestock health. Production efficiency has improved with technologies in robotics, computing, and communications. There is an increased demand for all-natural, organic foods.

Colorado Competitive Position. Livestock is the most significant agricultural commodity produced in Colorado, generating 71.4% of total cash receipts in 2001. Crops provided 28.6%. The state has strong exports of live animals, meat, hides, skins, wheat, feed grains, and vegetables. Natural meats and organic dairy products represent a growing market for Colorado producers.

Location Requirements. Livestock and crop production depend on prime agricultural land and availability of water. The allocation of land and water resources between urban and rural users is essential. The close proximity of university biotech and biology research programs will aid in developing bioproducts, biofarming, and value-added farm products.

Growth Opportunities. All-natural and organic food products; value-added food products; and the application of biotechnology for energy, industrial, and pharmaceutical products offer growth potential for the industry.

Manufacturing

International and National Trends. Greatly increased efficiencies have combined with offshore outsourcing to areas with low labor rates to greatly reduce the manufacturing workforce in the United States over the past decades. For the most part, these jobs are not expected to return. U.S. exports of manufactured goods are also on the decline. The photonics sector of manufacturing has grown rapidly over the past decade, but growth was halted by the recent recession. The struggling telecom industry had a noticeable effect on the photonics sector. Consolidation has been common, and sales have fallen. Demand is rising rapidly in computer hardware and storage manufacturing. Increased competition is forcing prices way down, putting a strain on manufacturers.

Location Requirements. In general, manufacturing requires a large and qualified labor pool, significant capital, and developed transportation infrastructure. Low wage rates and other costs are advantageous. The photonics industry benefits from research universities and other facilities, and a highly educated workforce. Collaboration is vital in the sector, so strong industry associations and a cluster of existing photonics companies are greatly beneficial. Strong support and funding from both the public and private sectors are also needed in order for a photonics cluster to exist. Similar to photonics, computer hardware and storage

manufacturing also benefits from a highly educated workforce and the availability of local funding.

Colorado Competitive Position. After taking an especially hard hit in the recent recession, the state's manufacturing industries are expected to show only moderate growth over the coming decade, with some exceptions. High market demand and revenue in defense/aerospace, technology industries, and computer and storage devices will drive growth in Colorado's manufacturing sector. The state's photonics industry is very strong, bolstered by universities and federal labs and a concentration of related industries. The industry is concentrated in Boulder County. Other metro counties, along with El Paso and Larimer Counties, also have strong industries. Many of the same factors make the state's computer hardware and storage industry very strong. A number of major companies in the industry call Colorado home. Food and beverage manufacturing represents a significant portion of the state's manufacturing sector.

Growth Opportunities. Growth in general manufacturing is expected to be minimal, due to productivity gains and increased outsourcing. Defense/homeland security, aerospace, and technology industries will provide the majority of the growth. The photonics industry has growth potential by building on existing strengths and working closely with the state's aerospace, telecom, health-care, and high-tech industries. Availability of adequate funding and state support could become an issue, though. The computer hardware and storage industry should also remain strong. Global markets present major opportunities, and demand for mobile products is increasing rapidly.

Energy and Environmental

International and National Trends. As we continue to deplete our natural resources and pollute our natural environment, this industry is becoming more important. As populations grow and third-world countries develop, consumption of energy is expected to increase rapidly. Oil continues to be the largest provider of energy, followed by coal, natural gas, nuclear power, and renewable energy. This is expected to remain the same for the next 15-20 years, with natural gas surpassing coal. With heightened concerns about U.S. reliance on foreign energy sources, demand for domestic sources is expected to increase. Long-term energy plans involve the development and deployment of alternative and renewable energy sources, ranging from hydrogen to fusion, solar, wind, geothermal, and biomass.

Location Requirements. To be suitable for commercial power production, an area needs an abundance of the applicable natural resources, along with adequate transportation and/or transmission infrastructure and available capital. Environmental impacts to wildlife, watersheds, and recreational areas must also be taken into consideration.

Colorado Competitive Position. Colorado's economy was built around mineral and petroleum extraction industries. While mining has contracted in recent years, the industry still has a significant presence in the area. The state has abundant mineral and oil resources, and production continues throughout much of the state. Many locations also have wind and biomass resources to support development of commercial or community-level renewable energy production.

Growth Opportunities. Growth in this sector will result largely from the development of alternative energy sources. Many of the state's rural counties have potential in biomass and wind energy production. Public policy, access to transmission lines, and lack of sufficient capital are the most significant barriers to growth of the renewable energy industry.

Transportation

International and National Trends. In the United States during 2002, a total of 4.2 million people were employed in the transportation industry. Trucking, the largest sector of the transportation industry, provided 32% of the total transportation jobs and moved almost 68% of all domestic freight. The volume of airline travel has increased, and technology and deregulation have improved the efficiency of the industry, creating more competition among airlines. Transportation is directly affected by the performance of the local, national, and global economies and will continue to be greatly affected by increased security in the fight against terrorism.

Location Requirements. Key factors in the success of the transportation industry include a central location with easy access to highway, rail, and air infrastructure; the presence of manufacturers and distribution centers; and sufficient competition among companies to keep costs down for the consumer.

Colorado Competitive Position. DIA was ranked the 5th busiest airport in the nation and 10th busiest in the world during 2002. One of Colorado's main strengths is its central location, making it a potential hub for air, rail, and truck transportation. The close proximity of DIA to rail lines; the intersections of I-25, I-70, and I-76 near the center of the United States; and a strong infrastructure of airports located throughout the state create an excellent opportunity for these different sectors of the industry to work together to strengthen the presence of transportation throughout Colorado. One barrier to growth is the high cost of doing business in Colorado, evident in both the air and trucking industries.

Growth Opportunities. Growth of e-commerce will continue to increase demand for all modes of cargo transportation. With the longest commercial runway in North America now open at DIA, it is possible for fully loaded flights from Asia to fly nonstop into Denver. The development of an intermodal facility outside of Denver, the relocation of existing rail lines outside of the downtown area, and the development of commuter and light rail passenger services could possibly cut down on congestion in the metro area while increasing efficiency of cargo transportation. The national "Ports to Plains" project will designate highway corridors for transportation from Mexico to Canada, through southeastern Colorado and Denver, creating opportunities for related businesses.

Aerospace

International and National Trends. Since 1996, the commercial space sector has grown at a 16% annual growth rate. Satellite communications and GPS have been two of the fastest growing sectors. Aerospace related employment in the United States has fallen steadily since 1989. The industry has been dramatically affected by the events of September 11th. The commercial sector was devastated, but the military sector was given a substantial boost.

Location Requirements. Aerospace companies tend to locate in areas with highly educated workforces, and concentrations of other aerospace, defense, and high-tech industries. A strong military presence is often attractive to aerospace companies, and proximity to university or federal research facilities is beneficial.

Colorado Competitive Position. Colorado has a strong and growing aerospace industry, benefiting from the state's strong military presence, highly educated workforce, abundance of research facilities, and concentration of related high-tech industries. The state ranks 14th in aerospace employment concentration and 10th in aerospace average wages. Colorado has strengths in the areas of launch equipment and satellite communications employment. The state has also done a remarkable job of procuring funds from NASA.

Growth Opportunities. Colorado appears to be well poised for growth in the aerospace industry. Increased government support and increased collaboration between the public, private, and academic sectors will aid in the growth of the industry. Defense and homeland security related areas offer a major opportunity for the state.

Defense and Homeland Security

International and National Trends. Terrorist attacks and ongoing military activity around the world have drawn much attention to the defense and particularly the homeland security industries. The U.S. Department of Defense raised their budget 10.9% in FY2003, to $365 million, and is forecasting additional 5% increases for each of the next six years. Defense contractors are experiencing increased business, and the industry as a whole is thriving in the United States.

Location Requirements. The defense industry is concentrated in areas with high military and government presences and clusters of related high-tech industries nearby. Strong telecommunications and information infrastructure make an area more appealing to a defense contractor. In addition, some areas become defense hubs purely because they hold a key strategic location.

Colorado Competitive Position. Many of the largest defense contractors in the world already have a major presence in Colorado, and the state seems to be well positioned for expansion. The area's central geographic location, strong telecom and information infrastructure, clusters of high-tech industries—especially aerospace, software, and telecom—numerous research and development facilities, and a concentration of military facilities all aid in the development of a strong defense industry.

Growth Opportunities. As mentioned above, Colorado is well positioned for growth in the defense and homeland security sectors. These are two areas that are currently thriving and present significant opportunities for a myriad of businesses. In order to realize this growth potential, however, several things need to happen. The state's telecom infrastructure needs to be further expanded and developed into rural areas, the state's higher education facilities must improve, Colorado representatives need to fight more aggressively for federal dollars, and the state legislature must look at offering financial incentives to draw major defense business to the state.

Telecommunications

International and National Trends. The first year that there were more cellular subscribers than main telephone lines in the world was 2002. Worldwide revenue in the industry has grown at a CAGR of 8.4% over the past decade. Nationally, telecom has struggled in recent years, but the industry is expected to rebound, driven in part by an array of new technologies.

Location Requirements. Telecommunications is essential to our modern way of life; therefore services are needed wherever people can be found. Telecommunication hubs generally arise in areas with a central location, a highly educated workforce, a strong communications infrastructure, and a concentration of other high-tech industries.

Colorado Competitive Position. Colorado has long been recognized as a national telecom hub for the aforementioned reasons. Recently, financial and legal woes have plagued the state's telecom industry, but experts are optimistic that as the industry recovers, Colorado will continue to maintain its position at the head of the pack.

Growth Opportunities. New technologies such as Wi-Fi, voice-over IP, and web-conferencing services have drawn a lot of attention recently and could help to drive growth in the industry. The well-trained and highly skilled industry workforce that remains in the area following mass layoffs also presents a good opportunity for growth as the industry recovers and hiring resumes.

Bioscience

International and National Trends. The United States is the top biotechnology country in terms of total number of firms, and is the top producer of medical devices, with 9 of the top 10 medical device companies based here. Consolidation is expected to continue in the biotechnology industry through mergers, layoffs and cost reductions, and firms exiting the industry. The difficulty in obtaining pre-seed and seed funding will continue to be a problem in the biotech sector. Funding in the medical device sector is more optimistic due to a shorter time to market, which provides a more attractive option for venture funding. Like other areas of healthcare, the medical device sector will be impacted by higher costs, and Medicare budget limitations and lengthy reimbursement processes.

Location Requirements. Factors required for a successful bioscience sector include strong academic research institutions that are conducting basic research in biosciences and are actively engaged with industry, the presence of local venture capital for all stages of the business cycle, a highly skilled workforce, a stable and supportive public policy structure, federal or other R&D support, specialized support services, a cluster of related firms, and successful transfer of government-funded research to commercialization.

Colorado Competitive Position. Colorado has a highly skilled and educated workforce, with the highest concentration in the country of people 25 years or older holding a bachelor's degree. It also has a strong bioscience research capability at universities and federal facilities, along with the Fitzsimons Research Park and Centers for Disease Control. However, the state lacks a national image as a bioscience center and has no history of sustained investment in technology development. Colorado has a strong medical device cluster.

Growth Opportunities. The interrelationships of biosciences with other emerging technologies will be a significant growth trend in the future. Some of these growth areas include bioinformatics, industrial, agriculture, nanotechnology, and environmental biotechnology. Increasing concerns about bioterrorism have made the infection control and disposables market more important.

Nanotechnology

International and National Trends. Nanotechnology is very new, still in its initial exploratory stage. While some people say it will lead to an economic revolution, the extent of its commercial application is currently unknown. Nevertheless, significant research and development dollars are being poured into this area as the potential future reward appears too good to pass up.

Location Requirements. Proximity to research facilities and a highly educated workforce are advantageous for a nanotechnology cluster. The presence of other high-tech industries that will use this technology is also important. Dry climates are preferable for the manufacturing of nanotechnology.

Colorado Competitive Position. Colorado's strengths in other high-tech industries and its highly educated workforce, dry climate, and abundance of university and federal research facilities make it an attractive area to locate a nanotechnology firm. There are already a number of companies in the area doing work in the field. Colorado ranks 8th in the country in terms of the number of nanotechnology companies and 6th in terms of nanotech companies per square mile.

Growth Opportunities. The future economic potential from the development and commercialization of nano-based technologies appears to be enormous. With commitment from the higher education, research, government, private, and economic development sectors, this potential could be realized in the state. By offering financial incentives and building on current strengths, Colorado should be able to grow the industry. Growth is expected to come initially in the areas of coating and nano-powders. Within the next decade applications of nanotechnology could begin to influence the areas of aerospace/defense, biotechnology and drug delivery, and information technology/ microelectronics, as well as energy and nano-associated fuel cells, and batteries. Growth is anticipated to occur primarily along the Front Range.

Services

International and National Trends. The services sector is the largest and most diverse sector of the economy. This report focused specifically on financial, health care, research and development services, and call centers. As the population grows, the need for health-care and financial services increases; however, as technology improves, these industries are becoming more and more efficient. The financial services industry is undergoing broad-based consolidation stemming from the Gramm-Leach-Bliley Act. Health-care services are struggling with rapidly rising costs and an aging population. Research and development is growing especially in areas related to defense, biotechnology, and nanotechnology. Call

centers are becoming increasing popular as a way to enhance customer service, although companies are frequently choosing to move these operations offshore to low labor cost areas.

Location Requirements. Wherever there are people, there is a need for financial and health-care services. Improved technologies with online banking and ATMs are making it increasingly easy for a financial service firm to serve a very large area. The major firms in the industry tend to locate near the stock exchanges in large cities. Research and development industries often center in areas with clusters of high-tech companies that have needs for their services. Universities often play a key role in the industry. Call centers look for locations with adequate telecommunications infrastructure and low-wage and real estate costs.

Colorado Competitive Position. Colorado is not generally known as a national financial center. However, the Denver metro area has developed a very strong mutual fund industry. This industry has struggled with falling stock markets and has been plagued by scandals recently. The effect these events will have on Colorado's mutual fund families remains largely unknown. The state is not recognized nationally as a health-care center; however, Colorado does serve as a regional center. The state has a relatively low total health-care employment concentration, yet strengths exist in the areas of biotechnology, research and testing services, instruments and supplies, and medical and dental labs. Colorado has long been a research and development hub. The presence of several major universities and federal research labs, along with the highly educated workforce and strong entrepreneurial environment, provide a foundation for a strong industry. Several large call centers are located in Colorado; however, many firms are moving these functions to cheaper areas, either overseas or in rural U.S. locations.

Growth Opportunities. As the state population continues to grow, financial and health-care services can be expected to expand. Denver is growing as a center for alternative investing strategies such as hedge funds. The large presence of talented mutual fund managers, many of whom were laid off during the industry's troubled times, also offer a growth opportunity in the financial services sector. Consolidation is the major threat to growth in the area as large out-of-state firms are continually gaining shares of the Colorado market. Growth in the state's health-care industry will likely be driven by growing and aging populations. The state's strong emerging biotechnology industry also bodes well for growth. Areas of research and development that present growth opportunities include biotechnology and nanotechnology, as well as defense and homeland security areas. A broad-based economic recovery should lead to increased R&D spending. More companies are using call centers to perform a variety of customer-service and marketing-related functions; however, the trend of offshore outsourcing and the impact of the state and national "no-call" lists on telemarketing firms are both negatively impacting the industry in Colorado. If growth were to occur, it would likely be in the state's rural areas where low labor costs are available.

Software

International and National Trends. The information technology sector, which includes software, is expected to grow 34% worldwide between 2001 and 2006. If software piracy is reduced, this number could go much higher. Some of the more exciting growth areas within the software sector include identity management, electronic design automation, warehouse management systems, GIS (geographic information systems), and wearable computers.

Location Requirements. Key location requirements for the software industry include a large talent pool, high-speed connectivity, and a cluster of existing companies in the area.

Colorado Competitive Position. Software is a significant contributor to the Colorado economy. The state ranks fifth in the United States in software services employment, and the Boulder-Longmont area is recognized as the leading software area in the country. Colorado's strengths in the industry include a well-educated workforce, an active industry association, and a concentration of other high-tech industries that use software development capabilities. Weaknesses include a shortage of available venture capital and a lack of some highly specialized industry support services.

Growth Opportunities. The homeland security market offers a significant growth opportunity to Colorado software developers. Other prospects include biotechnology and defense applications. Further partnership between the private and the academic sectors would help foster growth in the state. The recent trend of outsourcing software development overseas will continue to result in a loss of jobs, even while it offers an opportunity for Colorado companies to cut costs with cheap labor. Outsourcing also offers firms an opportunity to expand their operations to include the global market and save money to reinvest in further growth of the company.

Tourism and Hospitality

International and National Industry Trends. In 2003 travel and tourism in the world is expected to generate $4,544.2 billion of economic activity (total demand), growing to $8,939.7 billion by 2013. It is projected that by 2013, the total number of jobs will increase to 247,205,000, or 8.4% of total employment. In 2003 travel and tourism in the United States is projected to generate $1,387.8 billion of economic activity, increasing to $2,560.4 billion by 2013. By 2013, travel and tourism employment is estimated to total 17,907,000 jobs, or 11.9% of total employment.

Colorado Competitive Position. Colorado ranks 5th in the list of states Americans dream of visiting. The state's scenic beauty is a major attraction, and national state parks and forests provide opportunities for sightseeing and outdoor recreational activities. Challenges include the distance from major travel markets and the lack of a permanent consistent level of funding for the Colorado Tourism Office.

Growth Opportunities. Industry segments that offer growth potential include ecotourism, agritourism, heritage tourism, and adventure tourism.

Film

National and State Industry Trends. The theatrical film box office in the United States soared to $9.52 billion in 2002, continuing an 11-year streak of expansion. Admissions also rose in 2002 by 10%, to 1.64 billion, the highest level since 1957. In Colorado producers in the industry accounted for 3,933 direct and indirect jobs and $205.5 million in direct and indirect wages in 2001. Supplier firms employed 681 workers in 2001, with $21 million in wages and $83.4 million in receipts. Sole proprietors totaled 675 establishments in 2001,

with $24 million in estimated receipts. In 2002 projects were filmed in at least 40 of Colorado's 64 counties.

Location Requirements. The state offers a wide array of locations that provide opportunities for any production. High-powered computers, high-density digital storage, and specialized software are becoming the new postproduction facilities. As Colorado has one of the highest concentrations of computer, communications, and technology companies in the country, it is positioned to jump on the digital bandwagon.

Colorado Competitive Position. Those who work in the industry find it difficult to attract "out of state [production] because other states have better tax incentives." In addition, the Colorado Film Commission lost its funding in spring 2003 and was moved under the auspices of the Colorado Tourism Office.

Growth Opportunities. Establish a new private-public film commission, build on plans by the Regal Entertainment Group (which has headquarters in Arapahoe County and Nashville and is owned in part by Denver billionaire Philip Anschutz) to change the movie-going experience, and capitalize on the recent filming of *Silver City* in Denver and Leadville by independent filmmaker John Sayles.

SUMMARY OF INDUSTRY ANALYSES

Colorado's Industries	Success Factors
Food and Agriculture	
Strengths lie primarily in livestock with opportunities in value-added food.	University biotech research. Allocation of land and water resources; vulnerability to climate changes and disease.
Manufacturing	
Strengths in aerospace/defense; high-tech industries, particularly photonics; and computer and storage devices.	Large, qualified workforce; transportation infrastructure; proximity to research; high-tech industry clusters; strong industry associations. Available funding.
Energy and Environmental	
Significant production of fossil fuels, potential in alternative energy sources.	Abundance of the applicable natural resource, and proximity to research facilities. Transportation and transmission infrastructure, available capital, and public policy.
Transportation	
Strengths in air transportation and potential to become a transportation hub for all sectors.	Skilled workforce; central location; strong highway, air, and rail infrastructure. Proximity to manufacturers and distribution center, low taxes and licensing fees for air and trucking, collaboration between all industry sectors.
Aerospace	
Well positioned in both communications and defense.	Highly educated workforce, proximity to other high-tech industries, and proximity to military and higher education. Strong government support, and collaboration between public, private, and government.
Defense and Homeland Security	
Strong presence of industry leaders. Well positioned in related aerospace and communications fields.	Strong military presence, key strategic location, high-tech clusters, and strong telecom and information infrastructures. Aggressive representation in the fight for federal dollars and the offering of financial incentives.
Telecommunications	
Recognized as a national telecom hub, recent struggles should not affect the state's long-term position.	Highly educated workforce and strong communications infrastructure. Overcoming financial and legal problems, and regaining investor confidence
Bioscience	
A small but growing sector in Colorado comprised primarily of small firms. Medical devices is one of the state's stronger areas.	Strong academic research institution, presence of local venture capital, access to specialized facilities and equipment, a highly skilled workforce, a stable and supportive public policy structure, federal or other R&D support, and successful transfer of government-funded research to commercialization.
Nanotechnology	
Small but growing cluster that presents strong opportunities.	Highly educated workforce, presence of other high-tech industries that will use this technology, dry climate, and proximity to research facilities.
Services	
Colorado serves primarily as the regional center for both financial and health-care services. The state's R&D industry is very strong.	R&D – Cluster of high-tech companies, a highly educated workforce. Availability of funding. Health – Aging population, strength in biotech. Controlling rising costs and increasing consumer satisfaction. Financial – Growth of alternative investment strategies and mutual funds. Improved technologies and increased consolidation makes it harder for local firms to successfully compete with "super regionals."
Software	
Recognized as a top software area in the nation.	Highly educated workforce, critical mass of related companies, concentration of other high-tech industries that use software development capabilities, and proximity to higher education. Availability of venture capital and partnership between private and academic sectors.
Tourism and Hospitality	
Strong tourism industry, but depends heavily on overall economy performance and state budget.	Variety of attractions including casinos, national and state parks, ski areas, and other scenic locations; affordable accommodations. Consistent funding for state tourism marketing.
Film	
Existing base of film producers and suppliers.	Variety of locations for production, and availability of high-tech facilities. Presence of state film commission, large talent pool, state funding, and incentives for film production in the state.

FOOD AND AGRICULTURE

Food and Agriculture Market Trends

There have been significant social, economic, and technological changes in the food and agriculture sector in the last 20 years, including increased global competition, changes in farm and market structure, a demand for ecosystem services from the industry, increased product differentiation, and improved production with increased productivity. In the coming decade U.S. food and agriculture markets will continue to be shaped by changing demographics, technology, and a global economy.

Over the last century agricultural research and public policy have focused on improved food and fiber productivity resulting in significant gains such as the tripling of corn yields over the last 50 years. Productivity gains have been driven by scientific discoveries in plant and animal genetics, animal nutrition, and livestock health.

Production efficiency has improved with technologies in robotics, computing, and communications. For example, Internet access provides up-to-date information about commodity prices, world markets, and farm management. Tractors equipped with global positioning systems improve the ability to prepare and manage crops and fields (Ballenger 2003).

As we look ahead in the 21st century, the scientific emphasis will continue to be on efficient food and fiber production, but within the framework of improved public health, social well-being, and a safe environment. The new focus will include broadening food and fibers to include pharmaceutical, nutritional, and bio-based products. New efforts will be required to conserve biologic, land, water, and atmospheric resources. Additionally, the agricultural industry will be required to respond to advocacy groups concerned about the well-being of food animals, the sustained social and economic health of rural communities, and the globalization of the food economy. There will be new customers, including the organic food consumer, producers of pharmaceutical products, public and private natural-resource and land managers, conservationists, and entrepreneurs in rural communities (National Academies Press 2003).

One of the biggest drivers for future growth in the agricultural sector may be biotechnology, which includes transgenic plant technology. Plants have become one of the most inexpensive sources and means for the mass production of proteins. Biotechnology is used to enhance food production worldwide by creating plants that are resistant to disease, insects, and drought.

As technology enables production increases, there are opportunities for new markets throughout the world. Export revenues accounted for 20-30% of U.S. farm income over the past 30 years. In developed countries markets require value-added processed products with convenience, nutritional characteristics, and food safety. In middle-income countries demands are primarily for basic commodities and meats. And, while developing countries offer the greatest potential for new markets, income levels currently offer little opportunity for profitable trade (Caswell 2002).

National and International Industry Overview

National and international trends in major agricultural and food production segments relevant to the Colorado economy are discussed in this section.

U.S. red meat and poultry production is expected to decrease in 2003 and 2004 due to the effects of drought on feed and pasture conditions, the selling off of breeder cattle due to drought, and the time it will take to rebuild herds.

RED MEAT AND POULTRY FORECASTS (million lbs.)

	2002	2003	2004
Beef	27,090	26,244	25,350
Pork	19,664	19,533	19,450
Lamb and mutton	219	199	194
Broilers	32,240	32,371	32,725
Turkeys	5,713	5,691	5,775

Source: Economic Research Service, USDA (2003)

Beef produced in the United States in 2002 represents 31.7% of worldwide production. In contrast, Brazil is now the third-largest exporter of beef, with exports increasing to 750 million tons in 2000. U.S. pork represented 23.3% of world production, broilers 38.3%, and turkeys 6.7% (Gottschalk 2002) (*Wall Street Journal* 2002).

There are 40,000 cattle feeders in the United States, the largest 30 units of which provide 40% of fattened cattle. But the market share for these larger firms could rise to 45% by the end of 2002. The four largest cattle feeder states are Iowa, Kansas, Nebraska, and Texas. The beef sector has been hurt by mad cow disease, drought conditions and the September 11th terrorist attacks. Hedgersedge.com, a market research group for the agri-business community, notes that there has been a 3.5% decrease in beef demand since 9/11/01 (*Forbes* 2002).

Cattle feeders are losing money today for a variety of economic reasons, and the industry has outgrown itself so that tomorrow's profits are threatened. There are more feed bunks than there are cattle to eat out of them so that cattle feeders are bidding up the cost of calves and yearlings as they compete for the available supply. Dave Burkholder, president of the Nebraska Cattlemen, a statewide trade group, states that, "There are too many resources invested in the cattle industry, and if we filled the feeder bunk lines with cattle, we wouldn't have enough packers to slaughter them or consumers to eat them." Feedlot capacity rose from 11.7 million head of cattle in 1990 to 13.6 million in 2001, a 16% growth rate, even though the number of cattle on feed at one time never surpassed 11.9 million. Feedlots feed yearlings until they are about 1,200 pounds, before sending them to slaughter. Cow-calf operators, whose ranches and farms raise calves from birth until they are 550-pound yearlings and ready for the feedlots are expected to maintain better than expected profits as the price of their yearlings are bid up by the cattle feedlots (*Omaha World-Herald* 2002).

Marketing agreements between cattle feeders and packers are growing and will continue to grow while the cash, or spot, market is shrinking. A 2001 survey was conducted by agricultural economists at the University of Nebraska, Iowa State University, Kansas State University and Oklahoma State University. They surveyed 316 cattle feeders in their states. Respondents indicated that 23 % of their cattle were marketed under an agreement in 1996, a percentage that increased to 52% in 2001, and is projected to increase to 65% by 2006.

Furthermore, the survey found that 16% of respondents' cattle were marketed to a grid in 1996, 45% in 2001 and a projected 62% in 2006. In grid pricing, cattle feeders are paid premiums for high-quality, and high-yield but penalized for less-performing cattle, with each carcass priced to its merit, and the grid serving as the schedule on which the merit is measured (*Feedstuffs* 2002a).

Hog production continued its long-term consolidation in 2001 as the number of hog operations decreased and the number producing 1,000 head or more stayed the same or increased, as indicated by the hogs and pigs report in December, 2001. According to a report from the National Agricultural Statistics Service (NASS), 55% of the total hog inventory in 2001was held by the top 3% of hog operations (i.e., the top 250 operations owning 20,000 or more head). The number of hog farms in the United States decreased 6.1% in 2001 to 81,130 operations from 86,360 in 2000. The states with the largest decrease in the number of hog operations were New Mexico, Wyoming, and Georgia at 25% each, and Colorado with a decrease of 20% (*Feedstuffs* 2002b).

Regarding wheat farming, the U.S. Department of Agriculture's (USDA) Economic Research Service's economist Peter Riley forecasts U.S. wheat production for 2003 at 2,065 million bushels, an increase of 28% from the 1,616 million bushels in 2002. Furthermore, the June 1, 2003, wheat carryover forecast was 418 million bushels, down 46%, or 359 million bushels from 2002's 777 million bushels (*Milling & Baking News* 2003a).

The USDA reported that U. S. wheat exports for 2003 are projected to be 950 million bushels, a decrease of 21,700 tons. This is expected to be the lowest amount since 1985-86 (*Milling & Baking News* 2003b).

Potatoes provide U.S. farmers with annual receipts of $2.5 billion, 15% of all vegetable sector markets. Other vegetable cash crops (2001) include lettuce (12%), tomatoes (10%), onions (6%), sweet corn (5%), and a variety of others (52%). In addition, 85% of U.S. potato production occurs in the western states of Idaho, Colorado, and California. The growth of the fast-food industry has resulted in a trend toward increased use of frozen potato products and a decline in fresh use (U.S. Department of Agriculture 2003).

Organic agriculture has become a significant growth industry, as one million acres have been added for crops and pasture from 1997 to 2001. This has more than doubled organic cropland. During the last decade, consumer demand for organic foods has risen 20% annually. This dramatic increase in organic foods has brought about new government activities in research and education about organic farming systems. According to Datamonitor's U.S Organics 2002, organic food sales in the United States increased to an estimated $9.5 billion in 2001 from $3.6 billion in 1996. This represents a compound annual growth rate of 21.5%, yet the segment represents less than 2.0% of overall U.S. food sales. Organic food products are now available in leading natural and organic products retailers, conventional supermarket chains, mass-merchant retailers and other specialty food retailers across the United States. Datamonitor further estimates that conventional supermarket chains represented 46% of organic food sales while natural and organic retailers represented 54% in 2001. Factors contributing to the growth in organic products include growing consumer awareness of health and environmental issues, increased marketing and promotion by the retail sector, and a strong interest by major food manufacturers for developing organic product lines (Dimitri 2003).

U.S. sales of organic foods and beverages show increases in most categories from 2000 over 1999:

U.S. SALES OF ORGANIC FOODS AND BEVERAGES (in $millions)

Category	2000	1999
Fresh produce	$953	$833
Packaged grocery	652	692
Bulk/packaged	482	437
Frozen/refrigerated	333	323
Nondairy beverages (soy, rice, oat)	262	157
Dairy	273	171
Foodservice	120	127
Bakery	110	98
Snack foods	105	89
Coffee/tea	86	78
Other beverage (excluding beer/wine)	133	68
Home meal replacement	32	58
Fresh meat/seafood	44	35
Beer/wine	27	6

Source: Kortbech-Olesen 2002; Prepared Foods 2003

U.S. food manufacturing comprises 10% of total U.S. nondurable goods employment. In 2002, food manufacturing employed 1,525,100 while beverage and tobacco product manufacturing employed an additional 205,400 (U.S. Department of Labor).

The confectionery manufacturing industry is a $21 billion market. In the foodservice industry, more than 85% of commodity breads and rolls are purchased from commercial bakeries. Strong growth is forecasted in the change to thaw-and-serve frozen breads and rolls, due to enhanced consistency, and improved shelf life. Donuts are the fastest-growing product in the bakery market, along with variety breads and rolls, bar cakes, individual gourmet desserts, cookies and soft breads and rolls. Sales of bagels are off their historic growth rates, with growth stronger in foodservice than in the in-store bakery.

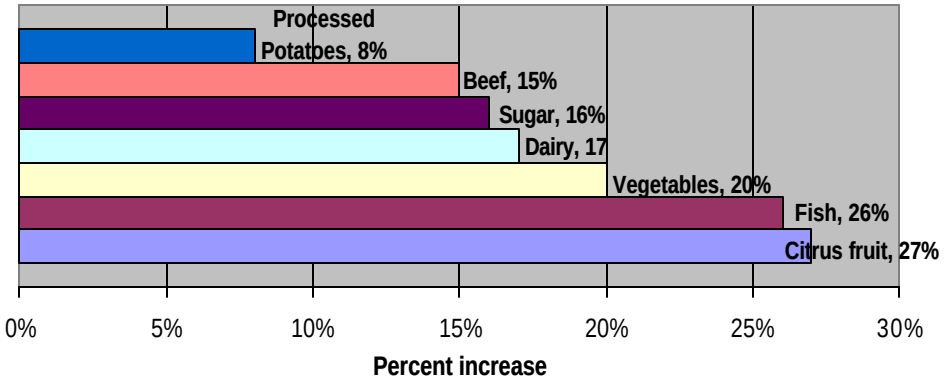
Growth Opportunities

Growth opportunities in the coming decade will be driven by major demographic, technological, and global trends.

Demographics

Food and agriculture markets in the United States will respond to three broad demographic trends: (a) More health conscious choices with increases in the population of Americans over 65 are expected to reduce demand for beef, cheese, sugar and fried potatoes and increase demand for eggs, fish, fruits, vegetables, and baked potatoes; (b) Rising incomes and higher standards of living for the general population are expected to lead to upgraded food choices such as luxury items and ready-to-eat meals; (c) An increased ethnic population will continue to diversify the American food repertoire and shift choices to more fruit, eggs, fish, poultry, and rice. Overall the U.S. population is expected to grow 18-28% by 2020 resulting in another 50 to 80 million people to feed. Taking all this into account, projected consumption growth from 2000 to 2020 is shown below (Ballenger 2003):

U.S. PROJECTED CONSUMPTION GROWTH
2000-2020



In response to the increased demand for safe and nutritious foods, the organic food sector is expected to continue to grow. The strong growth trend in organic agriculture is confirmed by data provided by the Economic Research Service of the USDA. Total certified organic cropland and pasture is now 2.3 million acres in 48 states. The U.S. government has adopted federal regulations, which were fully implemented in October 2002, to standardize organic certification requirements regarding pesticides, antibiotics, hormones, genetically modified organisms, and farming practices. Producers, in compliance with the new regulations are allowed to use the "USDA Organic" seal in product labeling, packaging and branding for products made with 95% or more organic ingredients.

There are almost 20,000 natural food stores and 73% of conventional grocery stores that stock organic products in the United States. Consumers spent $7.8 billion for organic foods in 2000 and $9.5 billion in 2001, half of which was purchased in conventional grocery stores. Soy products and meat/dairy alternatives are predicted to have the most impressive growth rates. Over 800 new organic food items were introduced in the market place during the first half of 2000, the majority of which were deserts and beverages. The natural product retailers that sell organic foods make up 1% of all food stores in the United States, but sell almost half of all organic foods. Organic farmers are taking an increasing amount of the consumer food expenditure through creative efforts that include on-farm processing, producer marketing cooperatives, and community-supported agriculture. Organic farmers are selling 23% of their organic produce directly to consumers through on-farm sales, farmers markets, and community-supported agriculture subscriptions. Another 20% was marketed directly to retail food stores and restaurants. According to Datamonitor's U.S. Organics 2002, from 1996 to 2001 the U.S. organic dairy market grew at a compound annual growth rate of approximately 57.9% per year, yet represents less than 1% of the $43.9 billion total retail market for U.S. dairy products. Organic milk and milk-based products, such as yogurt and kefir had a 56.4% increase in sales in 2000 (Dimitri 2003).

Technology

Technology will continue to create new opportunities for agricultural industry in the coming decade and beyond. These opportunities include increased quantity and quality of animal and crop production with less environmental impact; the ability to produce industrial chemicals, medicines and plastics from plants; and the cost-effective production of biofuels and energy

from agricultural residues. Biofuels and energy are discussed in the "Energy and Environment" section of this report.

Biotechnology delivers significant current and future benefits to farm animal and crop production. It increases animal health, develops animals with reduced fat; increases livestock, egg and poultry productivity; and transgenic crops are tailored to the dietary needs for various farm animals. Bio-based animal health products and services is currently a $2.8 billion market that is projected to grow to $5.1 billion by 2005. In addition, transgenic cows, goats and sheep produce milk that contain therapeutic proteins that treat emphysema, cystic fibrosis, burns, gastrointestinal infections and immunodeficiency diseases. Continued research will continue to introduce new therapeutics from "pharm" animals (Bio 2003).

Transgenic plant technology or genetically modified (GM) plants are providing innovative technologies to many areas of agriculture and industry. These areas include:

- increased crop production and improved food quality;
- the production of monoclonal antibodies;
- therapeutic proteins;
- edible vaccines for the pharmaceutical industry; and
- environmentally friendly outputs such as biodegradable plastics.

Present transgenic efforts are predominately centered on modified input traits for improved field production, and contain herbicide and insecticide tolerant traits. The United States dominates world production in this area, with more than 70% of the field releases. Corn, potato, and soybeans are the most common crops used in transgenic crop technology.

In 2002 U.S. growers planted 96.3 million acres with transgenic crops, a 66% increase in acreage over 2001. According to the National Center for Food and Agricultural Policy's 2002 report, the eight transgenic crop varieties used by U.S. growers in 2001 increased crop yields by 4 billion pounds, saved growers $1.2 billion by lowering production costs and reduced pesticide use by 46 million pounds (Bio 2003).

On the other hand, transgenic crops and seeds also represent a possible threat to U.S. grain markets. The content and implementation of international protocols that will be enacted to protect the safe transfer, handling, and use of modified organisms will have significant impact on the growth of markets for U.S. crops. Unnecessarily strict documentation requirements could have negative impacts on exports of all U.S. grains (National Corn Growers Association 2003).

The global market for crop protection and genetically-enhanced seeds is approaching $50 billion a year. This is attracting large agricultural and chemical companies who are acquiring small plant-genomics firms. By partnering with large firms, plant biotech start-ups can develop the technology for the next novel drug or super crop without getting involved in the regulatory and clinical processes that slow down commercialization of new products. Start-ups must structure their agreements with industry giants so they can enjoy revenue growth without becoming absorbed by the larger companies. According to one researcher, the best way to build a successful plant genomics company is to identify a need, and then find the gene that can meet that need. One example is phytoremediation a new technology developed by the Phytoworks Company, which genetically alters plants so they suck toxins like mercury

out of contaminated soil and make the toxins harmless with the plants' own biological processes. Plant genomics is the mapping of a plant's genetic structure, and it is attracting researcher's attention to the complicated chemistry of greenery to identify compounds that can be used to meet human needs. It appears that there are a wide array of substances in plants that may lead to cancer cures, super crops, and a new generation of plastics among other new technology applications (*TechCapital* 1999).

National agricultural biotechnology industry companies include Bionova Holding Corporation, San Diego, California, whose plant technology division has been closed, and Exelixis Plant Sciences, Inc., Portland, Oregon. Exelixis focuses on plant genomics. Its ATTAG gene technology provides plant disease resistance. The company is also researching crop-protection products including insecticides and nematicides. In 1999 Exelixis Plant Sciences and Aventis CropScience formed Agrinomics, LLC, which conducts research in agricultural genomics. Bayer CropScience/Aventis CropScience is attempting to create the world's leading crop science company. The three main segments of their business are: crop protection, green biotechnology and seeds (Hoovers.com 2003).

New technologies in seed corn in the next few years are expected to provide protection against a variety of corn worms. Monsanto is seeking Environmental Protection Agency approval for its YieldGard Plus corn that protects against corn rootworm and the European corn borer. Dow AgroSciences and Pioneer HiBred jointly developed a new variety of Herculex I which offers protection against the black cutworm and fall armyworm, and should be available in farm fields in 2003 (*Farm Journal* 2003).

Most of the leading players in the $30 billion a year agrochemicals industry see ag biotech as the area of greatest promise for increasing agricultural production to meet the needs of the future. Ag biotech includes areas such as transgenic plants, green biotech, plant biotechnology, biopharmaceutical crops, bio-based products, cellulosic plastic, polylactides, soy-based plastics, and sustainable biocomposites. In addition, a recent trend is the forming of contracts between farmers and biotech firms seeking new regions in which to grow biopharmaceutical crops (*Chemical Market Reporter* 2001).

With recent advances in plant biotechnology, transgenic plants have been targeted as an inexpensive means for the mass production of proteins for biopharmaceutical and industrial uses. However, the current plant purification techniques lack a generally applicable, economic, large-scale strategy (Desai 2002).

While there is considerable ongoing research to determine what new commercially feasible products are possible, there is controversy regarding the environmental and nutritional impact of agricultural biotechnology. Government regulators are attempting to establish standards and regulations to protect consumers, and approval by U.S. regulatory agencies is ongoing. There is a number of agrochemical companies involved in transgenic technology, and this industry is an important part of existing and new developments (Weck 2002).

In particular, "biopharming" requires changes in infrastructure and in outlook. Farmers must view these crops differently and handle them differently to prevent risks to the entire food chain. Of particular concern is the need for effective regulation governing plants used for pharmaceuticals and industrial uses. Most of these products are three to five years from commercialization and the regulatory system needs to be operational before products can be sold (*Food Chemical News* 2003).

The U.S. Department of Agriculture forecasts a record corn crop of 10.3 billion bushels for 2003, an increase of 1 billion bushels over 2002. Plastics and fibers made from polylactides derived from corn could be used to make plastics, fibers and molded parts. About 227,000 tons of plastic produced per year could be replaced by polylactides and other biodegradable polymers, an estimate provided by a Berkeley Heights, New Jersey, consulting group, Eldib Engineering and Research Inc. (EER). While total global capacity for biodegradable polymers is projected to be 400 million pounds per year, only a small proportion of that capacity is used, according to EER. In Japan and Europe, potential demand for biodegradables as plastic replacement is strong, especially as corn prices are more stable than oil prices. By using polylactides to make plastics the United States could help reduce its dependency on foreign oil imports (*Milling & Baking News* 2003c) (*Chemical Market Reporter* 2003).

One recent entry to the market is soy-based plastics that can be produced less expensively than petroleum-based plastics and that create high value markets for soy bean crops (*Journal Star* 2002). An example is the polyurethane injection molded plastic from Bayer Corp, Pittsburgh, Pennsylvania, being used by John Deere for panels on combines beginning with 2002 models (*Machine Design* 2001). Another example is a joint venture between Cargill and Dow Chemical near Minneapolis, Minnesota, to make polylactic acid from corn and sugar beet-derived starch for markets in films, thermoformed containers and fibers for apparel, and possibly extrusion coatings. Other companies and organizations are conducting research for future industrial applications from biofeedstocks that will produce polyester, glycerol, ethanol, benzene, toluene and xylene, succinic acid for food and pharmaceutical ingredients, detergents, and green solvents (*Chemical Market Reporter* 1998).

International Trade

Export of agricultural products depends on a variety of factors, including crop production in the United States and competing countries, valuation of the dollar versus other currencies, and economic conditions in trading countries. Global economic growth and a weaker dollar led to increased demand for U.S. agricultural products in 2003. Fiscal 2004 U.S. agricultural exports are expected to reach $57 billion, up $1.5 billion from estimated 2003. Forecasts include $600 million increase for grain and feed (corn and wheat); $1 billion decrease in oilseeds and products (soybeans); and an increase of $800 million for livestock, poultry and dairy products. Exports of hides and skins are forecast to remain unchanged at $1.8 billion through fiscal 2004. Fruits and preparations will increase $100 million, and the total horticultural export projection is raised by $200 million due largely to very strong sales of wine and essential oils. The largest country markets are Canada first with 16.1% of U.S. agricultural exports, Japan is second with 15.6%, followed by Mexico with 13.2% (Whitton 2003).

U.S. exports of red meat and poultry are forecast to increase slightly in the near term:

FORECASTS FOR U.S. EXPORTS (million lbs.)

	2002	2003	2004
Beef & veal	2,447	2,505	2,550
Pork	1,611	1,668	1,695
Broiler	4,800	4,875	5,200
Turkey	439	428	445

Source: Economic Research Service (2003)

Profile and Trends in Colorado Agricultural Industry

Agriculture is a major contributor to Colorado's economy with the market value of crops and livestock in 2001 totaling $4.7 billion in gross sales (Economic Research Service 2003b). Agribusiness (inputs, production, marketing, and processing) provide an estimated 105,000 jobs and generates $15.8 billion annually for the state's economy (Carlson 2003).

Livestock is the most significant agricultural commodity produced in Colorado generating 71.4% of total cash receipts in 2001. Crops provided 28.6%. Within the livestock products category, the proportion of cash receipts yielded by segments was:

- meat animals 62.0%;
- dairy milk products 6.1%;
- poultry and eggs 2.3%; and
- other 0.9%.

(Colorado Agricultural Statistics Service 2003a).

Cattle and calves accounted for most of the meat animals cash receipts. Data on the top five commodities and the relative importance of each to state and U.S. cash receipts is shown below:

TOP COLORADO AGRICULTURAL COMMODITIES 2001

Commodity	Value of Receipts Thousand $	% of state total Farm receipts	% of U.S. Value
Cattle and calves	$2,589,204	54.8%	6.4%
Dairy products	287,712	6.1	1.2
Corn	285,482	6.0	1.7
Hogs	263,659	5.6	2.1
Hay	243,848	5.2	5.4

Source: Economic Research Service 2003b

In addition to corn and hay shown above, other important crops generating cash receipts and their percentage share of total Colorado farm receipts were wheat (4.1%), potatoes (2.1%) and greenhouse/nursery (4.4%). Other crops, including dry edible beans, barley, sugar beets, sunflowers, grain and silage sorghum, and oats, each accounted for less than 1.0% of crop receipts (Colorado Agricultural Statistics Service 2003d).

Weld, Yuma, Morgan, Logan and Kit Carson Counties lead the state's agricultural production:

TOP FIVE COUNTIES IN AGRICULTURAL SALES - 1997

Counties	Percentage of State's Total Receipts	Million $
Weld	28.4%	$1,286.6
Yuma	10.6	481.4
Morgan	9.0	405.9
Logan	6.5	292.7
Kit Carson	3.9	177.1
State Total		$4,534.2

Source: Economic Research Service 2003b

In terms of international exports, Colorado's top agricultural export product in 2002 was live animals and meat. Compared to other states, Colorado ranked 4th in export value of hides and skins and 5th in export value of live animals and meat:

TOP FIVE AGRICULTURE EXPORTS (estimates) FY 2002

Commodity	Rank Among States	Value (million $)
Live animals and meat	5	$285.6
Wheat and products	10	147.8
Hides and skins	4	134.5
Feed grains and products	13	114.5
Vegetables and preparations	12	75.3
Overall	20	$904.0

Source: Economic Research Service 2003b

Beef is the eighth largest Colorado export product in terms of sales; however, export revenues from beef declined 3.6% from $189.8 million in 1998 to $182.9 in 2002. In contrast, "raw hides and skins of bovine or equine animals," grew significantly, from $63.5 million in 1998, to $137.3 million in actual sales in 2002 (World Trade Center Denver 2003).

In 2002 Colorado had 14,300 livestock operations of which 10,500 were beef cow operations, 1,900 were sheep operations, 780 were milk cow, 390 were hog and 275 were cattle feed lots (Colorado Agricultural Statistics Service 2003b). Colorado, in 2002, had 87 animal slaughtering operations, and there are 3,771 such businesses in the United States (Dun & Bradstreet 2003).

Only the largest 5 beef cattle farms had sales of $1 million or more in 2002 in Colorado, with the largest farm generating sales of $2 million. The fifty largest operations had sales of $270,000 or more in 2002, with the remaining 753 farms and ranches having sales below that amount (Dun & Bradstreet 2003).

Counties with the largest inventory of cattle and calves as of January 2003 were Weld, Yuma, Logan, Morgan, Kit Carson, and Prowers respectively. For beef cows only, the largest inventories were in Yuma, Weld, Logan, Kit Carson, Lincoln and Las Animas (Colorado Agricultural Statistics Service 2003f).

One of the leaders of natural meat products manufacturing is Coleman Natural Products, Inc., headquartered in Denver, Colorado. The Coleman Natural Meats line, which has no antibiotics, growth hormones or other additives, is marketed nationally in most natural foods stores, as well as some conventional grocery stores. The company's certified cattle raising

and production processes assure the consumer that its products are safe, and clean. Their natural meat sales are benefiting from changing consumer attitudes about foods that are being brought about by healthier eating habits, changes in demographics caused by aging "baby boomers," increasing concerns regarding food safety, freshness and purity, and a greater awareness of the environment. In 1995, The Trends Research Institute projected that one of the top 10 trends for 1996 and beyond would be a diet of foods free of artificial preservatives, coloring, irradiation, pesticides, drug residues, and growth hormones. A 1996 Food Marketing Institute consumer research study indicated that 97% of U.S. consumers are changing their eating habits to a healthier diet, and that nearly 8 out of 10 U.S. shoppers believe that hormones and antibiotics in meats constitute a health hazard (Coleman Natural Products 2003).

Dairy Cattle and Milk Production

In 2002 Colorado produced 2.16 billion pounds of milk and generated cash receipts of $250,986,000 from the sale of milk (Colorado Agricultural Statistics Service 2003c). In 2002, fourteen Colorado dairies had $2 million or more in sales revenues and an additional nine reported sales of $1 million and above. The largest dairy operations each with reported sales of over $3 million are located in Fort Morgan, Platteville, Loveland, and Milliken. (Dun & Bradstreet 2003).

A strong market niche for some Colorado dairy farms is the organic milk and milk products industry. Horizon Organic Dairies, Inc., headquartered in Longmont, Colorado, has a 70% market share of all organic fluid milk products in the United States sold in conventional supermarkets. They offer a full line of milk products, including yogurt, butter, and cottage cheese, among others. The company's total net sales have grown from $29.6 million in 1997 to $187.5 million in 2002, representing a compound annual growth rate of 44.7%. Competition for organic dairy products vary by region and include: Organic Valley, which is marketed by CROPP, a dairy cooperative located in Wisconsin; Stonyfield Farm, a national brand of organic yogurt located in New Hampshire, whose major investor is Groupe Danone, the maker of Dannon yogurt; Straus Family Creamery, a regional organic dairy located in California; Echo Springs, a regional organic and conventional dairy located in Oregon; Brown Cow West, Inc., a regional organic and conventional dairy located in Northern California; and Stremicks Heritage Foods, a regional dairy located in Southern California. Recently, there has been significant interest in the organic foods by conventional foods manufacturers. Groupe Danone has recently acquired a significant minority interest in Stonyfield Farm; General Mills Corporation has acquired Cascadian Farms, a leading organic food products company; H.J. Heinz Company has a significant investment in Hain Celestial Group, Inc., the largest organic food company in the U.S.; and Dean Foods Company has acquired White Wave, the leading producer of organic soy milk in the United States (Horizon Organic Dairies 2003).

White Wave Corporation, based in Boulder, Colorado, manufactures 40 different organic soy products and retails them in supermarkets and natural food stores across the United States. In 2002, it had over 100 employees and sales of about $85 million. Dean Foods and Horizon Organic Dairies recently announced a merger between the companies. If traditional food companies acquire or partner with existing organic brands, they could leverage their existing retail distribution to compete more effectively in the organic foods markets and provide continuing high growth rates (White Wave 2003).

Cheese Production

Colorado has 5 cheese manufacturing operations of the 748 companies in the United States. Leprino Corporation, with sales in 2002 of $737.3 million accounted for 95.6% of total cheese sales in Colorado. Organic cheese manufacturing is a potential high growth market niche for a cheese manufacturer in Colorado (Dun & Bradstreet 2003).

Grain and Feed Crops

Hay is Colorado's leading crop in value of production with a 2002 hay crop valued at $366.8 million. The five counties with the highest total hay production are Weld, Saguache, Prowers, Logan, and Morgan respectively (Colorado Agricultural Statistics Service 2003e). In terms of sales by individual farm operations, Moffat County is home to the two largest operations generating sales in 2002 of $1.5 million and $860,000 respectively. The third largest operation, with 2002 sales of $750,000, is located in Conejos County. Most other operations are small with 30 reporting sales in 2002 of $190,000 or more (Dun & Bradstreet 2003).

Corn was the second leading crop with combined value of corn for grain and corn for silage at $369.2 million in 2002. Weld County produces the most corn used for silage; while Yuma, Phillips, Morgan, and Kit Carson counties are the highest grain corn producers (Colorado Agricultural Statistics Service 2003e). In 2002, the top six individual Colorado corn growers had sales between $3.2 million and $1.0 million. The 50 largest corn farms had sales of $ 270,000 and above, with the remaining 492 farms generating sales of less than that amount. Most of the corn grown in Colorado is for feed. There are five wet corn milling companies in Colorado, with the largest selling $231.5 million in 2002, and the next largest with sales of $38.5 million (Dun & Bradstreet 2003).

Potatoes were the third leading crop with production valued at $216.2 million in 2002. There are 77,000 acres of land devoted to potato production in the San Luis Valley. Highest producing counties were Alamosa, Rio Grande, Saguache, and Costilla.

The 2002 wheat crop was valued at $148.9 million, down 21% from 2001. The highest production of winter wheat in 2001 was generated by Washington, Kit Carson, Adams and Yuma counties, while Saguache and Logan counties produced the most spring wheat (Colorado Agricultural Statistics Service 2003e). Only one Colorado farm operation had sales of over $1.0 million in 2002; however, 30 wheat farms had sales of $180,000 and above (Dun & Bradstreet 2003).

The Colorado fruit crop had a combined value of $15.7 million for 2002 with peaches the leading crop at 66.9% of total, followed by apples (23.5%), pears (8.8%) and tart cherries at .8% (Colorado Agricultural Statistics Service 2003e). In 2002, Colorado had 210 orchards with 76 in Delta County, 42 in Mesa County, 20 in Fremont, 17 in Montezuma and 12 in Montrose County (Colorado Agricultural Statistics Service 2002).

Data are collected on seven fresh market vegetable crops each year. These vegetable crops had a total 2002 value of $108.6 million with dry storage onions representing 46.7% of total, carrots (13.2%), cabbage (10%), sweet corn ($9.6%), lettuce (9.1%), cantaloupe (6%), and spinach (5.4%) (Colorado Agricultural Statistics Service 2003e).

In addition, there were 134 floriculture operations in the state with sales of $100,000 or more in 2001. The estimated value of sales at wholesale from all 134 operations totaled $86,240,000 in 2001(Colorado Agricultural Statistics Service 2003e).

COLORADO TOP AGRICULTURAL PRODUCING COUNTIES BY CROP (2002)

	Barley	Beans (Dry)	Corn Grain	Corn Silage	Hay Alf	Hay Other	Oats	Potatoes	Sorghum	Sugar Beets	Sunflowers	Wheat Winter	Wheat Spring
Adams												3	
Alamosa	4						4	1					
Baca									1		5		
Bent									4				
Cheyenne											1		
Conejos	5												
Costilla							3	4					
Jackson						1							
Kiowa									3				
Kit Carson			4	5								2	
Lincoln											4		
Logan				2	4					3			2
Moffat													
Morgan			3	4	5					5			
Montrose		3											
Phillips		5	2							4			
Prowers					2				2				
Pueblo									5				
Rio Blanco						4							
Rio Grande	1							2					
Routt						2							
Saguache	2				3	3		3					1
Sedgwick		4					2				3		
Weld	3	2	5	1	1					1	2	5	
Washington												1	
Yuma		1	1	3			1	5		2		4	

Source: Colorado Agricultural Statistics 2003

Additional detailed agricultural statistics by county are available in "Colorado Agricultural Statistics 2003," (CASS 2003g)

Colorado is the nation's largest producer of lamb, with more than 1 million head of sheep and lambs slaughtered annually, producing cash receipts in 2002 of $95,694,000. In 2002 there were 1,900 sheep operations in the state. Total January 1, 2003, inventory of sheep and lambs was 370,000 head. Colorado ranks third among states in the number of market sheep and lambs with a January 2003 inventory of 185,000 market animals (Colorado Agricultural Statistics Service 2003b).

Colorado has 15 trout producing operations in 2002 generating sales of $2.5 million and 19 operations that distributed trout (stockers and fingerlings) with a sales value of $5.48 million (Colorado Agricultural Statistics Service 2003b).

COLORADO FOOD MANUFACTURING - 2002

	Employment (thousands)	Establishments
Food Manufacturing	19.3	523
Beverage	5.9	62

Source: Colorado Department of Labor

In the United States there are 6,113 commercial bakeries, and Colorado has 68 of them. The top 15 commercial bakeries in Colorado had sales ranging from a high of $28 million to $1 million. The remaining 53 had sales below $1 million (Dun & Bradstreet 2003).

Confectionary manufacturers in the United States totaled 1,768 in 2002, with 31 located in Colorado. Two Colorado manufacturers had sales of about $1 million, 4 companies sold between $300,000 and $500,000, and 4 companies had sales between $100,000 and $250,000. The remaining 21 companies generated sales of under $100,000 (Dun & Bradstreet 2003).

Challenges for Colorado Agriculture

Agriculture has always been a risky business, with annual production dependent on uncontrollable vagaries of nature as well as good farm management, with revenues subject to overall supply and demand, and production costs requiring intensive capital investment in land and equipment. In the coming decade, Colorado agriculture will continue to face additional threats posed by the allocation of land and water resources between growing urban population needs and those of agricultural producers.

Due to the state's semi-arid climate, all of the prime agricultural land must be irrigated. Fifty-five percent of all Colorado farms have some irrigated land. About 3 million acres are under irrigation and 20% of the irrigated acreage depends on finite groundwater sources such as the Ogallala Aquifer in eastern Colorado. In addition, agricultural water resources are threatened by drought, with 2002 being the third year of drought and the driest year statewide since the 1700s. Increased water resources will also be required by urban population growth estimated to increase by 2 million people in the next 20 years. If use patterns continue, this will require an additional 500,000 acre-feet per year for nonagricultural consumption (Carlson 2003).

Colorado's rural leadership from the Western Slope, San Luis Valley and eastern plains, recognize the importance of water to sustainable agricultural economies (Focus Group/Survey 2003). Water resource conservation measures are being adopted by water restrictions and water reuse systems in urban communities and through improved irrigation systems on farms. Water allocation issues are beginning to be addressed through innovative agreements between urban water districts and rural water rights owners. Still, in times of poor crops and insufficient farm incomes, farmers will continue to sell other assets, including land and water, to generate needed revenue.

This is not a new trend. Based on the 1997 Census of Agriculture, agricultural land in Colorado has declined by 1.4 million acres in the 10 year period 1987-1997. This average decline of 140,000 acres per year has been equated to losing a strip of land 1.5 miles wide and 140 miles long each year - the distance from Ft. Collins to Colorado Springs (Carlson 1999a).

Still, farmers and ranchers own or manage 80% of water and 90% of the remaining private open land. As urban populations increase, this private land represents a significant asset that can be sold or placed in a conservation trust to generate income for the farmer, but at the cost of agricultural land.

In a 2001 survey by Colorado State University, 96.2% of the public indicated that maintaining land and water in agriculture is very or moderately important for food production and resulting open space and wildlife habitat (Fix 2001). There is a growing market in purchase of agricultural land for public recreational use funded by city and county governments and Great Outdoors Colorado. There is not enough public money to purchase all the desired open space, and new policies favor use of land conservation easements. In addition, urban areas are seeking ways to reduce infrastructure and public service costs by limiting sprawl and increasing open space through such mechanisms as clustered development. A new strategy for rural land owners is "Agricultural Preservation Associations" (APAs) that permit landowners to join together to structure land agreements to preserve agricultural land while benefiting from marketing combined properties at higher value for limited residential and commercial development. Thus public interest in open space and developer interest in land represents an emerging market and source of revenue for farmers that will require landowners to forge new partnerships with developers, land trusts, and natural resource groups. New types of technical assistance are needed to help landowners respond to this market in order to gain needed revenue while protecting future agricultural capacity (Carlson 1999b).

Diversification of crops is needed to protect the agricultural economy from future policy changes, and to position farmers in higher-value crop markets. Many Colorado crops (wheat, corn) are grown profitably due to federal farm subsidy programs. Should federal policies change in the future, these crops could not be competitively grown in Colorado. With market trends indicating future lower consumption of fresh potatoes; these growers need to be targeting value-added processing or considering alternative crops. While some technical assistance is available from Colorado State University and Cooperative

Extension, independent producers are reluctant and slow to change historical production patterns (Focus Group/Survey 2003).

Colorado Growth Opportunities

Colorado has a strong agricultural heritage that will preserve economically viable animal and crop production in the coming decade. As pastures recover from drought and herds are rebuilt, cattle and beef production will remain a strong sector with high economic value retained by in-state beef processing operations. Skins and hides have shown significant growth in global exports which will continue to bring revenue to the state. Lamb, poultry and fish should maintain market share with anticipated demand by older Americans and ethnic groups. Markets for dairy products and vegetables will also respond to projected increased U.S. consumer demand. And, producers in all sectors could increase revenues by joining the profitable and growing organic and natural food market.

Increased competition for land and water, and increased international competition for markets, will lead some growers to consider specialty crop alternatives such as vegetable, nursery, fruit, turf, ornamental, fiber, and herbs. Specialty crops offering high value also include organic produce and organic seed. These crops require a high degree of management yet offer higher revenues per acre. To help growers explore these options, training, as well as funding research and demonstration projects, is available through the Specialty Crop Program at Colorado State University (Stonaker 2003).

In some areas, the economy will diversify to include agri-tourism (discussed in the Tourism Industry Sector), and rural small business development. In part, this diversification will depend upon the state's ability to extend high-speed telecommunication networks "the last mile" to reach rural communities. Access to broadband networks is expected to create a level playing field and allow many types of small businesses to locate and/or expand in rural communities. This infrastructure enables businesses to obtain information, communicate with large customers, do business with the government, manage inventories, and much more (Focus Group/Survey 2003).

The strongest growth drivers for Colorado agriculture in the coming decade will be through the application of biotechnologies, value-added food processing, and opportunities for energy production from wind and biomass (discussed further in the Energy and Environment Industry Sector).

Food production that uses Colorado-grown commodities brings more value to the state economy and more profit to the producer. Value-added producers can address market predictions of increased U.S. consumer demand for convenience foods and luxury food items. Wines, jams and jellies from Colorado fruit, beer, bakery goods, and frozen vegetables are good opportunities. Processed potatoes and sunflower seeds provide additional opportunities. Producer cooperatives are already demonstrating the viability of producer-owned operations that add value to their agricultural commodities through production and marketing of food products. Examples include wheat farmers that produce

and sell bread, and sheep ranchers that produce and sell wool blankets (Focus Group/Survey 2003).

In addition to increasing the quality and quantity of animal and crop production, biotechnology offers opportunities that have already captured the attention of Colorado farmers, economic developers, and the biotechnology industry. These opportunities include the potential for bioproducts from corn such as industrial chemicals and plastics. Companies in high corn producing states have already begun to demonstrate the viability of these technologies. Colorado will need to look carefully at the quantity of corn, the dependence on federal corn subsidies, and the water resources that would be needed for cost-effective production. As other technologies develop, these products may become feasible using a variety of grasses and crops as well as agricultural residues such as manure, wheat straw, and corn stalks. These technologies may improve the potential for Colorado to enter these sustainable bioproduct markets.

The potential for biopharming in Colorado is also being explored. A permit for an exploratory plot of pharmaceutical corn in Phillips County has been granted to Meristem and a trial crop may be planted next year. This corn would produce lipase for the treatment of digestive disorder cystic fibrosis for use in clinical trials in Europe (Colorado Corn Growers 2003). Corn producing areas on the eastern plains have the potential for carefully controlled plots. Mesa, Montrose, and Montezuma Counties are also exploring biopharming, which could potentially benefit from the isolation of this area's corn fields from other corn producing areas, local water availability, and the ideal growing conditions provided by the warm days and cool nights in this region. The long term goal would be for crops that could be grown, and processed in the community, creating jobs for graduates of biotechnology and biology programs at Mesa State in Grand Junction. There is a high level of agreement on the importance of additional research to ensure the quality of the pharmaceutical product throughout the production, transportation and production process. Sound regulatory systems also need to be in place to prevent cross contamination of other crops and the natural environment (Focus Group/Survey 2003).

The continued development and activities of regional consortia will be important to the future sustainable agricultural economy in Colorado. Regional consortia (Club 20, Progressive 15, and Agricultural Coalition of Tomorrow) have formed to bring producers together with local government leaders and economic developers to set new directions for economic growth in rural communities. These structures will become increasingly important if farmers and rural land owners are to pursue opportunities in wind or biomass energy production, or large bioproduction facilities that require access to crop or waste resources from the multiple operations in the local production area.

BIBLIOGRAPHY

Ballenger, Nicole and J. Blaylock (2003). "Consumer-Driven Agriculture: Changing U.S. Demographics Influence Eating Habits." *Amber Waves*, April. <http://www.ers.usda.gov/Amberwaves/April03/Features/ConsumerDrivenAg.htm> September 8.

Bio (2003). "Agricultural Production Applications." Biotechnology Industry Organization. <http://www.bio.org/er/agriculture.asp> August 27.

Caswell, Margriet (2002). "A Role for Technology in 21st-Century Agriculture." *Agricultural Outlook*, Economic Research Service, United States Department of Agriculture, October 2002. <http://www.ers.usda.gov> August 28, 2003.

Carlson, David and J. Leeper (2003). "Agriculture and Water in Colorado." *Weathering Tough Times Together*, Colorado Agricultural Outlook Forum, February 2003, conference papers. <http://wwwcoloradoagforum.com/forumdocs/2003/insert.pdf> August 27.

Carlson, David (1999a). "Colorado Ag Land Losses Accelerate." Colorado Department of Agriculture. <http://www.ag.state.co.us/resource/documents/AgLandLossesAccelerateNewsrelease.html> September 3, 2003.

_____ (1999b). Colorado "Agriculture's Role in Colorado's Growth Debate." *Colorado Department of Agriculture*, June 1999. <http://www.ag.state.co.us/Resource/documents/99AgGrowthOutline.html>

Chemical Market Reporter (2003). "Polylactide: Specialties in Brief." *Chemical Market Reporter*, vol. 263, no. 17, p. 10, April 28. Secondary source: DIALOG(R)File 9: Business & Industry(R).

_____ (2001). "A Changing Landscape for Agrochemicals: Bayer's Pending Acquisition of Aventis CropScience Changes the Playing Field." *Chemical Market Reporter*, vol. 260, no. 23, p. FR9(4), December 17. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Chemical Market Reporter (1998). "Emerging Markets 98: Carbohydrate Feedstocks: Renewing Interest in Agricultural-Based Feedstocks." Vol. 254, no. 19, p. FR14, November 9. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Coleman Natural Products (2003). "Company Fact Sheet." *Hoovers.com*, August 5. <http:/www.hoovers.com>

Colorado Agricultural Statistics Service (CASS) (2003a). *National Agricultural Statistics Service*, May.

_____ (2003b). "Colorado Agricultural Statistics 2003." Colorado Department of Agriculture and National Agricultural Statistics Service, pp. 97-100, July. <www.nass.usda.gov/co> September 5.

_____ (2003c). pp 97, 114.

_____ (2003d). p 16.

_____ (2003e). pp 16, 18, 24, 25, 28, 60, 78, 80, 84.

_____ (2003f). pp 110, 112.

_____ (2003g). pp 118-41.

_____ (2002). "Colorado Fruit Tree/Vineyard Survey 2002." Colorado Department of Agriculture and National Agricultural Statistics Service, August 2002. <http://www.nass.usda.gov/co> August 27, 2003.

Colorado Corn Growers (2003). "Colorado Corn Enthusiastic about Future of Pharmaceutical Farming Despite Announcement Not to Grow Crop This Year." *Colorado Corn News & Events*, June. <http://www.coloradocorn.com/news/external/greeleypharm_0603.htm> August 27.

Desai, Urvee A., S. Gargi, S. Daunert, R. Babbitt, and L. Qingshun (2002). "Expression and Affinity Purification of Recombinant Proteins from Plants." *Protein Expression and Purification*, 25 (1):p195-202 June. Secondary source: DIALOG(R)File 9: Business & Industry.

Dimitri, Carolyn and C. Greene (2003). "Recent Growth Patterns in the U. S. Organic Foods Market." *USDA, Economic Research Statistics* <http://www.ers.usda.gov/publications/aib777/aib777c.pdf>

Dun & Bradstreet (2003). DIALOG(R)File 516 D&B Market Identifiers, July 16, 2003. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Economic Research Service (2003a). "Livestock, Dairy & Poultry Outlook." U.S. Department of Agriculture, August 18. <www.ers.usda.gov>

_____ (2003b). "Colorado State Fact Sheet." U.S. Department of Agriculture. <http://www.ers.usda.gov/StateFacts/CO.htm> September 3.

Farm Journal (2003). "Seed Corn Assembly Line." *Farm Journal*, vol. 127, no. 4, p. 8, February 15. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Feedstuffs (2002a) "Feeder-Packer Marketing Pacts Continue Growing." *Feedstuffs*, vol. 74, no. 28, p 8(2), July 15. Secondary source: DIALOG(R)File 9:Business & Industry(R).

_____ (2002b). "Consolidation into Larger Hog Operations Continues." *Feedstuffs*, vol. 74, no. 4, p. 8(1), January 28. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Fix, Peter J., G. Wallace, and A. Bright (2001). "Public Attitudes about Agriculture in Colorado." College of Natural Resources, Colorado State University, August. <http://www.ext.colostate.edu/staffres/agreport01.pdf> September 27, 2003.

Focus Group/Survey (2003). Focus group with 10 participants held July 24. Input from four rural development surveys and interviews and comments from two reviewers are included.

Food Chemical News (2003). "What Others Are Saying - Karil Kochenderfer, New Technologies Director, Grocery Manufacturers of America." *Food Chemical News*, vol. 44, no. 47, p. 30, January 6. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Forbes (2002). "Bovine Blues." *Forbes*, vol. 169, no. 2, p. 38, January 21. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Horizon (2003). "Annual Report, SEC *10*-K Report - Horizon Organic Holding Corporation." March 13. <http://ccbn.tenkwizard.com/filing.php?repo=tenk&ipage=2058136&doc=1&total=16&TK=HCOW&CK=1041255&CN=Horizon#Item1>

Gottschalk, Andrew, A. Barnhardt, and B. Wilson (2002). "Cattle Situation and Outlook." *HedgersEdge.com* <http://www.hedgersedge.com> March.

Hoovers.com (2003). "Fact Sheet." *Exelixis Plant Sciences*, July 31. <http://www.hoovers.com/free/co/factsheet.xhtml?ID=54464>

Journal Star (2002). "Princeton, Ill-Based Company Creates Plastics Derived from Soybeans." *Journal Star*, February 19. Secondary source: DIALO(R)File 9: Business & Industry(R).

Kortbech-Olesen, Rudy (2002). "The United States Market for Organic Food and Beverages." International Trade Centre, March. <http://www.intracen.org/mds/sectors/organic/foodbev.pdf> September 8, 2003.

Machine Design (2001). "Soy-Based Plastics Head Off to Harvest." *Machine Design*, vol. 73, no. 23, p. 40(1), December 13. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Milling & Baking News (2003a). "U.S.D.A. Economist Projects 28% Rise in Wheat Production This Year." *Milling & Baking News*, vol. 82, no. 2, p. 16, March 11. Secondary source: DIALOG(R)File 9:Business & Industry(R).

_____ (2003b). "Ingredient Week Trends: U.S. Wheat Exports Dismal." *Milling & Baking News*, vol. 81, no. 45, p. 33, January 7. Secondary source: DIALOG(R)File 9:Business & Industry(R).

_____ (2003c). "Record Corn Crop Predicted." *Milling & Baking News*, vol. 81, no. 52, p. 1, February 25. Secondary source: DIALOG(R)File 9:Business & Industry(R).

National Academies Press (2003). "Frontiers in Agricultural Research." *National Academies Press.* <http://books.nap.edu/books/0309084946/html/1.html> March 31.

National Corn Growers Association (2003). "NCGA Says Biosafety Protocol Will Impact Corn Trade Significantly." *News Direct From the Stalk, NCGA News*, June 16. <http://www.ncga.com/news/notd/2003/june/061603.htm> September 3.

Omaha World-Herald (2002). "Overbuilding of Cattle Feeder Space May Be Long-Term Problem." *Omaha World-Herald*, p. N/A, January 28. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Prepared Foods (2002). "Room for (Organic) Growth." *Prepared Foods*, vol. 171, no. 6, p. 18(2), June. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Stonaker, Frank (2003). "The Specialty Crops Program at Colorado State University." *Weathering Tough Times Together*, Colorado Agricultural Outlook Forum, February 20, conference papers. <http://www.coloradoagforum.com/forumdocs/2003/insert.pdf> August 27.

TechCapital (1999). "Wealth in the Seeds." *TechCapital*, vol. 3, no. 1, p. 58+, March. Secondary source: DIALOG(R)File 9:Business & Industry(R).

U.S. Department of Agriculture (USDA) (2003). "Potatoes: Background." Briefing room, U.S. Department of Agriculture, Economic Research Service. <http://www.ers.usda.gov/Briefing/Potatoes/background.htm> September 3.

Wall Street Journal (2002). "Where's the Beef From? Increasingly, the Answer is Brazil." *Wall Street Journal*, vol. 239, no. 63, p. A9, April 1. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Weck, Edward (2002). "The Transgenic Plant Market: Profits from New Products and Novel Drugs." *Drug and Market Development Publications*, August.<http://www.drugandmarket.com/9070>

White Wave (2003). "News & Media: Fact Sheets." White Wave Company <http://www.whitewave.com> August 19.

Whitton, Carol and E. Carter (2003). "Outlook for U.S. Agricultural Trade." United States Department of Agriculture, August 26. <http://www.ers.usda.gov>

World Trade Center Denver (2003). Foreign Trade Division, U.S. Census Bureau, *World Trade Center Denver,* May 15.

MANUFACTURING – GENERAL

Fifty years ago, one-third of U.S. employees worked in factories. Manufacturing industries offered stable, lifetime career employment. Today about one-tenth of the nation's workforce is employed in manufacturing. These changes reflect the industry's adaptations to global competition, including new production technologies that increase output and lower costs by eliminating workers; international supply chains and distribution channels; and workforce restructuring to use lower cost foreign labor. According to *Industry Week*, total manufacturing accounts for $3.2 trillion of U.S. gross domestic product (GDP) (Panchak 2003a).

According to the National Association for Manufacturing (NAM), over the past two decades manufacturing productivity gains averaged twice the annual productivity gains of the rest of the private sector. Manufacturing also drives growth of the national GDP because of a multiplier effect. Manufacturing growth generates more additional economic activity than any other sector. Every $1 of final demand for manufactured goods generates an additional $0.67 in other manufactured products and $0.76 in products and services from nonmanufacturing sectors (Popkin 2003).

U.S. Manufacturing

From 1993 to 2002 manufacturing employment in the United States decreased by 1.0%, with a decrease in jobs of 0.4% in the much larger durable goods sector and a 1.9% decrease in the nondurable goods sector. In 2002, manufacturing employment represented 11.7% of total nonfarm employment, down from 15.1% in 1993.

In the durable goods categories, there were 9.5 million employees in 2002. Three of the top four largest categories—transportation equipment, computer and electric products, and machinery manufacturing—showed a negative compound annual growth rate (CAGR) during the period 1993 to 2002.

U.S. DURABLE GOODS MANUFACTURING EMPLOYMENT

NAICS	Description	2002 Employment (in thousands)	CAGR vs 1993	% of Total 2002 Mfg
	Durable Goods with Positive Growth			
321	Wood Product Manufacturing	556.8	0.7%	3.6%
327	Nonmetallic Mineral Product Manufacturing	519.0	0.6	3.4
337	Furniture and Related Products	604.6	0.6	4.0
332	Fabricated Metal Products	1,547.8	0.3	10.1
	Durable Goods with Negative Growth			
339	Miscellaneous Manufacturing	691.9	-0.2	4.5
336	Transportation Equipment	1,828.5	-0.5	11.9
333	Machinery Manufacturing	1,237.4	-0.8	8.1
334	Computer and Electric Products	1,521.3	-0.9	9.9
335	Electrical Equipment, Appliance, and Components	498.9	-1.6	3.3
331	Primary Metal Manufacturing	510.9	-2.1	3.3
	Total Durable Goods	9,517.1	-0.4%	62.2%

Source: U.S. Department of Labor.

In the nondurable goods category, only plastics and rubber products, showed positive employment growth during the period 1993 to 2002. All other sectors experienced a decline in CAGR for 2002 compared to 1993.

U.S. NONDURABLE GOODS MANUFACTURING EMPLOYMENT

NAICS	Description	2002 Employment (in Thousands)	CAGR vs 1993	% of Total 2002 Mfg
	Nondurable Goods with Positive Growth			
326	Plastics and Rubber Products	853.5	0.1%	5.6%
	Nondurable Goods with Negative Growth			
312	Beverage and Tobacco Products	205.4	-0.1	1.3
311	Food Manufacturing	1525.1	-0.1	10.0
314	Textile Product Mills	196.2	-0.6	1.3
325	Chemical Manufacturing	929.5	-1.1	6.1
323	Printing and Related Support Activities	709.9	-1.1	4.6
322	Paper Manufacturing	549.8	-1.7	3.6
324	Petroleum and Coal Products	119.1	-2.3	0.8
313	Textile Mills	293.2	-5.3	1.9
316	Leather and Allied Products	49.9	-9.1	0.3
315	Apparel Manufacturing	357.6	-9.5	2.3
	Total Nondurable Goods	5,789.2	-1.9%	37.8%

Source: U.S. Department of Labor.

In spite of higher production, recent capacity utilization is abnormally low even for a stagnant economy (Wisconsin Department of Revenue n.d.). Output expressed as a percentage of capacity was 78.5 in January 2001, dropping to 74.1 in June and again in September 2002 (Economagic.com 2003). In 2003, it increased slightly in July, to 72.8, from 72.7 in June (Northeast Midwest Institute 2003). In part, excess capacity is being created by multinational companies taking advantage of equipment subsidies offered by nations seeking capital investments and foreign direct investments (Focus Group/Survey 2003).

Industry Trends

Manufacturing was hit hard by the recent U.S. recession and its lagging recovery is symptomatic of the declining strength of the sector and the numerous challenges it faces. Some conclude that manufacturing in the U.S. has changed forever, and that the sector is essentially dying. Others counter that the sector is undergoing a structural change that will replace lower wage jobs with higher skill, higher paying jobs. All seem to agree that the sector must continue changing to remain competitive and that the success of these efforts will have significant impact on the overall U.S. economy and standard of living.

Recent trends in the last half of 2003, point to slow recovery of some of the nation's manufacturing industries. The largest improvement is demonstrated by strengthening demand and increased revenues for technology industries specifically computers, and semiconductor and consumer electronics. In addition, military spending is expected to

continue growth in defense-aerospace industry over the next several years. Production growth is not, however, being matched by any increase in hiring. In the next one to two years, the few manufacturing sectors expected to hire on net include fabricated metal products, industrial machinery, and computers and electronic equipment (Koropeckyj 2003).

According to the National Association of Manufacturing, innovation is the key to future prosperity and higher living standards. Innovation and new technologies create new products and processes, and ultimately produce well-paying jobs, increased productivity, and competitive pricing. The most serious challenges facing the U.S. manufacturing base are loss of jobs, loss of export potential, reduction of capital and R&D investment, skilled manufacturing workforce, and rising cost of doing business in the United States (Popkin 2003).

Loss of Jobs

From the perspective of the nation's economic health, the loss of manufacturing jobs is perhaps the most serious indicator of changes in this sector. Since the recession began in early 2001, 2.4 million—or more than 1 in 10—manufacturing jobs have been lost (*The Washington Times* 2003). This continues a longer-term trend of decline in manufacturing employment caused by various factors including production technologies and off-shoring.

The success of the U.S. manufacturing productivity has permanently reduced the number of direct labor jobs, according to a study conducted by the Federal Reserve Bank of New York (Weisman 2003). From 1995-2002, global industrial production was up 30% while manufacturing employment fell by 11%. In August 2003, production increased at the fastest pace in four years but factories continued to cut workers, according to the Institute for Supply Management (Graham 2003). Indeed, Federal Reserve researchers found that more companies are cutting jobs and relying on productivity to weather recessions than laying off workers and recalling them (*The Oregonian* 2003). Productivity gains in the second quarter were more than twice the annual average of 2.5% from 1996-2000. The ability to produce more with fewer workers reflects past investments in computers and other equipment (Bloomberg News 2003).

For example, the use of robots in the production industry can increase quality and shorten production time. Production companies in North America purchased 17,591 robots worth $1.4 billion in 1999 (Chandler n.d.). The robotic market grew 50% from 1998 to 1999 in North America (Phillips 2000).

A recent Deloitte & Touche study found that 61% of manufacturers have moved production facilities to lower cost countries (Valdez, Gilbertson, and Higuera 2003). While some point out that the loss of production line jobs still leaves the United States with higher skill, higher pay, positions, even these high-end manufacturing jobs are facing increased competition as foreign countries build up their workforce skills (Broder 2003). Overseas production is moving from clothing and textiles to higher technology product areas. The National Association of Manufacturers reported that "more than a

quarter (28%) of the U.S.-China trade deficit is now in computers and electronics, the fastest growing manufacturing industry in the 1990s" (Broder 2003). Since February 2001, total U.S. manufacturing employment has decreased by nearly 2.5 million jobs. Roughly one third of these losses (798,000) are due to off-shoring (Zandi 2003).

Despite recent signs of a positive turn-around in the manufacturing job market, the effects of off-shoring may prove to be a considerable road block to any employment gains in the industry. Off-shore production is not expected to slow anytime soon. U.S. manufacturing firms are seeing increased cost savings overseas, especially in China and other parts of Asia, as currencies are becoming increasingly undervalued (Zandi 2003). The Chinese yuan, for example, is undervalued roughly 25% versus the dollar. Some U.S. policy-makers are calling for various measures like tariffs and a free floating yuan to try and limit the damage caused by off-shoring, but other experts note that this will only create a temporary fix. Ultimately, the cost saving benefits of moving manufacturing operations overseas are simply too much for U.S. firms to ignore.

The North America Free Trade Agreement (NAFTA) is also contributing to manufacturing job loss in the United States. Since 1993, 766,000 jobs have been lost, mostly in manufacturing because of NAFTA, according to a study by the Economic Policy Institute (Gerrie 2001). Due to the agreement and factors contributing to a growing trade deficit, job losses have been heavy in the following manufacturing subsectors: transportation equipment, communications equipment, paper and allied products, petroleum refining and related products, and fabricated metal products (excluding machinery and transportation equipment) (Scott 2001).

Loss of Export Potential

In the face of lower cost foreign products, U.S. manufacturers are increasingly unable to raise prices to offset higher costs. Consumers base buying decisions on product benefits, quality, durability, style, and price, with price often being the highest priority (Drickhamer 2003). As median incomes fall, price becomes the only metric and only the wealthy can afford to pay more for perceived quality (Focus Group/Survey 2003). In addition, "made in U.S." labels no longer serve as guides to products that support the U.S. economy. Such labels may simply indicate a product that is assembled in the U.S. from foreign made components. Similarly, foreign owned companies operating in the U.S. may be providing jobs while products of U.S. owned companies may be produced overseas (Drickhamer 2003).

The U.S. trade deficit has reached historic highs due to a decline in U.S. exports and an increase in purchases of foreign-made products, especially from countries that do not freely float their currencies. Manufacturing exports as a share of GDP have contracted since 1997 due to increased global competition, terrorist attacks of September 11, and the strong U.S. currency (Popkin 2003). Exports of manufactured goods declined $86 billion over the past two years and now account for only 6% of GDP, compared to 8% in 1997.

The emergence of China into the world marketplace has presented U.S. manufacturing with additional challenges to meet the influx of low-cost goods, and caused some to call for tougher enforcement of trade regulations. NAM's strategic plan for the industry calls for actions that level the playing field with policies to promote U.S. exports, reduce tax burden on trade and international commerce, eliminate undervalued currencies, complete more favorable trade agreements, and pressure China to meet WTO obligations (Walker 2003).

Loss of Capital and R&D Investment

R&D is critical to creating the innovations in process and product that have helped U.S. manufacturers remain competitive. Manufacturers conduct two-thirds of private R&D, however between 2000 and 2002 these expenditures grew at only half the pace of the previous decade (Popkin 2003). In addition, recent federal budget actions severely cut funding for the Advanced Technology Program (ATP), a program that has supported early stage pre-competitive industrial R&D (Panchak 2003b).

Just as R&D is critical to maintain a competitive manufacturing sector, some contend that U.S. economic growth will depend upon continued ownership and control of the manufacturing process. It is the manufacturing teams that are able to take a design and improve it to lower cost, and to add features, extend applications and even create new markets (Focus Group/Survey 2003).

Skilled Workforce

Even with fewer jobs in the manufacturing sector, there is a potential shortfall of highly qualified employees with skills needed to produce manufactured goods (Popkin 2003). According to a recent survey of manufacturers, more than 80% are currently experiencing a moderate to severe shortage of qualified job applicants. The industry projects a need for 10 million additional skilled workers by 2020 due to retirements. Careers in manufacturing are not understood or promoted by parents and school counselors. A cultural bias against two-year college degree programs is leaving many youth out of the higher education system and unprepared for manufacturing careers. In addition, the educational experiences of students do not prepare them with the skill sets needed in manufacturing. In addition to a basic K-12 education, workers need to adapt to change, be familiar with technology, be life long learners, and have stronger math and science education (AYPF 2003).

Cost of Doing Business

One factor contributing to the move of production overseas is the dramatic increase in the cost of doing business in the United States. Factors driving increased costs are healthcare, litigation and regulation (Popkin 2003). For example, the Council of Economic Advisors reports that the cost of the U.S. legal system, at 1.8% of GDP, is about double the cost in other industrialized nations (Walker 2003).

While not disputing these issues, others point to the ability of U.S. manufacturers to remain competitive by developing and implementing new production strategies and technologies to increase production and lower costs (Panchak 2003a).

Future Requirements

In spite of these industry challenges, others see a positive future for manufacturing in the United States. In the future, successful companies will continue the trend toward continual innovation. Company budgets will be further directed toward R&D to develop new technologies that cut production costs and produce a stream of new products that meet market needs. Successful companies will implement lean manufacturing and higher production methods to remain competitive (Hagenbaugh 2003).

In order to survive and thrive in the future, a skilled and enthusiastic workforce will be essential. According to a survey conducted by the U.S. Census Bureau in 2000, 40% of employers indicated they were unable to modernize operations because workers lacked the necessary skills. Companies need to reinvest in workforce training. Manufacturers also need to reorient their management toward knowledge and service to their U.S. customers to capitalize on the benefits of proximity and the ability to supply customized products. In order to successfully manage a geographically spread operation, management needs to clearly define the skills necessary for various tasks and determine where these tasks can be best performed and managed at competitive cost (Purdam 2003).

In addition, nanotechnology, e-commerce, wireless technology, smart materials, intelligent software, robotics, intelligent manufacturing, and other new technologies are expected to drive the economic growth of U.S. manufacturing (NCMS 2001).

Many of the challenges faced by manufacturing could also be addressed by changes in national policies dealing with regulation, health-care costs, litigation, international trade, and taxes. President Bush is creating a high-level government post to focus on the needs of the manufacturing sector (*The Washington Times* 2003). Depending upon the speed with which positive changes are implemented by the Administration and Congress, some of the pressure on the manufacturing sector could be reduced making it easier for manufacturers to recover and remain competitive. At the same time, however, recent federal budget decisions will cut FY2004 funding to the Manufacturing Extension Partnership Program, a national system that provides technical assistance and training to help small and medium-sized manufacturers implement competitive process and management techniques.

Colorado Industry Trends

Overall, the Colorado manufacturing employment landscape from 1998-2004 has been bleak. During this period, Colorado manufacturing employment has seen a CAGR of -3.8%. Employment fell every year during this period and a record 15,600 jobs were lost in 2002. A loss of 11,000 jobs in 2003 meant a small improvement for the manufacturing

industry in Colorado, and the expected loss of 1,100 jobs in 2004 shows signs that the industry may be recovering (Colorado Business Economic Outlook Committee 2003).

Production provides another, more positive, measure of the strength of the state's manufacturing industry. The Gross State Product (GSP) data measures the state's "value added" production and is equivalent to its gross output (sales or receipts and other operating income, commodity taxes, and inventory change) minus its intermediate inputs (consumption of goods and services purchased from other U.S. industries or imported.). Measured in these terms, Colorado manufacturing GSP has increased steadily each year from 1997 to a high in 2000 of $16,697 million, and decreased to about 1999 figures with a GSP of $14,991 million in 2001. In the durable goods categories, only primary metal products, furniture and fixtures, and stone and clay, continued a growing GSP into 2001. In the nondurable goods categories, food and kindred products, chemicals, textiles, and petroleum products show an increased GSP in 2001 (U.S. Department of Commerce 2003).

Much like the rest of the nation, Colorado is losing many manufacturing jobs due to the growing need to move production to lower cost labor areas. However, off-shoring is not the only problem impacting Colorado manufacturing employment. Domestic outsourcing is a major threat as well. According to a recent survey of Colorado manufacturers, 69% reported that they outsource their manufacturing operations domestically, and 17% outsource their operations internationally. In 2004, 21% plan to outsource their manufacturing operations overseas.

Another factor leading to decreased manufacturing employment in Colorado is the trend of increasing productivity in the industry. With production processes becoming more advanced and streamlined and technology changes occurring almost daily, firms are able to produce more goods with fewer workers.

There are 6,000 manufacturing establishments in Colorado, employing over 155,000 workers in 2003. This represents roughly 7% of the state's total employment base. The largest nondurable goods subsector in the state is food production, with 19,500 employees in 2003. Since August 2002, food shipments throughout the United States have increased 4.3% and national employment in the food production industry has been increasing since the start of 2003.

From 1993 to 2002, total Colorado nonfarm wage and salary employment experienced a CAGR of 3.0% as the number of jobs increased from 1.7 million to 2.2 million. In 2002, manufacturing employment represented 7.6% of total nonfarm employment, down from 10.0% in 1993. During this period, manufacturing employment decreased negligibly, with a CAGR of 0.3% in the durable goods sector and a CAGR of -0.5% in the nondurable goods sector.

Durable goods manufacturing in Colorado outperformed the United States because it has a much higher concentration of computer and electric product and nonmetallic mineral

product manufacturing. Over the period 1993 to 2002 this subsector had a CAGR of 0.3% compared to -0.9% for the United States.

COLORADO DURABLE GOODS MANUFACTURING EMPLOYMENT

NAICS	Description	2002 Employment (in thousands)	CAGR vs 1993	% of Total 2002 Mfg	Location Quotient
327	Nonmetallic Mineral Product Manufacturing	9.8	3.3%	5.9%	1.1
332	Fabricated Metal Products	15.7	1.0	9.4	.6
334	Computer and Electric Products	40.7	0.3	24.5	1.6
336	Transportation Equipment	10.4	-1.5	6.3	.3
	Other Durable (321, 331, 333, 335, 337, 339)	35.7	-2.7	21.5	.5
	Total Durable Goods	112.3	0.3%	67.5%	.7

Source: U.S. Department of Labor.

Colorado also outperformed the nation in employment growth for nondurable goods, primarily because it has a lower concentration of the industries that performed poorly, such as textile mills and apparel manufacturing.

COLORADO NONDURABLE GOODS EMPLOYMENT

NAICS	Description	2002 Employment (in thousands)	CAGR vs 1993	% of Total 2002 Mfg	Location Quotient
311	Food Manufacturing	19.5	1.0%	11.7%	.7
312	Beverage Manufacturing	5.9	-1.9	3.5	1.7
334	Printing and Related Support Activities	9.2	-3.0	5.5	.8
	Other Nondurable (313, 314, 315, 316, 322, 323, 324, 325, 326)	19.4	-0.2	11.7	.4
	Total Nondurable Goods	54.0	-0.5%	32.5%	.6

Source: U.S. Department of Labor.

Geographic Distribution of Nondurable Goods Employment

The Denver Metro area comprises the majority (53.2%) of nondurable goods employment in Colorado. Weld County and the Boulder/Longmont area make up the next largest areas of employment with 12.1% and 10.0%, respectively. Colorado Springs, Fort Collins/Loveland, Pueblo, and the rest of the state combine for the remaining 24.7% of total nondurable goods employment.

The Denver Metro area employs the majority of workers in all but four of the nondurable goods subsectors. These subsectors include chemical manufacturing (35.2%), food manufacturing (39.7%), textile mills (44.7%), and leather and allied products (47.3%). Denver Metro is strongest in the petroleum and coal products subsector, where it employs 88.4% of the state's workers, primarily in petroleum refineries in Denver and Adams counties, and asphalt, shingle, and roofing materials manufacturers in Adams County.

Nondurable goods employment in the Boulder-Longmont MSA is strongest in the chemical manufacturing subsector, where it employs 22.2% of the state's workers. This

employment is focused primarily in the medicinal and botanical manufacturing and pharmaceutical preparation manufacturing areas.

In Colorado Springs, printing and related activities makes up the strongest area of nondurable goods employment, with 17.0% of the state's employment – primarily in the other commercial printing category.

Although the Fort Collins-Loveland MSA makes up only 4.5% of Colorado's total nondurable goods employment, it does account for 15.4% of the beverage manufacturing employment in the state. This is due to the large number of breweries in the area.

Weld County's nondurable goods employment is focused largely in the chemical manufacturing and food manufacturing subsectors, where it makes up 31.4% and 19.1% of the total employment, respectively.

Pueblo has a very limited presence in the nondurable goods sector, comprising just 1.6% of the total employment. Pueblo has a small presence in the food manufacturing and plastic and rubber products subsectors.

The table below displays more detailed nondurable goods employment information.

NONDURABLE GOODS MANUFACTURERS EMPLOYMENT AND SUBSECTOR PERCENTAGE BY LOCATION

Description	Boulder Longmont	Colorado Springs	Denver Metro	Fort Collins Loveland	Weld	Pueblo	Balance
311 Food Manufacturing	1,637	432	7,302	338	3,507	499	4,662
Percentage of Subsector Total	8.9%	2.4%	39.7%	1.8%	19.1%	2.7%	25.3%
312 Beverage Manufacturing	185	175	4,300	903	15	9	280
Percentage of Subsector Total	3.2%	3.0%	73.3%	15.4%	0.3%	0.2%	4.8%
313 Textile Mills	7	0	80	0	0	0	92
Percentage of Subsector Total	3.9%	0.0%	44.7%	0.0%	0.0%	0.0%	51.4%
314 Textile Product Mills	118	45	1,225	73	16	24	436
Percentage of Subsector Total	6.1%	2.3%	63.2%	3.8%	0.8%	1.2%	22.5%
315 Apparel Manufacturing	66	80	740	23	7	10	134
Percentage of Subsector Total	6.2%	7.6%	69.8%	2.2%	0.7%	0.9%	12.6%
316 Leather and Allied Products	171	25	297	3	8	0	124
Percentage of Subsector Total	27.2%	4.0%	47.3%	0.5%	1.3%	0.0%	19.8%
322 Paper Manufacturing	40	148	2,301	27	103	0	16
Percentage of Subsector Total	1.5%	5.6%	87.3%	1.0%	3.9%	0.0%	0.6%
323 Printing and Related Activities	750	1,468	5,246	420	142	76	560
Percentage of Subsector Total	8.7%	17.0%	60.6%	4.9%	1.6%	0.9%	6.5%
324 Petroleum and Coal Products	0	1	617	26	18	8	28
Percentage of Subsector Total	0.0%	.1%	88.4%	3.7%	2.6%	1.2%	4.0%
325 Chemical Manufacturing	1,575	200	2,498	267	2,245	71	259
Percentage of Subsector Total	22.2%	2.8%	35.2%	3.8%	31.4%	1.0%	3.7%
326 Plastic and Rubber Products	673	292	3,252	272	277	132	347
Percentage of Subsector Total	12.8%	5.6%	62.0%	5.2%	5.3%	2.5%	6.6%
Total Nondurable Goods	5,222	2,866	27,858	2,352	6,338	829	6,938
Percentage of Subsector Total	10.0%	5.5%	53.2%	4.5%	12.1%	1.6%	13.2%

Source: ES202 Data Q2 2003

Geographic Distribution of Durable Goods Employment

Employment in the durable goods sector is also dominated by the Denver metro area. Denver metro makes up 41.6% of the total durable goods employment in the state, focused mainly in the transportation equipment and furniture and related products subsectors. Colorado Springs and Boulder-Longmont employ 16.8% and 14.3% of the state's total durable goods workers, respectively.

Denver's strength in transportation equipment is due to the prominence of the guided missile and space vehicle manufacturing subsector in Jefferson County. Lockheed Martin is the primary employer in this subsector. Strength in the furniture and related products subsector comes from the mattress manufacturing and blind and shade manufacturing industries in Denver and Broomfield Counties.

The computer and electronics manufacturing subsector makes up a large portion of Colorado's durable goods manufacturing. However, the subsector is largely confined to the Boulder-Longmont, Colorado Springs, Denver Metro, and Fort Collins-Loveland areas. The Boulder-Longmont area employs just over 30% of the state's workers in the computer and electronics subsector. Colorado Springs employs 27.1%, Fort Collins-Loveland employs 21.2%, and Denver Metro employs 18.7%.

Despite its strong presence in the computer and electronics subsector, the Fort Collins-Loveland area is strongest in the electrical equipment subsector, employing 27% of the workers in the state. This is due to the existence of a strong electric housewares and household fan manufacturing industry in Larimer County.

Durable goods employment in Weld County is focused primarily in the wood products manufacturing subsector, specifically, the wood preservation and truss manufacturing industries. Pueblo's claim to fame is its metal factories. As shown in the table below, Pueblo's durable goods employment is strongest in the primary metal manufacturing subsector. In fact, Pueblo employs nearly 50% of the state's total workers in this subsector.

Please refer to the table on the next page for more detailed durable goods employment information.

DURABLE GOODS MANUFACTURERS EMPLOYMENT AND SUBSECTOR PERCENTAGE BY LOCATION

Description	Boulder Longmont	Colorado Springs	Denver Metro	Fort Collins Loveland	Weld	Pueblo	Balance
321 Wood Products Manufacturing	503	293	1,559	514	664	97	963
Percentage of Subsector Total	11.0%	6.4%	33.9%	11.2%	14.5%	2.1%	21.0%
327 NonmetallicMineral Products	362	721	5,003	310	478	479	1,824
Percentage of Subsector Total	4.1%	7.9%	54.5%	3.4%	5.2%	5.2%	19.9%
331 Primary Metal Manufacturing	27	41	530	107	275	950	27
Percentage of Subsector Total	1.4%	2.1%	27.1%	5.5%	14.1%	48.5%	1.4%
332 Fabricated Metal Products	702	3,090	8,159	532	1,172	266	1,162
Percentage of Subsector Total	4.7%	20.5%	54.1%	3.5%	7.8%	1.8%	7.7%
333 Machinery Manufacturing	597	518	3,425	1,596	467	1,187	915
Percentage of Subsector Total	6.9%	6.0%	39.4%	18.3%	5.4%	13.6%	10.5%
334 Computer and Electronics	10,690	9,627	6,632	7,516	490	9	574
Percentage of Subsector Total	30.1%	27.1%	18.7%	21.2%	1.4%	0.0%	1.6%
335 Electrical Equipment	285	281	719	604	227	47	72
Percentage of Subsector Total	12.8%	12.6%	32.2%	27.0%	10.2%	2.1%	3.2%
336 Transportation Equipment	188	671	7,051	143	132	477	1,024
Percentage of Subsector Total	1.9%	6.9%	72.8%	1.5%	1.4%	4.9%	10.6%
337 Furniture and Related	523	637	4,323	489	102	32	836
Percentage of Subsector Total	7.5%	9.2%	62.3%	7.0%	1.5%	.5%	12.0%
339 Miscellaneous Manufacturing	972	1,561	5,831	583	87	112	757
Percentage of Subsector Total	9.82%	15.8%	58.9%	5.9%	0.9%	1.1%	7.6%
Total Durable Goods	14,849	17,440	43,232	12,394	4,094	3,656	8,154
Percentage of Subsector Total	14.3%	16.8%	41.6%	11.9%	3.9%	3.5%	7.9%

Source: ES202 Data Q2 2003

MANUFACTURERS EMPLOYMENT AND BY LOCATION

Description	Boulder Longmont	Colorado Springs	Denver Metro	Fort Collins Loveland	Weld	Pueblo	Balance
Total Nondurable Goods	5,222	2,866	27,858	2,352	6,338	829	6,938
Percentage of Total Nondurable	10.0%	5.5%	53.2%	4.5%	12.1%	1.6%	13.2%
Total Durable Goods	14,849	17,440	43,232	12,394	4,094	3,656	8,154
Percentage of Total Durable	14.3%	16.8%	41.6%	11.9%	3.9%	3.5%	7.9%
Total Manufacturing	20,071	20,306	71,090	14,746	10,432	4,485	15,092
Percentage of Total	12.8%	13.0%	45.5%	9.4%	6.7%	2.9%	9.7%

Source: ES202 Data Q2 2003

Summary

Challenges facing the U.S. manufacturing sector also impact Colorado companies. Since manufacturing productivity gains and multiplier effect significantly impact the overall economy, the state's ability to retain and expand manufacturing operations will be important to the strength of our future economic growth.

It is increasingly difficult for Colorado manufacturing companies to remain competitive in the global economy. Manufacturing companies continue to struggle with the rising costs of doing business in the state; including costs of health care, energy, financing, and

labor rates. Companies also identify a disproportionate share of taxes (personal property tax for example) as a further barrier.

Job loss due to domestic and foreign outsourcing is increasing. From a company perspective, outsourcing enables them to remain competitive by moving jobs to areas with lower labor rates and lower costs of doing business. And, with fewer Colorado manufacturing jobs available, there are more qualified applicants for each position allowing companies to improve the skill level and work ethic of their employees. As a result, however, the state also loses jobs as well as skilled workers who leave the state to go where the manufacturing jobs are located.

On the positive side, the ability to innovate has been a strong attribute of the Colorado economy supported by a highly educated workforce and advanced research capabilities in universities and industry. The presence of software, photonics, nanotechnology, bioscience, materials, and other technology clusters that support manufacturing should continue to give Colorado manufacturers an edge in developing and implementing the process and product innovations needed to remain competitive. These technology industries face their own challenges, however, with state budget cutbacks limiting support for university-industry research, facilities and new educational programs (see separate sections of this report for more information on technology industries). In addition, there is the risk that this highly educated workforce and jobs associated with manufacturing R&D will move with the production process.

Overall, the state's manufacturing industries are expected to show only moderate growth over the coming decade, with some exceptions. Notable predictions for higher market demand and revenue in defense/aerospace, technology industries, and computer and storage devices will drive growth in Colorado's manufacturing sector. In addition, recovery of the state's producers of fabricated metal products, industrial machinery, and computers and electronic equipment, could show improvement in the manufacturing employment picture. In the nondurable goods sector, food and beverage production will continue to be an important sector of the Colorado economy. Growth in this sector could be realized with targeting of agricultural production toward changing consumer food preferences and development of additional value-added food and beverage production capability. See additional information on this sector in the Agricultural Industry section of this report.

BIBLIOGRAPHY

AYPF (2003). "Keeping America Competitive: How a Talent Shortage Threatens U.S. Manufacturing." American Youth Policy Forum, April 25. <http://www.aypf.org/forumbriefs/2003/fb042503.htm> December 8.

Bloomberg News (2003). "Fewer Job Cuts Planned in August." <http://www.sunspot.net/business/bal-bz.jobcuts03sep03,0,196638.story?coll=bal-business-headlines>. September 3.

Chandler, Kris (n.d.). "The Effects of Robots in the Production Industry: Today and Tomorrow." <http://www. louisville.edu/~kmchan02/robots.html>.

Drickhamer, David (2003). "Bye-Bye to 'Buy American'?" *Industry Week*, September 1. <http://www.industryweek.com/CurrentArticles/Asp/articles.asp?ArticleId=1473 > December 8.

Economagic.com (2003). Economic Time Series Page. <Econohttp://www.economagic.com/em-cgi/data.exe/feddal/mub00004>. September 9.

Gerrie, Sharon (2001). "Pact Cost Jobs, Report Says." *Las Vegas Review-Journal.* <http://www.reviewjournal.com/lvrj_home/2001/May-01-Tue-2001/business/15977230.html>. September 8, 2003.

Graham, Jed (2003). "Activity Up, But Still No New Jobs in ISM's Aug. Survey." *Investor's Business Daily*, <http://www.investors.com/editorial/feature.asp?v=8/30>.

Hagenbaugh, Barbara (2003). "U.S. manufacturing jobs fading away fast," USA Today, 12-12-2002. <http://usatoday.com/money/economy/2002-12-12-manufacture_x.htm> December 8.

Jasinowski, Jerry J. (2003). "Made in China." <http://www.washingtontimes.com/op-ed/20030519-095612-1469r.htm>.

Koropeckyj, Sophia (2003). U.S. Industry Outlook, Economy.com, November 26. <http://www.economy.com/dismal/pro/data/outlook.asp?type=5> December 10.

National Association of Manufacturers (2003). "Statistics on Manufacturing and the Overall Economy." <http://www.nam.org/secondary.asp?TrackID=&CategoryID=1155>.

NCMS (2001). "Game Changers: How Will They Affect Your Company?" National Center for Manufacturing Science, Futurist Think Tank Conference, February 23. <http://www.ncms.org/pressroom/news/NCMSHostFuturist.htm> December 8, 2003.

Northeast Midwest Institute (2003). General manufacturing statistics. <http://www.nemw.org/mfgfact.htm>. September 8.

The Oregonian (2003). "Growth Spurts and Hiring Lags in Recovery Unlike Earlier Ones." <http://www.oregonlive.com/business/oregonian/index.ssf?/base/business/1062244817237360.xml>. September 3.

Panchak, Patricia (2003a). "A Celebration of U.S. Manufacturing." *Industry Week*, December 1. <http://www.industryweek.com/Columns/Asp/columns.asp?ColumnId=975> December 8.

_____ (2003b). "The Real Crisis in U.S. Manufacturing," *Industry Week*, June 1. <http://www.industryweek.com/Columns/Asp/columns.asp?ColumnId=936> December 8.

Phillips, Todd (2000). "Robotic Resurgence: Robotics Researchers Push Frontiers and Expand Focus for Shop Floor Use." <http://www.advancedmanufacturing.com/September00/robotics.htm>. September 3, 2003.

Popkin, Joel and Company (2003). *Securing America's Future: The Case for a Strong Manufacturing Base.* Executive Summary. <http://www.pmihome.org/mfg.pdf>.

Purdum, Traci (2003). "Survival of the Fittest." *Industry Week*, October 1. <http://www.industryweek.com/CurrentArticles/Asp/articles.asp?ArticleId=1496 > December 8.

Scott, Robert E. (2001). "Where the Jobs Aren't: Particular Industries and States Bear Brunt of Dislocations Wrought by Trade Agreements." <http://www.epinet.org/content.cfm/issuebriefs_ib168>. September 8, 2003.

U.S. Department of Commerce (2003). GSP Colorado. Bureau of Economic Analysis, Regional Economic Analysis Division.

U.S. Department of Labor (2003). Bureau of Labor Statistics <http://data.bls.gov/labjava/outside.jsp?survey=ce>. September 1.

Valdez, Diana Washington, Dawn Gilbertson, and Jonathan J. Higuera (2003). "A Decade of NAFTA Left Losers, Winners." June 22. <http://www.globalexchange.org/countries/mexico/863.html>. September 4.

Walker, Rich (2003). "U.S. Manufacturing Must Rise to Long-Term Challenges." *Industry Watch*, September. <http://www.aamanet.org/pdf-files/

The Washington Times (2003). "Bush Creates Commerce Post to Help Keep Factory Jobs." <http://washingtontimes.com/national/20030902-121410-7295r.htm>. September 3.

Weisman, Jonathan (2003). "Jobs Lost Since '01 Are Gone for Good." *The Denver Post*, September 7, pp. 4A.

Wisconsin Department of Revenue (n.d.). Economic Outlook – U.S. <http://www.dor.state.wi.us/ra/0305/0305okus.pdf>.

Zandi, Mark (2003). "Off-Shoring Threat." *The Dismal Scientist*. <http://www.economy.com/dismal/pro/article.asp?aid=2460>

MANUFACTURING – COMPUTER HARDWARE/STORAGE

The computer hardware industry is a very broad-reaching industry. Some companies focus on providing the individual consumer with personal computers, peripherals, and accessories. Some focus on providing multi-billion dollar enterprises with their massive mainframe systems, storage networks, and end-user computing systems. Some companies have been able to successfully compete in both markets.

The tech boom and subsequent fallout has made for a few turbulent years in the computer industry as a whole, but with computer and wireless technology still advancing at a tremendous pace, and data storage becoming a primary requirement among CEOs and CIOs throughout the country, the industry appears to have a solid foundation on which to grow.

The computer hardware industry is broken up into the following sectors, according to the North American Industry Classification System (NAICS):

333293	Printing Machinery and Equipment Manufacturing
333313	Office Machinery Manufacturing
333315	Photographic and Photocopying Equipment Manufacturing
33411	Computer and Peripheral Equipment Manufacturing
334111	Electronic Computer Manufacturing
334112	Computer Storage Device Manufacturing
334113	Computer Terminal Manufacturing
334119	Other Computer Peripheral Equipment Manufacturing
334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing
334290	Other Communications Equipment Manufacturing
33461	Manufacturing and Reproducing Magnetic and Optical Media
334613	Magnetic and Optical Recording Media Manufacturing
423420	Office Equipment Merchant Wholesalers

Industry Leaders

The two main leaders in computer hardware are IBM and Dell. The two companies combined represent a total market cap of over $245 billion. Both companies have operations in the consumer market and the enterprise market, however, a large part of IBM's revenue comes from areas other than computer hardware, while Dell is focused primarily on hardware. Below is a list of the top five companies (as determined by market capitalization) in the computer hardware industry.

Top five industry leaders (market capitalization):

- IBM – $153.0 billion
- Dell – $92.3 billion
- Sun Microsystems – $11.4 billion
- Apple Computer – $8.3 billion
- Legend Group – $3.5 billion

Trends and Opportunities for Growth

Worldwide, the technology sector has seen a decline since it hit its peak in 2000. Although the sector appears to be picking up some steam in 2003, there are a number of trends that will have a big impact on the tech sector as a whole, as well as the computer hardware and data storage industry. First, hardware is becoming more and more of a commodity, which can be a double-edged sword. With competition among hardware companies driving prices lower, sales are increasing. Worldwide PC growth, for example, is at nearly 15.7% in the third quarter of 2003 (IDC 2003c). Demand has been steadily increasing as PC prices fell to an average of roughly $800 for a desktop and $1500 for a notebook in early 2003 (ZDNet News 2003). Computer chipmakers Intel and AMD both plan price cuts for their chips in late 2003, which will continue to drive PC costs down. While this is good news for consumers, the price drops are forcing hardware companies to consider supplementing their businesses by adding products like software and consulting services.

Another recent trend has been the increasing importance of storage in the enterprise. Over the last few years, the most valuable corporate asset is data. Companies have terabytes upon terabytes of critical data that must be available, reliable, and recoverable if something goes wrong. A recent report by IDC estimated that by 2004, companies may be able to manage up to 48 terabytes of data per storage manager. In the second quarter of 2003, worldwide revenue for disk storage systems was $4.73 billion, and over 181 petabytes of storage capacity was shipped (one petabyte is equal to 1024 terabytes) (IDC 2003c). IDC also predicted that the worldwide storage services market will grow at a compound annual growth rate of 6.4% from 2002-2007, reaching $28.9 billion. There is clearly a lot of potential for the market, and the big storage manufacturers plan to take advantage of the fact that large, complex storage systems have become such a necessity among corporations. Some of the storage firms that will benefit the most from the growing market are EMC, Seagate, and Sandisk. In 2003, the three companies had market capitalizations of $31.7 billion, $10 billion, and $5.3 billion, respectively (IDC 2003a). The top five leaders in market capitalization are as follows:

- EMC - $31.7 billion
- Seagate - $10 billion
- Sandisk - $5.3 billion
- Maxtor - $3.1 billion
- Western Digital - $2.6 billion

One thing that may stand in the way of growth in the storage industry is the falling prices of storage hardware, which have been brought on by increased competition in the

industry. Many storage manufacturers have begun to develop complex software packages that supplement their hardware offerings, as prices fall and margins grow thinner for the hardware side of the business.

Wireless technology is becoming a major opportunity for growth within the computer hardware industry. Analysts predict that over 96 million Americans will be using wireless technology for internet access by 2005 (TechSector Trends 2003). Worldwide, it is predicted that there will be 1.7 billion wireless subscribers by the end of 2006, 500 million of whom will be using wireless internet access. With new standards and protocols being developed at an incredible pace, there looks to be tremendous opportunity for growth in the near and distant future.

Another trend facing the industry is the global outsourcing of manufacturing operations. Low labor costs are attracting many firms to outsource the manufacturing of their products to places like India, China, Russia, and Taiwan. In India, where the software sector is already flourishing, hardware is developing into a viable industry as well. Some experts believe that the Indian electronics hardware industry could grow into a $70 billion market by 2010 (Hindustan Times Online 2003). As a result of this move toward outsourcing, many U.S. workers are losing their jobs. The unemployment rate among computer hardware engineers in the United States is particularly high, at 6.9% (IDG News Service 2003).

Colorado Competitive Position

Strengths

Colorado companies have been involved in the computer hardware and storage industry for many years. Growth of this industry is partly driven by the market demand of Colorado's strong high-tech sector. In a recent study conducted by the Progressive Policy Institute in 1999, Colorado was ranked first in the nation in high-tech jobs (as a percentage of total employment) and second in the concentration of technology firms (Colorado Office of Economic Development and International Trade 2001). Colorado's high-tech industry ranks 10th in total employment, 1st in employment concentration, 5th in job growth from 1995-2001, 6th in average wages, and 11th in number of establishments (AEA 2003). IBM, HP, StorageTek, Sun Microsystems, and McData all have operations in Colorado. StorageTek, which is headquartered in Louisville, Colorado, employs over 7,000 people worldwide, including 3,000 in Colorado. The company is one of Colorado's biggest employers and generated $2 billion in revenue in 2002. As a result of StorageTek's success in Colorado, many other smaller storage firms have begun to emerge in the past few years, making the Front Range one of the most important locations in the storage world. Companies like LeftHand Networks, CreekPath Systems, SANZ Inc, and Tabernus are growing into major players in the storage systems and networking field. The highest concentration of hardware manufacturing firms is in the counties of Boulder and El Paso. Boulder County is home to 126 firms and El Paso is home to 81. Employment is roughly 10,703 in Boulder and 10,063 in El Paso. Together, these two counties account for over 56% of the total employment in the hardware

manufacturing sector. Other counties with significant employment concentration include Larimer, Adams, Arapahoe, Jefferson, Weld, Denver, and Broomfield. In storage, Boulder County accounts for over 92% of the total storage employment in the state, with 3,681 total employees. El Paso has the second highest concentration of storage jobs, with 290.

The presence of many universities and research centers within the state create another area of strength for this industry in Colorado. The state's research universities create a highly educated employment base, and provide research support for the computer hardware and storage industry. The University of Colorado at Boulder has undergraduate and graduate level programs, as well as certificate programs in data storage, and CU-Colorado Springs is home to the Network Information and Space Security Center (NISSC). In 2003, NISSC became part of the StorageNetworking.org academic advisory board, which will work to develop regional and local data storage user groups (SNIA 2003). Colorado Springs is also home to the Storage Networking Industry Association (SNIA) Technology Center. The center conducts storage research and development and also provides educational courses for industry leaders, including manufacturers, vendors, partners, and end-users.

Weaknesses

Like most industries in Colorado, the computer hardware and data storage industries have experienced some difficulties as a result of the economic downturn of the last few years. Before the decline, venture capital could be found relatively easily in Colorado, especially for tech-related companies. Access to capital resulted in significant new business development in the hardware and storage industries. In 2003, money from venture capital and other private investors is much harder to find, forcing small companies to postpone development or expansion of their businesses. The lack of available money caused many established companies to put a hold on spending during the recession of 2001/2002. Business spending in Colorado declined for six straight quarters in that period. However, things may be starting to turn around, according to an article that appeared in the *Denver Post* in November 2003 (Svaldi and Young 2003). Business investment grew 11.1% in the third quarter of 2003. Spending on software and equipment increased 15.4% in the quarter. This provides some hope for a rebound in the tech-related industries and the Colorado economy as a whole.

Keeping with the national trend, many Colorado manufacturers have begun to utilize overseas production as a way to cut labor costs. This issue was discussed in a recent focus group held by the Leeds School of Business with a number of manufacturing industry leaders. One participant commented specifically on the hard drive manufacturers located in the Boulder, Broomfield, and Longmont areas. These companies are moving essentially all of their manufacturing operations overseas, and concentrating purely on research and development, prototyping, product design, and product management here in Colorado.

Opportunities for Growth

There are a number of opportunities for growth in the computer hardware and data storage industry in Colorado. First, international sales in the industry look to be increasing for many U.S.-based companies. Europe, China, and Japan have been showing great strength in the PC and wireless markets. PC sales in Europe increased 17.5% in Q3, 2003 and sales in Asia increased by 10%. Strong demand for mobile technologies, such as laptops with wireless capabilities, is driving the growth (IDC 2003c). The world's top PC maker, Dell, saw worldwide PC shipments increase by 27.9% overall, with growth in Asia/Pacific (excluding Japan) of over 50% for Q3 2003. Even in Canada, where year-over-year PC sales have been declining for nine straight quarters, PC shipments have increased by 23.2% from Q3 2002 (IDC 2003b). As these regions continue to grow, Colorado companies should be able to take advantage of this globalization and see increased business.

In storage, the Boulder/Broomfield area and the city of Colorado Springs show a lot of potential for growth. Both regions have been able to build up a strong presence in storage and should continue to develop the industry. In Boulder and Broomfield, the concentration of hi-tech firms like Sun Microsystems and Level 3 Communications, along with a large number of biotech firms, has provided a major need for storage capacity. Local companies like StorageTek will continue to grow and newcomers like LeftHand Networks and CreekPath Systems should continue to grow with such a large number of potential customers in the region and a highly educated workforce available to them. The major defense presence in Colorado Springs will provide the demand for storage and other computer technology in the region. As the Department of Defense continues to stress the importance of military information systems, companies that build communications and storage systems will benefit. Additionally, Colorado Springs has the opportunity to become a center of storage networking research. The Storage Networking Industry Association Technology Center will continue to develop into an important centerpiece of research and development in the industry, and the CU-Colorado Springs Network Information and Space Security Center will add to the solid backbone of technology, defense, and storage research and education in the region.

Summary

The computer hardware industry is a vast industry reaching all the way from the individual consumer to the multibillion dollar corporation. From PCs, to peripherals, to communications equipment, hardware manufacturers make the products that keep businesses alive. The speed of technological advancements makes for a market that is constantly growing and changing. New trends like WiFi and Tablet PCs seem to emerge daily and keep the industry on its toes. Along with the increasing importance of data storage in the enterprise, these new developments will ensure that the industry continues to prosper.

There are a number of trends that are changing the appearance of the hardware industry. First, hardware is essentially becoming a commodity, as competition and low materials

costs are driving down prices. These lower prices are turning into higher sales. Worldwide PC shipments, for example, grew 15.7% in Q3, 2003 and in Canada, where they have been declining for nine straight quarters, shipments grew by 23.2%. While higher sales is usually good news for PC manufacturers, the lower prices are convincing a lot of companies to move into other markets like software and consulting, in order to supplement their businesses. Hardware manufacturers are also attempting to cut costs by outsourcing many of their operations to overseas factories. India, China, and Taiwan are becoming major centers for hardware manufacturing. Though this does reduce labor costs to the manufacturing firms substantially, many American workers are losing their jobs as a result. Other trends in the industry include the growth of the data storage sector, and the fast-developing wireless sector.

Colorado has a prominent place in the hardware industry. Companies like HP, IBM, Sun, and StorageTek all have operations in the state, and the research universities in Colorado produce a highly educated workforce that is necessary for the technology industry to flourish.

One weakness that is hindering the industry in Colorado is the general economic downturn that the country has experienced in the last few years. The recession has made it very difficult for businesses to find money for growth and development, especially tech-based businesses like hardware and storage makers. Colorado hardware manufacturers are also following the national trend of outsourcing, which has hurt employment growth in the industry.

There are some definite areas of opportunity for the hardware industry in Colorado. First, the PC and wireless markets in Europe and Asia are growing tremendously. PC sales in Europe are up 17.5% in Q3 2003, and sales in Asia are up 10%. Big PC makers like Dell, HP, and IBM are already seeing major growth in these overseas markets and Colorado companies should be able to take advantage as well. Within Colorado, there are also some good opportunities for hardware and storage companies. The major defense presence in Colorado Springs and the biotech presence in the Boulder/Broomfield area create significant demand for storage components. The SNIA Technology Center in Colorado Springs conducts storage research and development and provides educational training to industry leaders. This asset should support the growth of the industry in El Paso County.

BIBLIOGRAPHY

American Electronics Association (AEA) (2003). *Cyberstates 2002.* <http://www.aeanet.org/Publications/IDMK_cyberstates2002_press_releases.asp>

Colorado Office of Economic Development and International Trade (2001). *Colorado's Business Climate at a Glance.* <http://www.state.co.us/oed/busclimate2001.pdf>

Hindustan Times Online (2003). *India Strives to Emerge as Global Computer Hardware Hub.* <http://www.hindustantimes.com/2003/Oct/07/181_406008,00030001.htm>

IDC (2003a). *Worldwide and U.S. Storage Services Forecast and Analysis.* March. <http://idc.com/getdoc.jhtml?containerId=pr2003_03_26_144518>

_____ (2003b). *Canadian PC Market Back in the Black, According to IDC.* October. <http://idc.com/getdoc.jhtml?containerId=pr2003_10_30_183223>

_____ (2003c). *Consumer Notebooks Drive Worldwide PC Growth to 15.7% as HP Narrows Dell's Lead, According To IDC.* October. <http://idc.com/getdoc.jhtml?containerId=pr2003_10_14_151735>

Storage Networking Industry Association (2003). *Planning Starts for StorageNetworking.org.* <http://www.snia.org/news/newsletter/2003/06/storagenetworking>

Svaldi, Aldo and Andy Young (2003). "Business Investment Rebounds Spending Bodes Well for State." *Denver Post*, November 2.

TechSector Trends (2003). *Wireless Technologies.* <http://www.techsectortrends.com/document_76.html>

Yahoo Finance (2003). *Computer Hardware Industry Center.* <http://biz.yahoo.com/ic/cmptrs.html>

ZDNet News (2003). *Study: PC Prices Rocking to the Bottom.* <http://zdnet.com.com/2100-1103_2-995560.html>

MANUFACTURING – PHOTONICS

Photonics, the science of light, is closely related to optoelectronics, which is the combination of optics and electronics. Uses of optoelectronics can be seen in our everyday lives, and are apparent in many different industries including computing, communication, entertainment, education, electronic commerce, health care, transportation, and defense. The uses of optoelectronic products and components can be broken down into four major applications. These include communications, storage, display, and image acquisition.

Manufactured photonics products can be divided into components and enabled products/equipment. Components are a critical element in the function of the enabled product, making these two markets very dependent on one another. Enabled products and equipment are often categorized in one of the following seven subcategories: imaging equipment, displays and portable components, optical storage disk sales, optical communications, optical storage drives, energy conversion, and other optoelectronic equipment. The components market can be divided into storage media, passives, flat panel display, connectors, fiber and cable, modules, and semiconductors. Typically the enabled product market size is three to four times the size of the underlying component market.

Examples of optical components:

Lenses	Light sources	Displays (LCD, flat panel, video, etc.)
Mirrors	Lasers	Optical fibers and connectors
Prisms	Modulators	Coatings for heat-reflecting or UV-blocking
Diffraction gratings	Detectors	

Examples of optical equipment:

Sensors (image, thermal, distance, etc.)	Laser and LED printers
Imaging (video, digital, and film cameras)	Telescopes
Optical information storage (CD, DVD)	Microscopes
Xerographic copiers	Photolithography equipment
Rapid-prototyping equipment	Medical diagnostic and surgical instruments
Fiber optics	Laser-based cutters, welders, and markers
Laser communications systems	Remote sensing and surveillance systems
Digital and bar code scanners	

National Trends

In North America, optoelectronics businesses, research labs, and universities are active in 40 states and across Canada, and provide skilled and productive jobs for an estimated 150,000 people. The Optoelectronics Industry Development Association (OIDA) was formed in 1991 to track and foster growth of the industry. Since its inception, the optoelectronics market has grown from $4 billion to over $20 billion in revenue for its components and equipment producers (OIDA 2002). The actual photonics market is

much larger as these optoelectronic market figures do not include other passive photonics components and systems such as cameras, coatings, optical instruments, and the like.

Historically, the industry has been characterized as having many small firms and few large firms. As segments of the industry tied to telecommunication declined and the general economy experienced a downturn in 2001, there was noticeable consolidation. This consolidation is expected to continue through the next couple years with growth picking up as the U.S. economy recovers and additional growth is driven by defense and aerospace markets. Optoelectronic component sales in 2002 totaled $49 billion, decreasing by 13% from $56.4 billion in 2001. While this appears to be a significant drop, it is less than the 20% fall experienced between 2000 and 2001 following many years of uninterrupted growth. Equipment (selected optoelectronics enabled products) finished 2001 almost flat overall, falling only 3%, to $114 billion.

OPTOELECTRONIC COMPONENT SALES 2001

Component	Sales	% of market
Flat Panel Display	$22.5	40%
Sources and Det.	11.5	21
Fiber and Cable	9.9	18
Storage Media	5.2	9
Modules	3.2	6
Connectors and Hardware	2.4	4
Passives	.9	2

Market demand for optoelectronic products appears to remain strong, creating hope for future growth. Digital cameras outsold conventional film cameras along with DVD players outselling VCRs starting in late 2001. Sales of optical-storage lasers, used in DVD players, grew 82% in 2002, to $1.4 billion (*OIDA News* 2003). Optical rewritable CDs and DVDs have all but displaced removable magnetic disk storage. The number of new Internet users worldwide continues to increase at about a 30% annual rate. Broadband access is also increasing with an annual growth rate of 80% in the United States (OIDA 2002). Flat panel monitor sales continue to rise along with the increasing market share of notebooks and laptops in the personal computer market. Sales of liquid-crystal-display monitors increased by 53% to $17.3 billion in 2002, a major portion of the $29.5 billion in total flat-panel displays sold (*OIDA News* 2003).

During 2002, the industry experienced a 73% drop in sales of optical fiber and telecom components. Laser sales for telecom fell even more drastically to $665 million in 2002 from $1.7 billion in 2001 and from around $5 billion in 2000. Early in the year, analysts expected the telecom industry's downturn to start improving slightly towards the end of 2003 and gain strength through 2007, with a compound annual growth of 12% (*OIDA News* 2003). Since telecom is one of the photonics industry's main markets, this would consequently increase the demand for optoelectronic products and services. A study conducted by KMI, released in September of 2003, indicated that carriers plan on increasing their optical-networking equipment spending in 2004 and beyond (*Laser Focus World* 2003).

Colorado Photonics Industry

In Colorado during 2002 there were a total of 242 organizations in the photonics industry consisting of industry organizations, education/training organizations, federal laboratories, and business support. The total employment of these organizations in 2002 was 36,560 people who are paid an estimated total of $2.2 billion in wages. About 78% of the work force is involved in manufacturing. Approximately 13.5%, or 4,940 of the total workers are required to have knowledge of photonics. The total wages for this specific group are about $285 million, and the average wages paid to each of these workers is $57,689, 46.5% higher than the average state wages (Colorado Photonics Industry Association 2003). Colorado ranks 5th in the nation in terms of photonics manufacturing employment (AEA 2003).

Despite the recent economic downturn, the photonics industry in Colorado grew from 206 organizations in 2001 and is expected to grow to 280 organizations by 2004. The industry continues to become more geographically diverse in the state. Almost half of the state's photonics organizations are located in Boulder County. Other counties with high concentrations include El Paso, Denver, Larimer, Adams, and Arapahoe.

Based on the North American Industrial Classification System (NAICS), almost 83% of the total organizations are directly involved as manufacturers or in research and development. About 50% of the organizations produce end products, while about 20% produce components. The top products and services of photonics companies in Colorado were research and development, optical components, lasers, and optoelectronic devices. The primary industries where photonics products and services are used in Colorado are aerospace, military/defense equipment, medical equipment, and telecommunications (*Colorado Photonics Industry Directory* 2002).

Location Requirements

The photonics industry can be strengthened by a diverse base of universities, research facilities, companies, suppliers, and associations located together in a central area to form a cluster or critical mass. While the individual presence of each of these organization types is important to the success of a photonics industry, it is even more beneficial if they are all located near each other. Universities allow for increased research and collaboration with local companies, strengthening both the companies and the university's photonics and optics programs. Local universities and community colleges with photonics programs also contribute to the requirement of a skilled and educated workforce in the area by training students for numerous jobs in the industry. A large and diverse base of companies creates the opportunity for collaboration and competition which allows them to work together with similar companies and outsource locally rather than going out of the state or country. Another important requirement in the success of the photonics industry is some kind of association to help the different kinds of organizations work together and encourage cooperation among groups.

Before these organizations are established in one area or are expected to grow, there needs to be sufficient funding for the companies and programs to start. While a lot of the funding comes from the individual companies, it is important that there be strong support from local and state governments (Focus Group/Survey 2003).

Strengths

As mentioned in the previous section, there are many factors that contribute to the success of the state's photonics industry. Colorado has a number of factors that strengthen the industry including major research universities with photonics programs, federal labs, a wide variety of photonics-related companies, and a strong association tying them all together.

The presence of four major research universities strengthens the photonics industry in Colorado. Universities in the state with programs in photonics include the University of Colorado at Boulder, Denver University, Colorado State University, and the Colorado School of Mines. More than 55 professors at these universities have research groups that are focused on some aspect of optics and photonics. In addition, Front Range Community College created a photonics technician program in 1999 based on the need for qualified employees in areas other than photonics research and design in the Colorado industry. The combination of these programs contributes a large number of workers to the state's industry creating a large base of technology expertise and skilled workers (*Colorado Photonics Industry Directory* 2003).

In October 2003 a $17 million National Science Foundation grant was awarded to researchers from Colorado State University, the University of Colorado at Boulder, and the University of California at Berkeley. These universities are working together to develop laser technologies that will be used to help create the smallest, most powerful computer circuits ever developed. The goal is to develop solutions to a variety of challenging scientific and industrial problems by using short wavelength light in the extreme ultraviolet range of the electromagnetic spectrum. The new Engineering Research Center is expected to create significant national economic benefits in the near future along with supporting a number of industries (Colorado State University 2003).

Along with the universities, four federal laboratories in Colorado also strengthen the state's photonics industry. The National Institute of Standards and Technology (NIST), the National Center for Atmospheric Research (NCAR), and the National Oceanic and Atmospheric Administration (NOAA) are all located in Boulder, and the National Renewable Energy Laboratory (NREL) is located in Golden. These laboratories have significant photonics activities in their research programs and are an important resource for universities and companies in Colorado.

The photonics industry in the state also benefits from the location of a diverse base of large and small companies. About 62% of the companies associated with the industry in Colorado are classified as manufacturers. While there are some large companies located in the state such as Agilent, Hewlett Packard, Ball Corporation, and Lockheed-Martin,

most of the state's firms are small and have a high potential for growth. Approximately 43% of the total companies have fewer than 10 employees.

In 1997 the Colorado Photonics Industry Association (CPIA) was formed as a nonprofit organization to promote the photonics industry in the state. Since then the CPIA has worked as a common link between the schools, research facilities, and numerous companies to increase awareness of the industry and collaboration among its members. At about the same time, the Colorado Advanced Photonics Technology (CAPT) Center, a state-of-the-art photonics testing and education facility, was initiated with a $4.5 million grant awarded by the state legislature. In addition, the Colorado Photonics and Optoelectronic Program (CPOP), which provided seed grants to photonics university researchers to collaborate with industry, operated for more than 10 years. Financial support from the state to create the CPOP seed grants and the CAPT Center have fostered strong collaboration among the state's four, geographically-dispersed universities and companies throughout the state.

Weaknesses

While the state photonics industry was strengthened by state support and funding in the 90s, budget cuts following the economic downturn have threatened the growth of the industry. In 2002 all of the CAPT Center's operational funding for the year (between $150,000 and $200,000) was cut, along with the state funding for CPOP, which was around $342,000. These large funding losses for the development of technology will greatly affect the industry in the state by possibly reducing the number of startup companies, and making Colorado less attractive to small companies and graduate students (Neff 2002). Since most companies in this industry are small to medium in size, they cannot afford to perform much research without the assistance of some government funding. History has proven that relatively small investments in manufacturing infrastructure can enable the development of a range of products. This would be emphasized by the high degree to which photonics technologies enable the development of other products in many sectors (National Institute of Standards and Technology 2003).

Photonics is made up of numerous technologies that are considered enabling technologies because they contribute to advances in diverse fields, ranging from telecommunication to medical imaging to transportation. While this forces the photonics industry to be diverse and contribute to a number of different industries, it makes it very difficult to identify the extent of the photonics industry. There are some pure photonics companies that make only photonics products, but there are many companies that apply photonics to an application such as telecom, aerospace or biosciences making it difficult to categorize these companies (Focus Group/Survey 2003).

Offshore manufacturing in the photonics industry can be considered both a strength and a weakness. While manufacturing outside the United States allows companies to be more competitive in the industry by cutting costs, bringing in new ideas, and developing a presence in new markets, it also decreases the amount of photonics production jobs available to U.S. workers. It can be beneficial to a company to outsource, but if all of the

production is done in another country it cuts down on the product innovation and development capability (Focus Group/Survey 2003). Huge sales in the liquid-crystal-display area have mostly bypassed American companies because nearly all LCDs come from Taiwan, South Korea, and Japan (*OIDA News* 2003). The United States currently controls only 9% of the $16 billion photonics component manufacturing market but consumes approximately 40% of the products. A balance between U.S. production and consumption would create the potential for many high-paying American jobs (National Institute of Standards and Technology 2003).

Growth Opportunities

One of the major opportunities for growth in Colorado is the presence of a nationally recognized diverse photonics cluster. In September of 2003 the International Society for Optical Engineering (SPIE) held an International Symposium in Boulder on Optical Materials for High Power Lasers. In 2004, SPIE's 49th annual meeting will take place in Denver. Taking advantage of the strong industry base that Colorado has will strengthen the photonics industry in the future. The entire industry would benefit from building on the existing combination of universities, labs, and companies and by using the unlimited resources of each of these organizations. Another source of growth would be to work even more extensively with different industry sectors such as aerospace, defense, bioscience, and medical (Focus Group/Survey 2003).

The need for technological advancements in defense and homeland security has increased as war and the threat of terrorism have become more visible to the United States. It is estimated that the global market for large defense electronics systems projects will be worth nearly $182 billion over the next decade (Lewotsky 2003a). Defense has always been a major market for the optoelectronics industry in Colorado, but demand for products used especially for imaging and surveillance such as lasers, sensing devices, and remote-sensing devices is growing. Cameras and various sensor technologies to gather information at a distance have become increasingly important. The new Jigsaw Program, a joint effort of the U.S. Army's Future Combat Systems and the Defense Advanced Research Projects Agency (DARPA), aims to develop a 3-D laser radar (ladar) that can fly on an unmanned aerial vehicle (UAV) and perform rapid, reliable, and confident identification of targets day or night, through foliage or camouflage (Hauge 2003). In addition, there is a growing need for high-resolution satellite imaging. Earlier this year two Colorado-based companies, Space Imaging and DigitalGlobe, were awarded multiyear contracts for high-resolution satellite imagery as part of the government's Clearview digital-mapping database program. The continuing danger of chemical and biological attack and the ability to detect these agents in the environment is critical to the safety of the nation's military and civilian population.

Another growth opportunity in the photonics industry is in the healthcare field. "There's been a tremendous growth in the field of biomedical optics and optical technology," says Bruce Tromberg, professor of biomedical engineering at the Beckman Laser Institute, University of California. "What people are realizing is that optical signals can provide quite valuable and unique information about physiology that can't be obtained using any

other radiological approach." The global market for medical imaging equipment is expected to rise from $19.9 billion in 2003 to $26.6 billion by 2007 (Lewotsky 2003b). The field of biomedical optics has grown substantially in recent years, and there is a significant amount of venture capital available to photonics companies that are interested in the medical field. With the telecom industry downturn, an aging population, and efforts to bring healthcare costs down, opportunities for photonics in biotechnology are the best they have been in 10 years (Savage 2002).

BIBLIOGRAPHY

American Electronics Association (AEA) (2003). *Cyberstates 2002*. <http://www.aeanet.org/Publications/IDMK_cyberstates2002_press_releases.asp>

Colorado Photonics Industry Association (2003). September 2. <http://www.coloradophotonics.org/> October 14.

Colorado Photonics Industry Directory (2002). Longmont, CO: Colorado Photonics Industry Association.

Colorado State University (2003). "Colorado State, in Partnership with CU-Boulder and UC-Berkeley, Announce $17 Million NSF Grant for Engineering Research Center." October 1. <http://newsinfo.colostate.edu/index.asp?page=news_item_display&news_item_id=685848753> October 15.

Focus Group/Survey (2003). Manufacturing/photonics focus group and survey conducted in August.

Hauge, Robert (2003). "Ladar Puts the Puzzle Together." The International Society for Optical Engineering, *OE Magazine*. April. <http://oemagazine.com/fromTheMagazine/apr03/ladar.html> October 20.

Laser Focus World (2003). "Carrier Survey Indicates Spending Upswing." September 26. <http://lfw.pennnet.com/Articles/Article_Display.cfm?Section=ONART&Subsection=Display&ARTICLE_ID=188195> October 13.

Lewotsky, Kristin (2003a). "Opportunity in the Skies." The International Society for Optical Engineering, *OE Magazine*. April. <http://oemagazine.com/fromTheMagazine/apr03/specialfocus.html> October 20.

_____ (2003b). "Seeing into the Body." The International Society for Optical Engineering, *OE Magazine*. July. <http://oemagazine.com/fromTheMagazine/jul03/seeing.html> October 20.

National Institute of Standards and Technology (2003). "ATP Focused Program: Photonics Manufacturing." <http://www.atp.nist.gov/atp/focus/photonics.htm> October 28.

Neff, Todd (2002). "TAG: You're Not It, Legislature Says." *Front Range TechBiz*, July 5. <http://www.coloradophotonics.org/PDF/PressArticles/FrontRangeTechBiz/FRTBTag5July2002.pdf> October 28, 2003.

OIDA News (2003). "Storage and Display Gains Brighten a Still-Grim Market." Vol. 12, no. 2. April 2003. <http://www.oida.org/pdfs/oidanews/oidanews0403.pdf> October 13.

Optoelectronics Industry Development Association (2002). "Worldwide Optoelectronics Markets." <http://www.oida.org/markets.html> October 13, 2003.

Savage, Neil (2002). "NIH Shows Photonics the Money." The International Society for Optical Engineering, *OE Magazine*, December. <http://oemagazine.com/fromTheMagazine/dec02/busspot.html> October 20, 2003.

ENERGY AND ENVIRONMENTAL

This section focuses on economic opportunities for Colorado in energy and environmental industries in the coming decade. The overview will include environmental products and services, energy resources (petroleum, natural gas, and coal), mineral and aggregate extraction, and emerging renewable energy and biofuels industries.

National and International Trends

In the 1980s and 90s environmental products and services in the United States experienced high growth rates. Now most sectors of the environmental industry are stable and mature with modest growth rates projected for the 2002-04 timeframe. The modest growth predicted for environmental businesses reflects changes in government policy, inconsistent enforcement, lag times between policy changes and market demand, and economic realities of customer ability to pay. Growth in demand for environmental services in U.S. markets has declined as major cleanup activities have been addressed and manufacturers have reduced hazardous wastes by adoption of cleaner production processes. Water treatment and conservation, biohazard detection, air pollution control, international markets, and niche areas will drive growth in specific sectors. In the 2002-04 timeframe, the leading growth sector will be clean energy systems and power from renewable technologies (*Environmental Business Journal* 2002).

THE U.S. ENVIRONMENTAL INDUSTRY 1990-2001 ($ bil)

Industry Segment	1990	85-90 Growth	1995	90-05 Growth	2000	95-00 Growth	2001	00-01 Growth	2002-04 Projected
Services									
Analytical Services	$1.5	1.33%	$1.3	-12%	$1.30	-3%	$1.31	.9%	.8%
Wastewater Treatment Works	19.8	27	23.4	18	27.78	19	28.81	3.7	2.8%
Solid Waste Management	26.1	48	32.5	25	39.41	21	40.83	3.6	2.6%
Hazardous Waste Mgmt	6.3	188	6.2	-2	5.10	-18	4.93	-3.3	-0.5%
Remediation/Industrial Svs	11.1	116	11.1	0	11.18	1	11.28	.9	.6%
Consulting & Engineering	12.5	191	15.5	24	17.41	12	18.02	3.5	3.4%
Equipment									
Water Equip. & Chemical	13.5	34	16.5	22	19.84	20	20.33	2.5	3.6%
Instruments & Info Sys.	2.0	197	3.0	51	3.64	21	3.80	4.4	3.8%
Air Pollution Control Equip.	13.1	93	14.8	13	17.60	19	18.27	3.8	2.2%
Waste Management Equip.	8.7	43	9.8	13	9.85	0	9.71	-1.4	2.4%
Process & Prevention Tech.	.4	173	.8	100	1.16	41	1.26	8.6	8.0%
Resources									
Water Utilities	19.8	32	25.3	28	29.90	18	30.86	3.2	2.8%
Resource Recovery	13.1	48	16.9	29	16.02	-5	13.75	-14.2	4.0%
Clean Energy systems & Power	4.3	69	5.6	31	8.56	52	9.96	16.4	16.5%
Totals	$152.2	59%	$182.9	20%	$208.7	14%	$213.1	2.1%	2.2%

Source: Environmental Business International Inc. www.ebiusa.com, San Diego, Copyright 2002 EBI Inc.

Sources of electricity generation worldwide are oil, coal, natural gas, nuclear power, and renewable energy (RE) sources. Consumption, driven largely by growth in developing countries (China, India, and South Korea primarily), is predicted to grow 58% over the next 25 years. The natural gas share of total energy consumption is projected to increase from 23% in 2001 to 28% in 2025, while nuclear power consumption will drop from 19% to 12%, and coal will fall from 24% to 22%. Over the past several decades oil has held the highest share of world energy use and is expected to retain its lead while dropping only slightly from 39% in 2001 to 38% in 2025. Even though renewable energy use will grow by 56% between 2001 and 2025, this growth will just maintain its 8% share of world energy consumption. Most of this growth will result from large-scale hydroelectric projects in Asian countries (Energy Information Administration 2003).

U.S. locations with oil, natural gas, and coal reserves will continue to enjoy economic benefits from their natural resources and production capacity. Mining is an important contributor to this industry sector, providing the needed raw materials for products and energy to meet electricity needs in the United States and the world. The combined direct and indirect economic impacts from mining are estimated at $523.6 billion. The United States is the world's second largest producer of coal and gold and the leading producer of clay, copper, gypsum, lithium, magnesium, phosphates, salt, silica, and sulfur (Colorado Mining Association 2003).

Growing energy consumption in the United States combined with concerns about national energy security will increase reliance on and demand for U.S. energy sources. In 2000 the nation imported 55% of oil consumed in the U.S. Energy demand is predicted to increase 32% by 2020, far exceeding predicted increase in domestic supply and stimulating support for domestic resource development and for new clean power technologies (U.S. Department of Energy 2003).

The U.S. Department of Energy Strategic Plan recognizes that the long-term solution is to "make a fundamental change in our mix of energy options." Toward this end, DOE plans to develop advanced technologies to reduce the cost and environmental impacts of nuclear energy; to produce, store, and use hydrogen as a sustainable and emissions-free energy carrier; and to develop fusion energy, the process that powers the sun." It will take many years for most of these strategies to be fully developed and deployed. The DOE strategy includes the "FutureGen" program, a cost-shared $1 billion international initiative to design, build, and operate a nearly emissions-free, coal generation plant that could provide incentives for investment in new, cleaner, coal-based generation facilities. While this technology could be demonstrated by the end of 2008, its actual deployment in a power plant is not expected until 2020. Similarly, the "FreedomCAR" initiative is projected to have initial technical milestones accomplished by 2010, setting the stage for a decision by industry to begin to commercialize fuel cell vehicles and deploy the supporting hydrogen infrastructure in 2015 (U.S. Department of Energy 2003).

The DOE predicts that energy production from renewable energy sources (excluding hydropower) will double over the next 20 years (U.S. Department of Energy 2003). The RE industry is defined to include solar, wind, biomass, and geothermal resources, and

excludes hydroelectric sources. Proponents cite a major advantage of RE generation as the avoidance of harmful air emissions produced by burning fossil fuels in power plants, and avoidance of land-use impacts from coal and gas extraction or from large hydroelectric dam projects. Thus, advances in renewable energy technology are expected to create new economic opportunities for localities with wind and biomass resources to become cost-competitive in energy markets.

Over the next decade, solar photovoltaics (including modules, system components, and installation) will grow from a $3.5 billion global industry in 2002 to more than $27.5 billion by 2012; wind power will expand from $5.5 billion to $49 billion, and fuel cells will grow from $500 million to $12.5 billion (Makower 2003).

According to the American Wind Energy Association (AWEA) the installed capacity of wind generators in the United States is expected to grow by 25% in 2003 in spite of financing difficulties that are impacting the entire electrical generation market. This growth would boost U.S. installed wind power capacity from 4,700 MW to approximately 6,000 MW (enough to serve 1.5 million homes). New Mexico will construct the world's third largest wind farm creating up to 150 jobs during the construction period, and 12 permanent jobs to maintain the facility. Economic benefit to the area is estimated at more than $40 million over 25 years (American Wind Energy Association 2003).

Wind turbine manufacturers are meeting industry demand with current products as well as improved turbines. Leading turbine manufacturers include GE Wind Energy and NEG Micon North America (EERE Network News 2003).

Demand for ethanol as a high octane gasoline additive is growing due to bans on use of MTBE, demand for clean fuel alternatives, and the desire for increased use of domestic fuels to address energy security issues. In 2002 ethanol production in the United States increased 20% over 2001 and 45% over 1999 (Renewable Fuels Association 2003a).

Currently there are 72 ethanol plants operating in the United States, providing a combined production capacity of more than 2.85 billion gallons per year. Ten plants were under construction in early 2003, including farmer-owned plants in Iowa, South Dakota, Illinois, and Kansas (EERE Network News 2003).

Ethanol production facilities bring jobs, value-added markets, and increased tax revenues to rural areas. Based on a June 2002 report by John Urbanchuk, AUS Consultants and Jeff Kapell, SJH & Company, an average 40 million gallon per year corn-to-ethanol plant is estimated to provide the following economic benefits:

- One-time boost of $142 million to the local economy during construction.
- Expand local economic base by $110.2 million year through the direct spending of $56 million.
- Create 41 full-time jobs at the plant and 694 jobs throughout the economy.

- Increase the local price of corn by an average of 5-10 cents a bushel, adding to farm income in the area surrounding the plant.
- Increase household income for the community by $19.6 million annually.
- Boost state and local sales tax receipts by an average of $1.2 million.
- Provide an average 13.3% annual return on investment over ten years to a farmer who invests $20,000 in the facility (Renewable Fuels Association 2003b).

Growth Opportunities

With the increased demand for domestic energy sources, all segments of the energy industry will continue to bring economic benefits to U.S. suppliers. While many technology-based solutions could have economic advantages in the long term, this report will focus on the higher market growth areas predicted for clean energy systems and power. Growth for RE industries will result from technological improvements, manufacturing capability, cost competitiveness, and government investments to achieve energy security.

In the United States the federal government is increasing its investment in development of RE technologies in an effort to achieve energy security and boost economies in rural areas. In addition, biomass technologies that create new bioproducts from agricultural commodities are also receiving increased federal funding. The Department of Energy's FY2003 budget for biomass research is $114 million, while U.S. Department of Agriculture requests $259 million for research in bioconversion, agronomic practices, and incentives. The National Science Foundation 2003 budget supports approximately $50 million in biomass research including metabolic engineering, biotechnology, plant biology, and genomics. In April 2003, the U.S. Department of Agriculture and Department of Energy released a $21 million biomass solicitation to promote innovation and development while cities and states seek to implement new biomass facilities and wind farms. For example, a proposed $50 million biomass electric generation facility near Raton, New Mexico, is planned to convert waste from tree thinning and agriculture into power to serve 20,000 to 35,000 homes (*Biobased Fuels, Power, and Products Newsletter* 2003).

The western United States is home to 5 of the 10 fastest growing states in the country. Renewable resource development can help meet the growing demand for electricity over the next decade by providing clean, low-risk power while providing energy independence, system diversification and reliability, rural economic development, and fuel price stability (Nielsen 2002).

The following list presents five predicted growth trends in RE markets in the next decade. (1) Centralized large electricity production from utility scale wind farms and large-scale solar towers. Industry players include GE Wind Energy, Enercon, Duke Solar (now Solargenix), FPL Energy, and Vestas. (2) Hydrogen energy from renewables rather than from reformation of gasoline, methane, fossil fuels, or natural gas. Companies include Honda, Proton Energy, Melis Energy, Northern Power, and Virent Energy Systems. (3) Defense applications to solve logistical and tactical fuel supply issues support increased

development of fuel cells and advanced rechargeable batteries. Involved firms include Acumentrics, Air Products, Mechanical Technology, MesoFuel, Plug Power, and MTI Microfuel Cells. (4) Advancements in photovoltaics technology and manufacturing are expected to achieve higher efficiency and lower costs to make solar PV cost competitive. Companies include Konarka Technologies, AstroPower, NanoSolar, Unisolar, and Xantrex. (5) New technologies to optimize the efficiency and reliability of the existing power grid include real-time pricing, "grid-friendly" chips, smart software to improve distribution of renewable-produced energy. Companies include Encorp, Itron, Optimal Technologies, Sixth Dimension, and utility Automation Integrators (Makower 2003). Other large players in electricity production from utility scale wind farms and solar towers are Shell Renewables, BP Solar, SeaWest Windpower, RES-North America, and PacifiCorp Power Marketing (Focus Group/Survey 2003).

As new technologies are deployed, new market opportunities for ethanol producers will include:

- E diesel™, a mixture of ethanol, diesel, and a blending agent, has the potential to increase ethanol use by hundreds of millions of gallons once regulatory and technical challenges are met.
- Technology is under development for cost effective ways to produce ethanol from cellulose feed stocks (corn stalks, rice straw, forest thinnings, yard waste, switch grass, etc.). This technology will dramatically increase production capabilities and solve environmental waste disposal issues.
- Ethanol use in mobile and stationary fuel cell applications will generate fewer greenhouse gases than gasoline or natural gas, uses an existing distribution infrastructure, and offers environmental, health, and safety benefits over hydrogen or methanol (Renewable Fuels Association 2003c).

In the longer term, advances in research and development of fuel cell technologies are expected to enable a more renewable form of hydrogen-based energy and electricity than conventional combustion-based technologies that use fossil fuel. Fuel cells are more efficient and less polluting than conventional combustion technologies. Some share a vision of a future "hydrogen economy" where almost all fuel and energy sources are fueled by hydrogen. Michigan, Ohio, Illinois, and New Mexico are among the states that have launched fuel cell initiatives to position their states as leaders to benefit from future economic growth based in fuel cell technologies (Hopkins 2003e, pp. 19–21).

Location Requirements

Growth of RE markets will have some impacts for environmental retail and service companies specialized in sale and installation of small off-grid solar, wind, and biomass applications. The largest economic development potential, however, will be from commercial or community scale power and/or fuel production plants.

To be suitable for commercial RE power production the location must have adequate natural resource, access to transmission connection, and capital for large facility

construction. “The Energy Atlas of the West” provides maps with estimates of available wind, solar, and biomass resources in western states. More complete and detailed renewable energy resource mapping is in process. Suitable locations must also consider environmental impacts to wildlife habitat, watersheds, recreation areas, and parks (Nielsen 2002).

Difficulty in arranging financing is the biggest current barrier to development of any new commercial power plant regardless of energy source. For example, the upfront cost of determining the economic feasibility of a commercial wind farm can be a significant barrier. While the energy resource maps highlight natural resource areas and indicate the potential of RE development in western states, actual determination of feasibility and implementation requires additional data specific to the proposed site. The development of a wind farm for example, requires the use of on-site anemometers placed on 60-foot-high towers at test locations around the proposed site to measure wind velocities through an entire year. The collected data help determine commercial feasibility of the site and the best locations for wind turbine placement. The expense of these measurements, however, is an up-front cost preliminary to a determination of project feasibility which is necessary to obtain project financing for construction.

Similarly, geothermal resource estimates generally require test drilling to determine whether a location is suitable. In addition, the feasibility and size of a biomass to energy or fuel processing facility is determined by detailed assessment of the quantity and type of biomass or waste available, the cycles of availability, and the cost of processing and transporting the waste resource.

Access to transmission lines can also be a barrier to the commercial feasibility and location of electricity production facilities including renewable energy projects. “Access to transmission is an important component of developing large-scale wind, solar, geothermal or biomass facilities, which are often sited far from load centers. As wholesale electric markets have developed over the last decade and electric demand has grown, many major transmission paths across the west have become increasingly constrained, at least during some hours of the year. Absent new transmission system investments or changes in how existing transmission capacity is allocated, transmission constraints may limit large-scale renewable energy development in the region. On the other hand, some renewable resources can be installed near load centers and may gain an economic edge due to their ability to ease congestion.” The atlas provides a map of major transmission lines, substations, and constrained transmission paths (Nielsen 2002b).

In the absence of transmission connectivity, however, community level power generation to supply site-specific or local area needs provide alternatives for local economic impacts (Focus Group/Survey 2003).

Colorado Competitive Position

Mineral and Energy Resources

Colorado's economy has long been based in mineral extraction and petroleum industries. The state has abundant mineral resources with the mining industry contributing an estimated $7.7 billion in direct and indirect economic benefits to the state. The industry includes coal (with the majority of production in Gunnison, Routt, Moffat, and Delta, and lower activity in Rio Blanco, Montrose, La Plata, Las Animas, and Garfield Counties), gold (Teller County), lead, gypsum (Eagle County), limestone (Larimer County), silver (Teller County), molybdenum (Lake and Clear Creek Counties), titanium (Gunnison County), uranium (Jefferson County), zinc, marble (Gunnison County), and aggregates (sand, gravel, crushed stone). Miners' average annual earnings in 1998 were $58,835. Direct jobs from this industry were 5,900 with approximately 3,900 in coal and nonmetals mining (Colorado Mining Association 2003).

According to the Colorado Geological Survey, 91% of the coal mined in Colorado is used for electricity generation, 9% for industrial plants, and the rest for coking, residential, and commercial use. In addition, about half of the coal produced in the state is burned at Colorado power plants.

In 2002, Colorado's aggregates industry produced sand, gravel, and stone valued at $319,000,000 (U.S. Aggregates 2002).

Oil and gas wells are located in 42 of Colorado's 64 counties. The top three counties in oil production are Rio Blanco, Weld, and Cheyenne. La Plata, Weld, and Garfield Counties lead the state in natural gas production. There have been no new oil discoveries in Colorado since 1977 and production remains flat at 17.3 million barrels in 2000. Natural gas produced in 2000 totaled 355 billion cubic feet (bcf) showing a steady increase that is expected to rise with development of the Western Colorado Piceance Basin (Mesa and Rio Blanco counties). This potential resource is estimated at 31 trillion cubic feet, representing the largest discovery in the Rocky Mountain region. Colorado produced 385 bcf of coal bed methane (CBM) in 2000 representing 52% of the state's total gas production and placing Colorado first in the United States (Colorado Petroleum Association 2003). Two refineries operate in Commerce City (Adams County), Suncor Energy U.S.A., and Valero Energy.

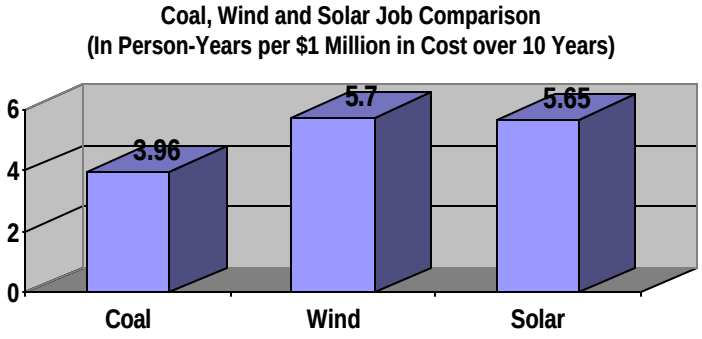
Total production value in 2000 for oil, gas, and carbon dioxide in Colorado was $2,830 million, generating $161 million in severance tax, property tax, and federal royalties. Employment in this industry averaged 7,200 jobs in the state in 2000, only a slight increase over 1999 (Colorado Petroleum Association 2003).

Electricity generated in Colorado comes primarily from fossil fuels, with over 83% produced from coal. An increasing amount of power in Colorado is generated from natural gas, which has led to volatile and unpredictable price swings in recent years.

Renewable Energy Potential

Just as coal mining and energy produced from in-state coal resources results in jobs and revenues for some counties in Colorado, developing renewable energy sources which employ native resources and local production, can create future employment and economic impact for other areas of the state. In many communities, money spent for residential, commercial, and industrial activities, leaves a community, going to outside utilities or energy suppliers. Developing renewable energy resources can mean that energy dollars are spent in the local economy and generate local revenue, as opposed to purchasing energy generated outside the community. "According to estimates for Nebraska, money spent on renewable energy and energy efficiency has a multiplier of $2.32, while money spent on conventional fossil fuel energy sources has a multiplier of $1.48" (Hopkins 2003a).

Furthermore, studies show that renewable energy production can create more jobs for the money invested since it is generally more labor-intensive than that of traditional fossil fuel-based energy. A recent study by the Renewable Energy Policy Project, found that wind and solar electricity production offers 40% more jobs than coal (Hopkins 2003a).



Source: Renewable Energy Policy Project, *The Work That Goes Into Renewable Energy*

Looking to the future, Colorado has the resources to become one of the top ten clean energy-producing states in the nation. With the National Renewable Energy Laboratory (NREL) located in Golden, Colorado, the state could better capitalize on this local resource for renewable energy technologies and research expertise. For example, NREL has formal relationships with RE business incubators in other states; however, in Colorado there is no public-private initiative or funding to support business development of RE technology companies. The value of NREL's technology is illustrated by its receipt of a 2003 R&D 100 award from R&D Magazine for developing a new process for depositing semiconductor layers onto photovoltaic (PV) modules, an award that recognizes the year's 100 most significant technological innovations. The new process, developed in partnership with First Solar, an Ohio firm, will enable a high deposition-rate mass-production method of manufacturing thin-film solar electric modules. Furthermore, NREL has received 35 such R&D 100 awards: potent testimony to the perceived value and economic potential of NREL research (National Renewable Energy Laboratory 2003).

Proponents of renewable energy development cite the rural economic benefits that could be gained from use of renewable resources such as wind, biomass, biogas, bioethanol, biodiesel, and biohydrogen. These "farm fuels," promise to decrease dependence on foreign energy sources while delivering economic benefits to farmers and rural communities. The New Center for Rural Economic and Energy Development provides three examples to demonstrate how these sources of energy income could benefit Colorado economies.

- Wind turbine clusters – interested farmers and towns in a high-wind area buy a few wind turbines from local wind farm developers at marginal cost, install and operate them to off-set the use of large local power consumers or to provide power to local "green" buyers through the electric co-op."

- Drought-resistant oilseeds – County government, schools, and large farm producers commit to buying biofuels at a slight premium, giving the market go-ahead needed to cultivate the crops locally and build a pilot oilseed-to-biodiesel plant.

- Liquid farm fuels from cellulosic and other waste – National, regional, and local biofuel interests collaborate to build a pilot plant that converts low-cost rural waste products (e.g., corn stover, animal wastes, and forest thinnings) into bioethanol, biomethanol, and biodiesel (Potter 2003).

The cost of producing electricity from renewable sources has decreased markedly over the past twenty years through advanced technology and growth in the market. Since there are no costs for fuel, the cost of energy from wind and solar are predictable and stable providing an advantage over fluctuating costs of fossil fuel based power plants.

Solar

In California, solar thermal power plants generate electricity for 8-10 c/kWh, however, a new conventional plant could generate electricity for 7 c/kWh. Because solar systems produce increased power during high usage periods they are cost-competitive in the peak power market. PV systems generate electricity for 12 to 25 c/kWh which is cost-competitive only for off-grid applications including use in the developing world. Since nearly all the cost of PV generation is in the cost of equipment, the factor most directly effecting future competitiveness will be increases in volume sold to the point where manufacturers reach needed economies of scale. In 1999, the U.S. growth rate of PV module manufactured was 52%. At this level the industry will be competitive with traditional energy costs by 2013 (Zugel 2003a).

Colorado has over 300 days of sunshine per year providing the opportunity for growth in sale and installation of solar photovoltaic (PV) and solar thermal energy systems for business, residential, and community buildings. In addition to these local off-grid applications, three technologies are available for commercial solar thermal power plants: parabolic troughs, power towers, and dish/engines. The southern part of the state would

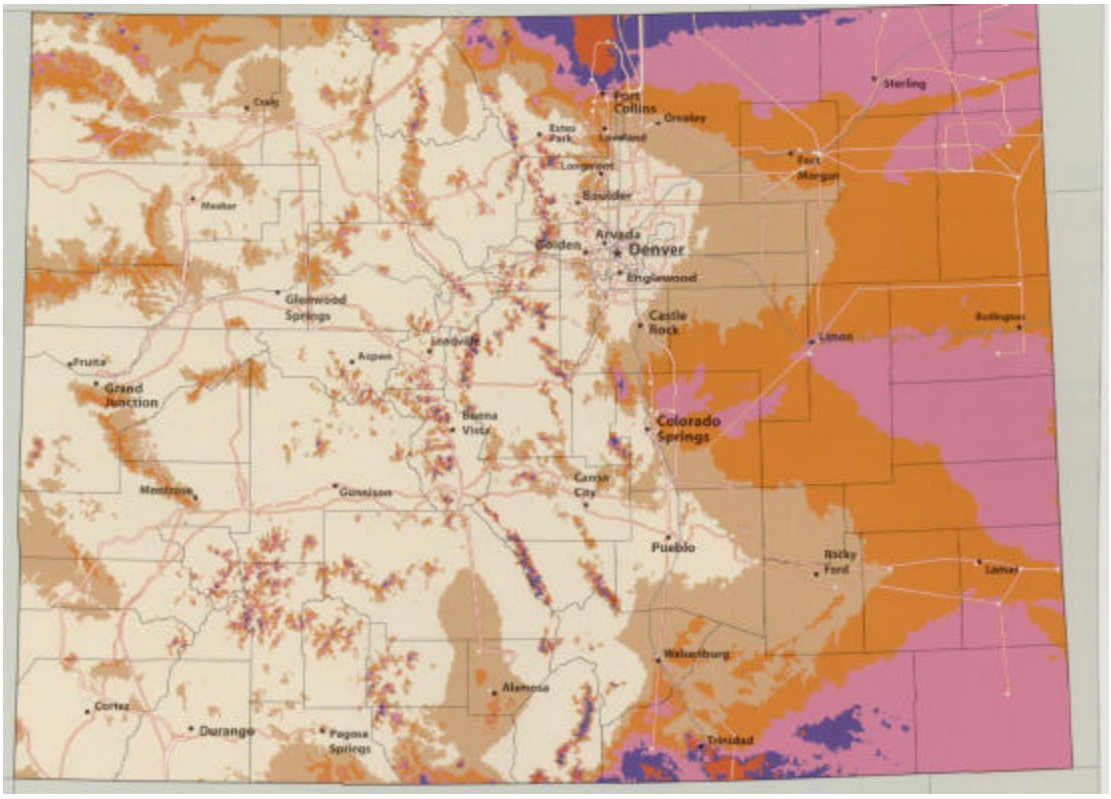
be appropriate for such a solar thermal plant. While solar systems are cost effective over the lifetime of the system, the biggest impediment to growth in this market is the significant upfront capital costs (Zugel 2003b).

Wind Resources

The current cost of producing electricity from wind varies based on the size of the plant and the average wind speed with large plants delivering power for 3 c/kWh or less. A small plant with moderate wind velocities may generate electricity at up to 8c/kWh, which is still lower than retail in many areas. In the near future, wind energy costs could fall to 2.5c/kWh, lower than most conventional energy sources (Zugel 2003a). The competitiveness of wind is enhanced by the 1.8-cent federal production tax credit, which helps "level the playing field" with conventional energy technologies. This credit is due to expire at the end of 2003, but there is bipartisan congressional and Administration support for its extension for at least three years (Focus Group/Survey 2003).

Colorado has excellent wind resources with an estimated 6 million acres of wind resource lands, particularly on the eastern plains. As indicated by darker shaded areas of the wind map on the next page, the highest potential for wind - Rated "6-Outstanding and 5-Excellent"- include northern portions of Larimer and Weld counties along the Wyoming border and southern areas of Las Animas County along the border with New Mexico. Areas rated "4-Good" cover much of the eastern plains including portions of the counties of Larimer, Weld, Logan, Sedgwick, Phillips, Washington, Yuma, Kit Carson, Cheyenne, Lincoln, Kiowa, Prowers, El Paso, Las Animas, and Baca (Nielsen 2002).

COLORADO WIND RESOURCES POTENTIAL



Colorado has a small and growing wind power industry. At the end of 2001, facilities in Weld and Logan counties produced 61 MW, and a 162 MW wind farm near Lamar came on line in 2003. Due to more efficient turbine technology, this new facility sells wind power to Xcel and GE at a competitive price of 3.261 cents per kWh. Xcel's consumers have consistently demonstrated strong support for wind-generated electricity since the company's first "green pricing" program was rolled out in 1997, making it one of the most successful such programs in the nation. This program, "WindSource," enables customers to purchase wind energy at a 2.5 cent/kWh premium. The new 162MW wind farm near Lamar is unique in that its construction was mandated by the Colorado PUC, which determined in its 2001 ruling that the Lamar facility "will likely lower the cost of electricity for Colorado's ratepayers,…[and] is justified on purely economic grounds, without weighing other benefits of wind generation" (Madsen 2002) (PUC).

The competitive position of wind power was further evidenced with the recent announcement by Xcel Energy that three new wind power projects were included, with natural gas-fired generation, as finalists to meet the company's recent 1,000 MW all-source solicitation. Dave Eves, Xcel Energy's vice president for resource planning and acquisition commented that "the strong showing of wind power in this bidding process indicates that wind has become competitive with traditional electricity generating fuels to

meet a portion of our future energy needs." The wind projects will be built in Minnesota (*Wind Energy Weekly* 2003).

Economic benefits for Prowers County from the Lamar facility include:

- 83 installation jobs lasting for one year, and indirectly supporting 95 additional jobs which could be located in other parts of the state.
- 23 full-time operation and maintenance jobs for workers who will be employed locally for at least 25 years, supporting another 26 indirect jobs.
- Increased landowner income of $350 thousand per year from lease payments.
- Increased sales of local goods and services of $810,000 per year for the operation and maintenance needs of the wind farm.
- With an assessed value of around $25 million, the facility will provide approximately $1.4 million per year in increased property tax revenue, raising the tax base of the county by 29% (Madsen 2002).

Other counties with higher wind potential could anticipate even greater increases in tax base from installation of similar size facilities, as illustrated below:

PROJECTED TAX BASE INCREASE FROM 162 MW WIND FARM

County	Increase in Tax Base (Est)
Baca	46%
Bent	52
Costilla	40
Huerfano	29
Kiowa	100
Kit Carson	29
Lincoln	52
Phillips	61
Prowers	29
Sedgwick	82

Source: Madsen 2002 (pg. 23)

Proponents assert that developing just 10% of the state's reasonably accessible wind resources could meet all anticipated growth in electricity demand in Colorado from now until 2020. Developing enough wind power to meet only half of new demand in the coming decade and three quarters of new demand in the following decade could create an estimated 6,300 one-year jobs in wind farm manufacturing, installation, and supporting areas, with a payroll value of $210 million. Development of wind power at this rate would also create 1,300 long-term, highly local (rural) jobs in wind farm operation, maintenance, and supporting areas with an annual payroll value of $51 million. It would also generate $230 million in additional property tax revenue for rural counties, and $76 million in royalties paid to rural landowners (Madsen 2002).

Wind farm development offers many benefits to rural landowners. Typically lease terms represent 2.5% of gross revenue from electricity that could increase a farmer's economic

yield of their land by 30% to 100%. Since the actual footprint of each turbine is small, the farmer can continue to grow crops or graze animals (Madsen 2002).

One economic disadvantage of large wind generation facilities such as the one in Lamar is that the financing for this and similar projects is too large for the community. As is true for development of any energy resource, when financing comes from out-of-state or off shore, a large percentage of profits go out as well. An alternative for economic development would be smaller-scale, community size projects for wind and biomass to energy or biomass to ethanol. Projects in the $2 to $5 million range, which can be handled by the local bank with farmer/rancher and community ownership, would prevent leakage of economic value from the community. In addition, smaller energy production facilities where local demand can absorb all output means that access to transmission lines, and concerns about constant generation output, are no longer concerns (Focus Group/Survey 2003).

Additional opportunities are evident in the manufacture, sale, and installation of wind turbines and equipment to supply a worldwide market. Wind turbine sales are predicted to increase fivefold by 2005. Wind installations worldwide will total more than 75,000 MW generating more than $75 billion in business in the next decade (Hopkins 2003b).

Biomass

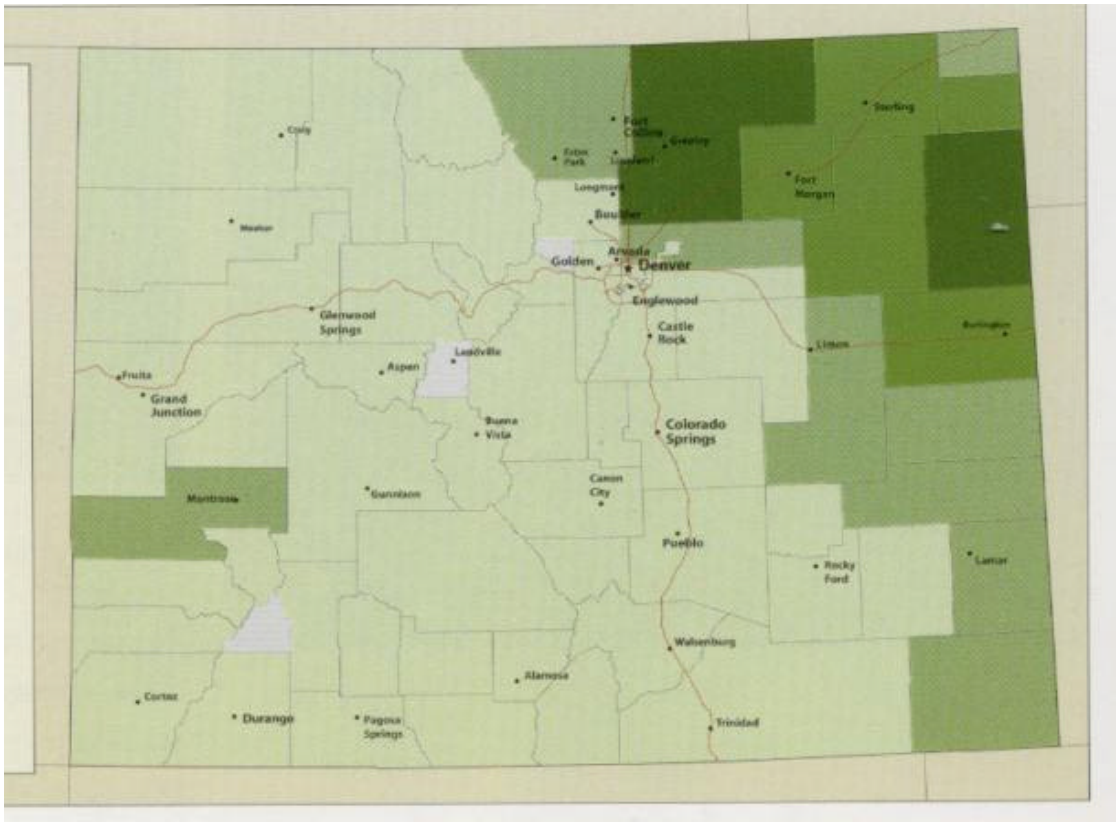
Technology advances will create opportunities for rural Colorado to benefit from increased use of biomass-to-energy and biomass-to-fuel (ethanol and biodiesel) within the next decade. Implementation of processing plants using biomass technologies could also position the state for future participation in other growth markets for a wide range of bio-based products including polymers and industrial chemicals.

Colorado is just beginning to generate economic gains from biomass. Since 1999 Kiowa County has used technology developed at Colorado State University to produce specialized motor oils from sunflower seeds, canola, and soybean oil. These bio-based oils are marketed by Great Plains Oil (www.greatplainsoil.com). In addition to creating a value for locally grown crops, the company employs three to six people in the start-up stage with plans to expand as sales increase. Another emerging Colorado company, BlueSun Bio-Diesel, is already distributing biodiesel within the state and plans to establish its own biodiesel production facility in 2003 creating a higher-value for Colorado-grown canola, a drought resistant oilseed.

Another bio-based product that anticipates increased market demand is ethanol, a fuel additive. Until recently, ethanol was produced most economically from corn, canola, and other oil grains making corn-growing states the optimal location for large ethanol production plants. In 2002, Colorado produced only 1.5 million gallons from a plant at Coors Brewing Company, Golden, Colorado, which produces ethanol from waste beer. In comparison, Illinois produced 766 million gallons per year (mgy) from corn, Iowa produced 695 mgy, and Nebraska produced 422 mgy (Renewable Fuels Association 2003d).

New technologies are establishing cost-competitive ways of producing fuels and energy from agricultural waste, forest thinning, and other cellulose waste biomass, which provides Colorado with the potential to support rural economies. Weld, Larimer, Yuma, and Morgan Counties will have a high potential for processing plants capable of producing ethanol from crop residues (wheat, corn, and barley stalks and straw) and from manure generated by large cattle feed lots, dairies, hog, and poultry operations. The darkest areas of the map below indicate the highest biomass potential (Nielsen 2002).

COLORADO BIOMASS POTENTIAL



Western Slope counties are exploring biomass to energy projects using small diameter timber from forest thinning. Current projects are small, designed to generate energy to supply all or part of the energy needed for a community building or school and determine whether energy production from forest waste can be feasible on a larger scale. One concern, important to determining project feasibility, is whether the cost of thinning the forest could be covered by public funds for fire suppression, outside calculations of economic cost-benefit of producing energy or fuel (Focus group/Survey 2003).

Colorado currently has small emerging firms that are developing leading edge technologies in biomass. For example, with funding support from the U.S. Department of Energy and Small Business Innovation Research grants from the National Science Foundation, PureVision Technology, Inc., of Ft. Lupton, Colorado, (PureVision), is one of the U.S. firms leading R&D efforts to recover and produce bioproducts from biomass including agricultural residues, wood waste, municipal solid waste, and manure. These

"waste streams" have the potential for producing ethanol and other high-end industrial chemicals, pulps, bioplastics, textiles, building products, and pharmaceuticals. The company is currently installing a continuous pilot plant at the Western Research Institute bioprocessing laboratory in Laramie, Wyoming. Beginning in 2005, PureVision will be in a position to develop commercial biorefineries using its technology and processes. PureVision and its development team expect to begin constructing commercial biorefineries during 2006. A 10.8 million gallon facility for the production of ethanol would employ an estimated 24 people (Focus Group/Survey 2003).

Weaknesses

Current issues for Western Slope producers of coal are the high costs of rail transportation and (in some areas) the lack of rail access. In addition, profitable development of new coal reserve areas may depend on the feasibility of constructing a coal-fired power plant on site; a solution which is constrained by the availability of transmission lines. Also coal methane natural gas development is affected by the need to ensure that water aquifers are not contaminated when water is removed from the drill site and returned to another fissure. One strategy would be to leave the gas in place for the future when it will command a higher price due to dwindling reserves in world markets; however, natural gas from coal methane creates jobs that are needed in these areas now (Focus group/Survey 2003).

Proponents of RE development in Colorado urge changes in state policy to help provide market guarantees for renewable power. An established guaranteed purchase of electricity supplied from renewable sources (a renewable energy standard) would help attract the initial capital investment for RE commercial facility costs. In addition, state tax incentives to customers installing off-grid RE generation equipment would stimulate market demand for residential and commercial site applications. At the same time, these distributed energy applications reduce total energy demand from the grid enabling utility companies to meet peak demands without investment in new power plants and the higher utility rates required to support these investments (Focus group/Survey 2003).

Such policy changes in Texas, Minnesota, and Iowa are driving the development of wind energy to benefit the economies of these states. For example, a renewable energy purchasing standard in Texas allows new wind farms to produce power at less than three cents per kWh, competitive with fossil fuel generated power and low natural gas prices. Policy changes that could boost this industry include:

- Renewable energy purchase requirements (renewable energy standard)ensuring that a certain amount (i.e. more than half of new demand) for electricity generation will be met with renewable sources;
- Tax incentives for wind farm construction or manufacturing to reduce the high initial capital costs;
- Public Benefit Fund - A small service charge on utility bills to raise funds to support research, development, promotion, and other activities to grow the RE industry and retain more energy dollars in Colorado (Madsen 2002).

According to a recent report by the Council of State Governments, the most popular tools states are using to stimulate their renewable energy industry are renewable portfolio standards and public benefit funds (PBFs). Currently, 15 states have some form of renewable energy fund to support industry development, while12 have enacted a renewable portfolio standard. PBFs are pools of money created from a very small mandatory fraction (hundredths or thousandths per penny) charged to residential, commercial, and industrial utility bills to support renewable energy projects, new technologies, promotion of renewable or energy efficiency initiatives, funding for research and development, low-income energy programs, rebates for installation of renewable energy or energy efficiency equipment, as well as rebates for purchase of green power. These programs have the effect of offsetting initial capital costs of investments in renewable equipment and stimulating market demand that will create economies of scale and lower future costs to more competitive levels (Hopkins 2003c).

States establish Renewable Energy Standards by either mandating a specific percentage of generation or sales from renewables as an ongoing standard or to phase in such a requirement over a period of years. Qualifying renewable energy sources can be specific or include anything from wind energy to biomass to solar, depending upon the state's renewable resources. The idea is to create new markets for renewable energy that will help reduce market barriers and create a more level playing field for renewable sources to compete with conventional energy suppliers (Hopkins 2003d).

Similar state legislation and policy changes would allow Colorado to compete with other states in the renewable energy field. The Union of Concerned Scientists (UCS) report on states support of renewable energy awarded Colorado an "F". This rating was given to 34 states that have no supporting state policies, yet have the potential to generate between two and 200 times their current electricity needs from renewable resources. California and Nevada received an "A-," while New Mexico, Massachusetts, and Minnesota received a "B." The UCS report also placed Colorado in the "most likely to improve" category based on fairly strong support for a renewable energy standard in the legislature in 2002 and 2003 (Union 2003).

In the 2002 and 2003 Colorado legislative sessions, bills to establish a renewable energy standard were introduced. In 2002, the RES bill passed both the Senate and House, but failed to get calendared for a concurrence vote in the Senate before the final gavel on adjournment day. In 2003, RES legislation passed the House by a 2-1 margin, but was defeated in Senate committee. Proponents cited rural economic development benefits, and stabilization of electric power prices for consumers, while opponents successfully cited outdated stereotypes of renewable energy, such as cost and "unreliability," to defeat the legislation (New Energy Technologies 2003).

One reason Colorado doesn't have an ethanol plant is the metrics used in determining the economic feasibility of facilities to produce ethanol from corn. Feasibility studies of biomass to ethanol facilities consider the subsidies offered by other states, and currently Colorado gives no subsidies, so there is more profit in building elsewhere. In addition,

the studies cite the cost of corn per bushel as a primary determinant, and use the cost of buying the corn out of state versus paying 10 cents a bushel more for Colorado produced corn. It has been suggested that if these studies considered the economic multiplier benefits of keeping money in the community by buying Colorado grain, at a slightly higher price, the economics could show the value of supporting a Colorado ethanol plant. State policies, tax incentives and the like, could help Colorado be competitive with states like Wyoming (Focus Group/Survey 2003).

Summary

Colorado has a long history as an energy state based on coal, natural gas, and petroleum extraction industries. These energy resources are expected to continue to provide jobs and economic benefit for counties where resources exist, extraction is cost effective, and transportation is available, as well as for communities near transmission lines where power plants are based. Political interests, such as recent steps to increase "energy security" through development of new domestic resource areas, will affect supply with attendant economic fluctuations.

The cost of electricity impacts every economic sector. The cost of electricity from newly commissioned power plants that utilize fossil fuels is increasing due to higher capital costs and increasing or fluctuating price of natural gas and imported oil. As a net importer of electricity, Colorado has future opportunity to keep more of its energy dollars in the state by developing renewable energy power sources. Renewable energy from wind and from biomass crops and cellulose wastes (agricultural residues and forest trimming) is becoming cost competitive with electricity produced from natural gas and coal.

Counties with the highest potential to develop commercial plants to generate electricity or produce fuels from wind or biomass resources are: Morgan, Larimer, Weld, Las Animas, Logan, Sedgwick, Phillips, Washington, Yuma, Kit Carson, Cheyenne, Lincoln, Kiowa, Prowers, El Paso, Las Animas, and Baca. It may be feasible for other counties on the eastern plains, as well as Mesa, La Plata, and other central mountain and Western Slope counties to develop smaller scale, local, off-grid, community level electricity or biofuel production from forest or agricultural crops and waste streams.

As with any large utility project, the primary barriers for renewable energy development are upfront costs of determining feasibility, and the initial capital investment required for large wind farms. In some areas, the cost of connecting to transmission lines is an additional barrier. Development of smaller, community-based projects where energy is utilized locally could help overcome these financing and transmission barriers and keep more of the economic benefits in the community.

Within 5 to 10 years, ethanol and biodiesel will not only be produced from corn and oil seeds, but from agricultural residues and manure. Development of ethanol and biodiesel facilities create markets for higher-value crops that can be grown in many rural areas of the state and increase profits by using wastes generated by farms, dairies, and feedlots. In addition, these facilities could create a future capability to produce industrial chemicals

and other high-value products as newer technologies are deployed over the coming decade.

As with any industrial development activity, state policies and incentives comparable with those of other states could significantly affect Colorado's ability to compete and could ultimately determine whether the state will realize the rural economic development potential from renewable energy and fuels. A renewable energy standard is one basic policy that could be adopted without state financing.

Some states are making investments toward creating a competitive advantage in the future economic growth potential of industries based in fuel cells and energy from hydrogen. Colorado has recently formed the Colorado Energy Research Institute (CERI), involving Colorado School of Mines, Colorado Office of Energy Management and Conservation and Gas Technology Institute, to conduct advanced research in hydrogen and fuel cell technologies. In the near term, CERI is expected to impact the economy by attracting additional research funding. In the long term, this research could result in new spin-off companies establishing in the state. As these technologies still need significant development, the economic potential and return on investment cannot be quantified nor is a significant economic impact anticipated within 10 years.

Although most individuals involved in the study, encouraged support of local companies rather than providing incentives to attract and import companies, some opportunities may exist to attract manufacturers of wind turbines, or out-of-state companies that currently supply the coal mining, natural gas or petroleum industries (Focus Group/Survey 2003).

BIBLIOGRAPHY

American Wind Energy Association (2003). "U.S. Wind Industry on Track to Grow More than 25% in 2003." AWEA News Release, May 8. <http://www.awea.org/news/news030508gro.html> June 2.

Biobased Fuels, Power and Products Newsletter (2003). "Biomass R&D Technical Advisory Committee and Interagency Board Hold First-Every Joint Meeting," April 4.

Colorado Mining Association (2003). "Facts about Mining in the United States." <http://www.coloradomining.org/colomining.html> June 25.

Colorado Petroleum Association (2000). "Colorado Oil and Gas Industry – Facts and Figures." <http://www.coloradopetroleumassociation.org/facts.htm> June 25, 2003.

EERE Network News (2003). Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy, May 21. <http://www.eere.energy.gov/>

Energy Information Administration (2003). "International Energy Outlook 2003." EIA Reports, May 1. <http://www.eia.doe.gov/oiaf/ieo/index.html> May 5.

Environmental Business Journal (2002). "Industry Overview 2002." Vol. 14, no. 7/8, 2.

Focus Group/Survey (2003). Energy and Environment focus group and survey conducted in July.

Hopkins, Barry (2003a). "Renewable Energy and State Economies." *TrendsAlert, Critical Information for State Decision-Makers*. Council of State Governments. May, p. 9. <http://www.csg.org/CSG/Policy/infrastructure/renewable+energy+and+state+economies.htm> August 6.

_____ (2003b). P. 28.

_____ (2003c). Pp. 7, 30.

_____ (2003d). Pg. 32.

_____ (2003e). Pp. 19-21.

Madsen, Travis, S. Bonin, and M. Baker (2002). "Wind Energy: Powering Economic Development for Colorado." November. Colorado Public Interest Research Foundation. <http://environmentcolorado.org/envcoenergy.htm> May 1, 2003.

Makower, Joel, R. Pernick, and C. Wilder (2003). "Clean Energy Trends 2003." Clean Edge, Inc. <http://www.cleanedge.com> June 30.

National Renewable Energy Laboratory (NREL) (2003). "NREL Research Team Wins R&D 100 Awards." National Renewable Energy Laboratory. NREL News and Information Service, press release, September 12.

New Energy Technologies (2003). "Colorado: Renewable Energy Standard Legislation." <http://www.newenergytechnologies.org/colorado/news/2003-04-28.htm>

Nielsen, John; S. Innis, L. Pollock, H. Rhoads-Weaver, and A. Shutak (2002a). *Energy Atlas of the West: A Guide to the Region's Resource Potential."* Land and Water Fund of the Rockies and Northwest Sustainable Energy for Economic Development, July.

_____(2002b). *"Energy Atlas of the West: A Guide to the Region's Resource Potential."* Land and Water Fund of the Rockies and Northwest Sustainable Energy for Economic Development, July. Pg. 22.

Potter, Tom (2003). "Bioenergy for Rural Empowerment." *In Business*, March/April, p. 22.

Public Utilities Commission (2001). <http://www.dora.state.co.us/puc/decisions/2001/CO1-0295_99A-549E_PHASEII.pdf>

Renewable Fuels Association (RFA) (2003a). "Ethanol Industry Outlook 2003." <http://www.ethanolrfa.org/outlook2003.shtml> June 3.

_____(2003b). Pg. 12.

_____ (2003c). Pg. 15.

_____ (2003d), Pp. 3, 8.

Union of Concerned Scientists (2003). "Handful of States Lead U.S. in Prospecting for Renewable Energy." <http://www.ucsusa.org/news.cfm?newsID=343> June 30.

U.S. Aggregates (2002). "2002 U.S. Construction Aggregates, Sold or Used by Producers." <http://www.aggregatemarket.com/agg02dat.htm> June 25, 2003.

U.S. Department of Energy (2003). "The Department of Energy Strategic Plan – Protecting National, Energy, and Economic Security with Advanced Science and Technology and Ensuring Environmental Cleanup." August, pp. 13-19. <http://strategicplan.doe.gov/Draft%20SP.pdf> August 20.

Wind Energy Weekly (2003). "Xcel Energy Selects Three Wind Projects for All-Source Bid." Vol. 22, no. 1049, June 27.

Zugel, Marianne (2002a). "Clean Energy Solutions." Colorado Public Interest Research Foundation, February, pp 29-31.

_____ (2002b). "Clean Energy Solutions." Colorado Public Interest Research Foundation, February, p. 18.

TRANSPORTATION

There are two roles that the transportation industry plays in the development of communities. One is the infrastructure provided by transportation modes, such as air, bus, rail, and highway systems, which contribute to the efficiency of doing business in a certain area. A good transportation infrastructure will make it easier to transport raw materials and finished products, and to commute and do business, consequently drawing companies to the area and strengthening other industry sectors. The other role transportation plays is the employment growth specifically of transportation jobs. In the United States during 2002 there were over 4.2 million jobs alone in the transportation industry. This demand for jobs in air, rail, trucking and other transportation sectors contributes to the overall strength of the national and local economy.

The Transportation and Warehousing sector is broken down by the North American Industrial Classification System (NAICS) into smaller, more specific industries. These industries include transportation of passengers and cargo, warehousing and storage, sightseeing transportation, and transportation-related activities making up the NAICS codes 48 and 49 (see chart below).

From 1993 to 2002 the compound annual growth rate (CAGR) for transportation jobs in the United States was 1.9%. The largest sector, trucking transportation, had a similar CAGR of 1.7% and made up almost 32% of all transportation employment. The sectors with the strongest growth included transportation support, couriers and messengers, sightseeing transportation, transit and ground passenger, and warehousing and storage. The only sectors showing negative growth for the same time period were water, rail, and pipeline.

U.S. TRANSPORTATION EMPLOYMENT TRENDS

NAICS	Description	2002 Employment (in thousands)	CAGR vs 1993	% of Total 2002 T&W
488	Support Activities for Transportation	526.7	3.6%	12.5%
491/492	Couriers and Messengers	558.0	3.4	13.3
487	Scenic and Sightseeing Transportation	25.9	3.3	0.6
485	Transit and Ground Passenger Transportation	371.5	2.4	8.8
493	Warehousing and Storage	513.6	2.4	12.2
484	Truck Transportation	1,339.1	1.7	31.8
481	Air Transportation	559.3	0.9	13.3
483	Water Transportation	51.6	-0.3	1.2
482	Rail Transportation	218.1	-1.2	5.2
486	Pipeline Transportation	41.5	-3.8	1.0
	Total	4,205.3	1.9%	100.0%

Source: U.S. Department of Labor, Bureau of Labor Statistics

Slightly higher than national transportation employment, Colorado's employment grew by 2.2% (CAGR) for the same time period. Total transportation jobs in the state increased to 66.2 thousand. Warehousing and storage had the largest increase (5.1%), while air transportation was the only area showing a decrease.

COLORADO TRANSPORTATION EMPLOYMENT TRENDS

NAICS	Description	2002 Employment (in thousands)	CAGR vs 1993	% of Total 2002 T&W
493	Warehousing and Storage	8.6	5.1%	13.0%
482,483, 485, 486, 487, 488	Other Transportation	16.8	4.1	25.4
491/492	Couriers and Messengers	9.6	4.1	14.5
484	Truck Transportation	16.9	1.2	25.5
481	Air Transportation	14.3	-0.9	21.6
	TOTAL	66.2	2.2%	100.0%

Source: U.S. Department of Labor., Bureau of Labor Statistics

As shown in the table below, trucking makes up over 57% of the establishments in the transportation industry. While they do not have the highest wages in the industry, $34,320 compared to the average transportation salary of $37,808, trucking leads the employment and wage categories, providing 25% of the transportation jobs and 28% of the total wages for the industry.

48-49 NATIONAL TRANSPORTATION AND WAREHOUSING 2002

NAICS	Description	Employment	Wages (thousands)	Avg. Wages	Establishments
481	Air Transportation	615,994	$31,943,714	$51,857	6,086
482	Rail Transportation	318	12,023	37,808	49
483	Water Transportation	54,885	2,859,165	52,094	1,410
484	Truck Transportation	1,383,016	47,464,843	34,320	113,709
485	Transit and Ground Passenger Transportation	591,110	17,037,237	28,822	18,726
486	Pipeline Transportation	46,665	4,311,437	92,391	2,622
487	Scenic and Sightseeing Transportation	32,097	714,853	22,272	3,124
488	Support Activities for Transportation	205,202	8,543,051	41,632	6,822
491	Postal Service	871,707	36,794,750	42,210	18,834
492	Couriers and Messengers	596,899	19,125,019	32,041	14,533
493	Warehousing and Storage	517,631	16,617,433	32,103	12,992
	Total	5,336,691	$201,771,558	$37,808	231,248

Source: ES202b

Similar to the national industry, trucking makes up 55% of the transportation establishments in the state. A trucker's salary in Colorado is slightly less than the national average, but the average salary for transportation jobs overall is slightly higher in Colorado due to the highest paying sectors, air transportation and pipeline transportation, having higher salaries in the state than the national average.

48-49 COLORADO TRANSPORTATION AND WAREHOUSING 2002

NAICS	Description	Employment	Wages (thousands)	Avg. Wages	Establishments
481	Air Transportation	14,235	$792,305	$55,659	121
482	Rail Transportation	D			
483	Water Transportation	D			
484	Truck Transportation	16,870	572,269	33,922	1,875
485	Transit and Ground Passenger Transportation	4,292	102,478	23,877	185
486	Pipeline Transportation	807	75,450	93,495	48
487	Scenic and Sightseeing Transportation	345	7,206	20,887	30
488	Support Activities for Transportation	6,849	228,301	33,333	586
491	Postal Service	77	1,548	20,109	23
492	Couriers and Messengers	9,689	294,288	30,373	308
493	Warehousing and Storage	8,649	302,084	34,927	230
	Total	61,834	$2,376,641	$38,436	3,409

Source: ES202a. D- Disclosure of data. Publication of employment and wage data is withheld for any 2-digit subsection which consists of fewer than three reporting units or in which a single establishment accounts for 80% or more of an industry's employment. In the event that only one 2-digit subsection is restricted, the next smallest 2-digit subsection (by number of establishments) will also be restricted to allow disclosure of total industry information.

Each major sector in the transportation industry will be discussed separately in the following pages: 481- Air Transportation, 484 & 491 - Trucking and Warehousing, 482 - Rail Transportation, and 485 - Transit and Ground Passenger Transportation.

NAICS SECTOR 481 – AIR TRANSPORTATION

World Market Size and Expected Growth

According to the International Air Transport Association (IATA), the total economic output of the air transport industry is over $1.3 trillion (Aerospace and Aviation n.d.). Industry yields for both cargo and passenger services have steadily declined since 1970 due to airline productivity gains, technical improvements, and intensifying competition (Boeing 2002b). Boeing estimates that airlines will invest a total of $1.8 trillion in new commercial airplanes by 2021, doubling the world fleet to almost 33,000 jets (Boeing 2002a).

For the first half of 2003, overall passenger traffic was 7.1% below 2002 levels. Asia Pacific Carriers saw the largest decrease in traffic, down 15.6% from June 2002, possibly due to the effects of Severe Acute Respiratory Syndrome (SARS). However, even with this decrease, China's air traffic market is expected to be the largest commercial aviation market outside the United States over the next 20 years, growing at an average annual rate of 9% (Boeing 2002a).

Following the worst decline in history of the air cargo industry during 2001, world air cargo traffic is expected to more than triple over the next 20 years, increasing from 131.1 revenue tonne-kilometers (RTKs) in 2001 to over 464 billion RTKs in 2021. The U.S. share of the world market, currently 30.4%, will decline to 26.1% by year-end 2021 (Boeing 2002b). Freight traffic during the first half of 2003 showed 7.3% growth

globally, due to strong growth in North America (11.1%), Asia-Pacific (8.7%), and the Middle East (13.7%) (International Air Transport Association 2003).

National Market Size, Trends, and Expected Growth

The air transportation industry includes any aviation activities at commercial service, reliever, and general aviation airports throughout the country. Commercial service airports provide scheduled airline service on commercial airlines connecting major cities throughout the country and world. Reliever airports do not have scheduled airline service, but alleviate airspace congestion and operation levels at nearby commercial service airports. Airports devoted to general aviation use harbor the majority of based aircraft, and dominate in terms of total aircraft operations (Colorado Aeronautics Division 2002).

In 2000, the air transportation industry provided nearly 1.3 million wage and salary jobs in the United States, with a projected 24.9% increase by 2010, compared to a 16% increase for all industries combined. Almost 9 out of 10 air transportation jobs are found in companies with 50 or more workers (Bureau of Labor Statistics 2002-03b).

The FAA is projecting a 23.5% increase in towered-airport operations, and a steady increase in passenger enplanements and operations by the airlines, averaging 4% annually until the year 2013 (*Mountain Wave* 2002). More than 19.2 million passengers are projected to board planes nationwide during 2020, up from 14.8 million in 2001 (Federal Aviation Administration 2002). During 2003 the FAA projects boardings will climb by 14%, after a 12% decline in 2002 (*Mountain Wave* 2002).

According to the Aircraft Owners and Pilots Association, strong quarterly growth was found among issuance of student certificates (up 11%), private certificates (up 34%), and commercials up 18%, with a total of 3,280 commercial certificates issued.

Total aircraft registrations for Q3 2002 reached 14,133, but fell slightly behind 2001 (420 less, down 3%). Year-to-date figures present a slightly different scenario through an increase of 4% (1,640), suggesting stronger growth in the first two quarters of 2002 (Aircraft Owners and Pilots Association 2003).

According to the Air Transport Association, since the start of deregulation in 1979 the volume of airline travel has increased, average fares have decreased, safety has improved, flight operations are quieter, fuel efficiency has risen steadily, and customer service has improved considerably. The consumer price index increased 2.7 times from 65.2 in 1978 to 177.1 in 2001. In contrast, the price per mile for air travel increased only 1.6 times domestic and 1.3 times international for the same time period, significantly lower than the inflation of items such as the cost of housing and college tuition. While the volume of airline travel has increased, technology and deregulation have improved the efficiency of the industry. The average passenger load factor (PLF) between 1961 and 1970 was 53.2%. This increased to 70.8% for the time period of 2001 through 2002. With the rising number of departures, safety has continued to improve among U.S. airlines. Less than 0.5 fatal accidents per million departures occurred in 2002 (Heimlich 2003).

The hub-and-spoke airline structure established after airline deregulation made it possible for one airport to serve as a collection point for traffic, where aircraft from numerous points of origin arrive, exchange passengers, then depart again to numerous destinations. This system was a great innovation and increased the number of city pairs an airline can serve with a given number of flights, but is no longer economically sustainable because it has become so complex that it is too hard to generate profits. Low-cost carriers such as Southwest Airlines and Frontier Airlines are prospering by exploiting the huge cost-of-operations advantage they have over the large airlines (Hansson, Ringbeck, and Franke 2002). During 2002 Southwest Airlines spent 7.41 cents per available seat mile, while United Airlines spent 11.40 cents per available seat mile (Heimlich 2003).

Colorado Market Size and Expected Growth

Currently, there are 78 airports operating throughout Colorado: 13 commercial service and 65 general aviation, including 4 reliever airports. These airports employed a total of 14,300 people in 2002, a slight decrease since 1993 (-0.9% CAGR). In a study conducted in 2003 by the Colorado Department of Transportation Aeronautics Division, the annual economic activity of Colorado's public-use airports totaled $23.5 billion. Of this total, $9.8 billion is paid in the form of wages (earnings) to the 280,156 jobs that are directly or indirectly dependent on the airports (Colorado Department of Transportation 2003).

Commercial enplanements (the head count of every passenger boarding a commercial aircraft at a Colorado airport) have increased at a rate of 5.3% since 1988, compared to the national average for the same period of 3.1%. Growth in aircraft operations (an operation is counted every time an aircraft takes off or lands at a Colorado airport) is expected to increase from 2.2 million to 2.7 million by 2018 (*SW Aviator* 2000).

Denver International Airport (DIA) currently has 23 airlines providing nonstop daily service to 130 national and international destinations (*WingTips* 2003a). The total number of enplaned passengers at DIA during 2002 was 35.7 million, a 1.2% decrease from 2001. More recently, enplanements show and upward trend with 25.2 million passengers year-to-date as of August 2003, up 3.0% from August 2002 (Denver International Airport 2003c). The trend is reversed at the Colorado Springs Municipal Airport, with enplaned passengers in 2002 at 1.1 million, a .2% increase from 2001. As of August 2003, however, the number of enplaned passengers year-to-date totaled 685,721, a 7.0% decrease from the same month in 2002 (Colorado Springs Municipal Airport 2003).

<u>Colorado Industry Leaders (Firms/Market Share)</u>

United Airlines is currently DIA's largest carrier, with 51.63% of the market share year-to-date as of August 2003. Frontier has 12.79% market share, a 30.5% increase from last year and is currently looking to expand either in Denver or another airport if the space is not made available at DIA (Denver International Airport 2003). In November, a compromise agreement was reached between DIA, the City of Denver, and the two major carriers, ending disputes over expansion plans and gate assignments. The deal provides Frontier with the 16 gates it wants by next spring and enough long-term gates to pursue

its growth plan. United will receive expansion gates on Concourse B for itself and its regional partners. The plan is expected to increase competition, provide more flight choices and result in lower fares for consumers (Patty 2003).

The three top airlines at Colorado Springs Municipal Airport include United (30%), American (21%), and Delta (18%), making up 69% of the total airport market share in 2002 (Colorado Springs Airport 2002).

Growth Opportunities

New Technology Developments

As more consumers and businesses make purchases over the Internet, the growth of electronic commerce will continue to increase demand for cargo transportation. However, communication technologies such as fax machines, computer networks, e-mail, and teleconferencing have somewhat reduced the need for business travel and transport of documents by mail (Bureau of Labor Statistics 2002-03b). While it is highly unlikely that electronic transmission will completely replace express documents and parcel services, recent lower growth rates of both U.S. domestic and international express shipment traffic are evidence that the Internet and e-mail are having an impact on this high-yielding air cargo traffic due to their ease of use and lower cost (Boeing 2002b).

Industry Segment Growth Projections

Air cargo is a significant portion of airline activity at DIA, with 10 cargo airlines and 19 major and national airlines providing cargo service to the Denver area through DIA. Air cargo volume decreased at DIA by 4.1% in August 2003 (YTD) compared to August the previous year but is slated for a strong recovery in the next two years because of worldwide cargo growth led by the United States and China. In early 2003 Denver city officials traveled to China to meet with cargo and passenger carriers to pursue the establishment of nonstop air service to Denver. With the longest commercial runway in North America opening at DIA in September, it will be possible for fully loaded flights from Asia to fly nonstop into Denver. Ike Serna, Denver Air Cargo Association (DACA) President, estimates that an Asian cargo carrier to Denver could save shippers up to three days in transit time for inbound cargo (*WingTips* 2003b). FedEx Express, the largest cargo carrier at DIA, employs 280 workers at the airport and is doubling the size of its facility, which will also double the sorting capability. The Asia Pacific region, led by China, is the fastest-growing international market at FedEx, with 11 flights per week through the major gateways of Beijing, Shanghai, and Shenzen (*WingTips* 2003c).

Location Requirements

Infrastructure

There needs to be a sufficient amount of airports distributed throughout the state based on the population and land area. These airports provide services for commercial, general aviation, cargo, and military aircraft. Airports are typically concentrated in areas of high

population or with strong industries such as tourism or manufacturing, and located near major highways. DIA and Colorado Springs Municipal Airport are both located in the highest population areas in the state, providing mostly commercial and cargo service. Along with DIA, Front Range Airport is located near Adams County and the intersection of I25 and I70 where the state's highest number of industrial and manufacturing companies are located, making it easily accessible for cargo transport. Smaller commercial airports like Eagle County Airport, and Aspen/Pitkin County Airport are supported mostly by tourists and skiers and have continued to increase the number of flights. General aviation airports like Centennial Airport and Jefferson County Airport are located in areas with a high concentration of businesses nearby. While these airports do not offer scheduled commercial service some companies find it more cost efficient to have their own planes based at these airports for quick individual service.

Colorado Competitive Position

In 2002, Airports Council International (ACI) ranked DIA as the 10th-busiest airport in the world and the 5th-busiest in North America, maintaining its 2001 rankings. With 35.7 million total passengers in 2001 DIA trailed only Atlanta (76.9 million), Chicago (66.6 million), Los Angeles (56.2 million), and Dallas/Fort Worth (52.8 million) nationally (Airports Council International 2003).

Strengths

One of Colorado's main strengths in the air transportation industry is its central location, which makes it a hub for the east/west flow of domestic traffic. The close proximity of DIA to the intersection of I-25 and I-70 improves the efficiency of cargo movement to trucking and rail lines. The lack of competing airports within a 500-mile radius is also an advantage. DIA is an ideal location for regional jet activity, which has experienced a 120% increase in the number of weekly regional jet flights between December 2001 and December 2002 (*WingTips* 2003d).

DIA has excellent airfield efficiency and more than 50 square miles of surrounding land for future growth. A sixth runway finished in June is the longest commercial runway in North America (16,000 feet) and went into service in early September (Denver International Airport 2003). The $166 million runway will allow airlines to complete 40 more landings per hour at DIA in good weather and about 30 more in bad weather, reducing delays. At 4,000 feet longer than DIA's other runways, the new runway will help attract international carriers and passengers to Denver, by breaking the technical barrier to fully loaded nonstop flights between Denver and Asia.

Weaknesses and Barriers

The performance of the local, national, and global economies directly affects how the transportation industry performs. During economic down times, less goods need to be transported and fewer people travel, decreasing the demand for all means of transportation.

As more manufacturing companies relocate overseas, the manufacturing sector is not the only one suffering. The loss of these companies in Colorado has caused cargo transportation to decline. Colorado could support the transportation industry by encouraging manufacturers to come to the state and stay here by offering incentives and making Colorado more competitive in this industry (Focus Group/Survey 2003).

Another barrier to growth in the air transport industry is the higher costs of doing business here. For example, the landing fees, land lease rates, and taxi times at DIA for cargo planes are the highest in the industry. In addition, a 3.5% surcharge on maintenance spare parts (that no other hub airport in the United States has), prevents airline maintenance facilities from locating at DIA, and a high state tax on business real property and equipment, including flight simulators, discourages airline training facilities (Focus Group/Survey 2003).

Political turf issues also get in the way of bringing interested air operations to the metro area. The area would have more success if the state, cities and airports involved had a consistent message and growth plan (Focus Group/Survey 2003).

DIA is the newest airport in the United States, but also carries one of heaviest debt loads in the country. This is caused by a number of circumstances including, a $4 billion debt to get the airport off the ground eight years ago, the bankruptcy of its major carrier, United Airlines, and the worst downturn in U.S. commercial-aviation history. The airport's debt-per-passenger ratio ($229.00 per passenger) is second only to that of San Francisco International Airport, and far higher than the nation's average of $70 per passenger (Kesmodel, Milstead, and Draper 2003).

While security at commercial airports has increased tremendously since September 11, 2001, minimal changes have been made at the nation's general aviation airports. General aviation is more open and potentially vulnerable to terrorist actions than commercial aviation, but the question remains if the level of damage would be sufficient for the purposes of terrorists. The cost to apply increased, government-mandated security at thousands of urban and rural airports across the country would be enormous and of questionable value. Some airports have invested in their own security precautions though, including Centennial Airport in Arapahoe County. The airport along with companies operating there have spent more than $2 million on fencing, smart gates, cameras and other equipment in the last two years (Griffin 2003).

While numerous airlines fly into the large commercial airports in the state, the smaller airports with only a few scheduled flights suffer if there is not competition from more than one airline. Many small airports in rural areas and mountain towns throughout Colorado have been hit hard by airlines cutting back in the economic downturn. Once competing airlines leave these airports it allows one airline to have a monopoly on the small market, increasing prices and making it impractical for people to use the airport (Focus Group/Survey 2003).

The average one-way fare out of DIA during the fourth quarter of 2002 was $178, down from $202 in the same period of 2001. DIA fell from the 6th highest fares to 12th. A number of factors have contributed to DIA's high fares, including its location far from other large cities creating more long-haul flights that tend to cost more. It has a dominant full-service hub carrier which decreases competition in fares among the airlines, and the carriers at DIA have to deal with repaying debt and operating costs of the nation's newest airport (Kesmodel 2003).

NAICS SECTORS 484 AND 493 TRUCKING AND WAREHOUSING

World Market Size, Trends, and Expected Growth

International trucking between the United States and its North American Free Trade Agreement partners, Canada and Mexico, accounted for more than $397.8 billion during 2002. Freight transported by truck between the United States and Canada during 2002 totaled in value of $236.2 billion. Trucking between the United States and Mexico valued $161.5 billion for the same time period (Bureau of Transportation Statistics 2002). In September 2003, U.S. Transportation Secretary Norman Mineta announced $46.7 million in grants to help ensure the safe operation of Mexican commercial motor vehicles that operate in the United States and to help improve traffic flow at U.S.-Mexico border crossings through construction and improvement to the facilities in the four states bordering Mexico (U.S. Department of Transportation 2003).

National Market Size, Trends, and Expected Growth

The trucking and warehousing industry provided more than 1.8 million wage and salary jobs in 2000, in addition to an estimated 289,000 self-employed workers in the industry. Three out of four of these employees work in small establishments that employ fewer than 10 workers. The number of wage and salary jobs in the industry is expected to grow 22% from 2000 through 2010, compared with projected growth of 16% for all industries combined (Bureau of Labor Statistics 2002-03a).

A total of 8.9 billion tons of freight was hauled by trucks in the United States in 2002, or 67.9% of all tonnage carried by all modes of domestic freight transportation. Motor carriers collected $585 billion or 87% of total revenue earned by all transport modes. American Trucking Associations' seasonally adjusted Truck Tonnage Index decreased 9.5%, to 140.3 (1993=100), in August 2003 more than erasing the increases in June and July. Compared to August 2002, the unadjusted index fell by 2.1%. Economists expected the low number because of manufacturing production decreases, the blackout on the east coast and the low level of retail sales, but remain confident that truck tonnage is on a recovery path (American Trucking Association 2003a).

According to American Trucking Associations' U.S. Freight Transportation Forecast to 2014, the trucking industry will continue to dominate domestic freight transportation modes, increasing to 68.2% its share of all freight tonnage moved throughout the United States by 2008 (American Trucking Association 2003c).

There were more than 15,000 public warehousing and storage facilities throughout the country in 2000. These firms were primarily engaged in operating warehouse and storage facilities for general merchandise and refrigerated goods, along with providing self-storage mini-warehouses that rent to the general public (Bureau of Labor Statistics 2002-03a).

Colorado Market Size, Trends, and Expected Growth

Trucking employed 16,870 people in Colorado during 2002, paying over $572.3 million in total salaries, or an average of over $33,922 for each employee (ES202). Colorado truck operators pay over a quarter of a billion dollars in state and federal taxes and fees. Trucks transport 456,772 tons of essential manufactured goods in Colorado each day, moving 90% of all manufactured products in the state. Eighty-one percent of all Colorado communities are solely served by truck for their freight needs (Colorado Motor Carriers Association 2001).

Warehousing and storage employed 8,600 people in Colorado during 2002, and had the highest compound annual growth rate (5.1%) since 1993 of any transportation sector in the state. These jobs accounted for 13% of the transportation jobs in Colorado, with a high concentration of the employment in Adams County, almost 20%.

New tractor emissions are over eight times cleaner than a 1988 truck, which has led the Colorado Motor Carriers Association (CMCA) to offer incentives making it beneficial for drivers to operate cleaner burning vehicles. CMCA has worked with other business and environmental groups to establish a series of attractive incentives for cleaner burning vehicles that include tax credits, a sales tax exemption for low emission vehicles, and access to the HOV lanes for inherently low emission vehicles (ILEV) (Colorado Motor Carriers Association 2001).

<u>Colorado Industry Leaders (Firms/Market Share)</u>

The top trucking companies with operations in Colorado based on number of employees are Bullocks Express Transportation Inc., Graebel Co., North Park Transportation Co., Roadway Express Inc., Trans Montaigne Inc., and Yellow Transportation (ReferenceUSA 2003).

ProLogis, a leading provider of global distribution facilities and services, is headquartered in Denver. They have 226.7 million square feet in 1,728 distribution facilities owned, managed and under development in 90 markets throughout North America, Europe, and Asia (ProLogis 2003). The Denver headquarters is located northeast of Denver, off I-70, and creates almost 100 jobs in the area (ReferenceUSA 2003).

Growth Opportunities

An intermodal facility is being developed near Front Range Airport in Adams County that is aimed to enhance the trucking, air cargo, and rail industries in Colorado. TransPort

is being developed as a reflection of the Perot Development in Texas. The planners hope to provide these three modes of transportation all in one location, making it easy to access and cut down on costs for cargo transportation. Alliance Texas, the intermodal park opened in 1989, currently has over 20 million square feet of buildings, and generates $147 million in property tax and 18,000 jobs. TransPort will bring together air cargo from Front Range Airport and DIA, rail lines that will eventually be diverted around the metro area, and trucks from I-70, I-25, and I-76 that all intersect nearby. The potential of this type of intermodal facility is to attract business from the coasts for distribution through Denver. For example, containerized shipments could be cost effectively picked up from ports and trucked to Denver, then opened and distributed throughout the region (Focus Group/Survey 2003).

The location of major highways throughout the state contributes to the strength of the state and local economies not only through the expansion of the trucking industry, but by increasing potential business near the major highways. Julie Bender, president of the DIA Partnership, said the new $250 million Southland regional mall in Aurora demonstrates the "powerful effect" of the E-470 toll road (Rebchook 2003). While the Denver area benefits from the presence of interstate highways, rural and small communities would also benefit from the expansion of existing highways and addition of new highways. Highway 50 between Grand Junction and Delta was recently expanded to four lanes resulting in the possibility of companies relocating to the area and the development of a new business park (Focus Group/Survey 2003).

Colorado will also experience future growth from the Ports-to-Plains Trade Corridor, a planned four-lane divided highway for transport of goods and people from Mexico through west Texas to Denver. The project will use U.S. 287 boosting economies in the eastern plains communities of Lamar, Kit Carson and Limon, along the way (Ports to Plains 2003).

New Technology Developments

As more consumers and businesses make purchases over the Internet, the growth of electronic commerce will continue to increase demand for the transportation and logistical services of the trucking and warehousing industry. However, the increased usage of computers and other automated equipment make workers more efficient and productive, decreasing the number of secretaries, bookkeepers, and file clerks needed (Bureau of Labor Statistics 2002-03a). Logistics provider Danzas Group introduced a paperless trading system on exports from Asia to Europe, allowing all paperwork to be transmitted electronically which cut lead-times and increased productivity throughout the company (TDC Trade n.d.).

Over the last three years, the state of Colorado and the trucking industry have worked together to introduce electronic clearance at all 11 ports of entry in the state. It is estimated that this may save the trucking industry up to $5 million annually, while the state will save by not having to increase staff or develop new facilities to address the

increasing volume of trucks on the highways (Colorado Motor Carriers Association 2001).

Location Requirements

Infrastructure

A successful trucking industry requires a location near other transportation modes and an area with strong industries. The most successful trucking industries are located in highly industrialized areas near rail lines, major highway intersections, and airports providing cargo services. Located at the crossroads of I-25, I-70, and I-76, the metro area is an obvious center for the trucking industry. Almost one third of the state's trucking employment is concentrated in Adams County and 22% of the state's total transportation employees work in Adams County (ES202 2003a). These major highway intersections providing north, south, east, and west access to the entire country have caused this area to grow into an industrial center. In addition, the location of DIA just east of Adams County, and the high concentration of industrial companies in the area increase the demand for a strong trucking industry in this area.

Labor Force

The trucking industry can be strengthened by a sufficient amount of experienced and trained drivers graduating from trucking schools to offset the amount of truckers retiring or leaving the industry. Nationwide there is a need for about 80,000 CDL drivers, but only about 35,000 drivers are being trained per year (Focus Group 2003). Historically in Colorado there has also been a shortage of people obtaining a Commercial Drivers License and pursuing a career in the truck load (TL) sector because the salaries are lower and drivers cannot return home at night. The less than truck load (LTL) sector has not experienced quite the same level of shortage because drivers can return home at night and earn a higher salary (Focus Group/Survey 2003).

Colorado Competitive Position

Trucking and warehousing establishments are located throughout the United States, with a higher concentration near major interstate highways and in heavily industrialized regions such as California, New Jersey, and Texas. With $67.3 billion worth of trucking to the nation's NAFTA partners, Texas was the top state in 2002 with the highest value of North American trade moved by truck, followed by Michigan, California, Ohio, and New York. Colorado ranked 27th overall, with a value of $2.8 billion. Denver was ranked as the 72nd trucking port city out of 203 cities in the country for North American trade (Bureau of Transportation Statistics 2002).

Strengths

Colorado's central location and presence of interstate highways makes it a main hub for the trucking industry. I-25, providing north/south access from Montana to Mexico, I-70, providing east/west access from California to Maryland, and I-76 providing access to I-80 north of the state, intersect in Denver, bringing a large amount of vehicles through the metro area each day.

Weaknesses and Barriers

One of the major weaknesses of the Colorado trucking industry is the high cost of taxes and commercial vehicle registration in the state. This has forced companies to license their trucks in neighboring states even if they are based in Colorado, causing the state to lose federal revenue that is based in part on the number of registered trucks (Focus Group/Survey 2003).

An operator of a typical five-axle tractor-trailer pays over $13,450 in state and federal transportation taxes each year. This is more than $1,200 per tractor more than the national average and over $2,000 greater per truck than for the surrounding states. Taxes and fees for Colorado trucking operators are the third highest in the country, which has led to a decline in the number of major trucking companies basing their operations within the state. Colorado truck operators pay over $500 million in state and federal taxes annually, equating to a tax bill of $9.95 million weekly (Colorado Motor Carriers Association 2001).

As previously mentioned in the air transportation section, the decline of manufacturing companies in Colorado is hurting the cargo transportation industry. With fewer manufacturers in the state, there will be fewer goods to transport to other states or countries. Colorado needs to be perceived as a good place to locate manufacturers, by offering incentives and becoming more competitive with the rest of the nation (Focus Group/Survey 2003).

Another similarity to the air transportation industry is the need for security since September 11. In September 2003, congress approved Homeland Security funding for fiscal year 2004 providing funding for a number of Transportation Security Administration programs of interest to the trucking industry. These include $22 million for the Highway Watch program, $50 million for the Transportation Worker Identification Credential, $17 million for Operation Safe Commerce and $7 million for HazMat security and truck tracking (American Trucking Association 2003b).

Like most areas of the transportation industry, trucking and warehousing is very susceptible to fluctuations in the national and local economies. As the economy grows, production and sales of goods increase, creating demand for transportation services to move goods from producers to consumers. In a recession, this industry is one of the first to slow down as orders for goods and shipments decline.

NAICS SECTOR 482 RAIL TRANSPORTATION

While rail transportation is currently a small sector in the Colorado transportation industry, it has the potential to grow into a major mode of cargo transportation. With the shortage of truck drivers, rail could become a more efficient alternative for long distance transport of bulk commodities and multiple carloads. In 2002 the states with the highest value of trade by rail to Mexico and Canada were Michigan, California, Texas, Ohio, and Illinois. Colorado ranked 33rd with $370 million worth of cargo transported by rail to Canada or Mexico (Bureau of Transportation Statistics 2002).

Currently there are only two rail lines in Colorado, Union Pacific and Burlington Northern, both operating at undersized intermodal facilities. Development of TransPort, the intermodal facility mentioned earlier, would be beneficial to both of these companies because it would allow the trains to bypass Denver which is between a four to six hour wait just to move freight through the city. The benefits of an intermodal facility northeast of town would be increased access to other modes of transportation, decrease of wait times to move freight, and the possibility of car distribution centers and manufacturers relocating to the area. With Colorado's central location, the facility could be a distribution point to the rest of the country for goods manufactured in Mexico and Canada (Focus Group/Survey 2003).

NAICS SECTOR 485 TRANSIT GROUND PASSENGER TRANSPORTATION

According to a recent study done by the Texas Transportation Institute, Denver drivers spent 64 hours waiting in traffic during 2001, the third highest in the country, significantly higher than the country's average of 26 hours. The only cities where drivers spent more time in traffic were Los Angeles with about 90 hours, and the San Francisco/Oakland area with 68 hours (CNN 2003).

With all this wasted time spent in traffic, it is obvious why individuals and companies want an alternative to the single occupant car. It could save both employees and companies financially in the long term by relieving congestion during peak periods, ultimately encouraging employers to locate here and stay here. Alternatives like expanding the existing light rail or adding commuter rail could potentially save commuters a great deal of time by using a fixed guide way that is not affected by congestion on the roads, and increasing the number of productive work hours each day. When the southwest corridor light rail line opened in July of 2000, it was projected there would be about 8,500 boardings on the 8.7 mile quarter the first day. Overall, there were a total of about 14,000 riders opening day, causing it to look like a holiday on Santa Fe with almost no traffic at all.

Similar to the air transportation industry, a possibility for expanding the state's infrastructure would be to create a joint authority that would allow transit agencies to get together and set up agreements where they would cross their boundaries and work together. While the Regional Transportation District (RTD) might operate commuter rail and buses in the metro area, they would work with transit agencies along the entire Front

Range to provide passenger transportation between Fort Collins, Loveland, Denver, Colorado Springs, Pueblo, and even farther (Focus Group/Survey 2003).

SUMMARY

Transportation is a significant portion of the Colorado economy, both as infrastructure helping to improve other industries, and as a sector creating employment growth on its own. A strong transportation infrastructure is important to the overall future economic growth of the state. In a recent assessment of the state's critical infrastructure conducted by the American Society of Civil Engineers, Colorado received a C+ overall based on grades in 12 categories including roads, bridges, aviation, dams, mass transit, water supply, and energy. The aviation sector had the highest ranking with a B+, while roads ranked the lowest with a D+. The roadway network has not kept up with growing demand with about 45% of the state highway system's pavement in poor condition and 18% of the state's bridges structurally deficient or obsolete. Mass transit received a grade of C even though there have been great improvements in the metro area; the remainder of the state suffers a lack of access to transit. While Colorado did not receive top grades, it scored higher than the country as a whole which scored a grade of D+ (Erickson 2003).

The overall strength of Colorado transportation is its central location and intersections of major interstate highways. This is beneficial not only to the trucking and rail industries but especially to aviation creating the opportunity for nonstop international flights, and increased accessibility to other modes of transportation. Bringing rail, highway and air facilities together in an intermodal center would create future opportunity for expansion of the transportation industry. This type of hub would also attract other types of business operations for which this type of transportation connection creates efficiencies and cost-savings. Coordination and cooperation of state, municipal, economic development and all segments of the transportation industry is needed to make intermodal facilities a reality.

Colorado should capitalize on its central location to realize the economic growth potential that can result from expansion of this industry. In addition, planned transportation infrastructure can be used to attract development to outlying areas and improve the urban business climate by diverting traffic from congested Front Range communities. Completion of the Ports-to-Plains Trade Corridor from Mexico to Denver offers opportunities for economic development in eastern plains communities as well as expanded truck and distribution operations in the metro-area.

DIA represents a major strength in the state's ability to participate in the global economy with international flights essential for air cargo, as well as business and tourist travel. Strengthening competition in flight service to small regional airports will be important to future economic growth in rural areas seeking to support tourism, manufacturing and technology sectors.

Other weaknesses and challenges that the state faces in the future include:

- High taxes and licensing fees for trucking and air transportation
- Large debt at DIA and instability of its major carrier, United Airlines
- Continuous loss of manufacturing companies in the state, leading to less cargo being transported out of the state
- Susceptibility to economic fluctuations in both large and small markets throughout the state

Colorado can also support the transportation industry with economic development activities that attract and expand manufacturing companies such as offering incentives and maintaining its image as a good place to do business. In the future, extending efficient public and commuter transportation systems in the metropolitan area will be essential to reduce traffic congestion and maintain a positive business climate.

BIBLIOGRAPHY

Aerospace and Aviation (n.d.). "Air Transport—Essential and in Crisis." Vol. 1, no. 3. <http://global.ihs.com/news/aero1.html> August 11, 2003.

Aircraft Owners and Pilots Association (2003). <www.aopa.org> September.

Airports Council International (2003). "2002 ACI Passenger Traffic Reports." <http://www.airports.org/traffic/pass2002.htm> September 15.

American Trucking Association (2003a). "ATA Truck Tonnage Index Drops 9.5 Percent in August." September 29. <http://www.truckline.com/insideata/press/092903_tonnage.html> October 6.

_____ (2003b). "Congress Appropriates Continuing Funding for Trucking Security." September 25. <http://www.truckline.com/insideata/isac/092503_funding.html> October 6.

_____ (2003c). "Trucking Will Dominate Freight Movement, ATA Publication Finds." March 7. <http://www.truckline.com/insideata/press/030703_freight_forecast.html> August 7.

Boeing (2002a). "Boeing Forecasts Continuous Growth for China's Aviation Market." November 4. <http://www.boeing.com/news/releases/2002/q4/nr_021103g.html> September 16, 2003.

_____ (2002b). "World Air Cargo Forecast 2002-2003 – Executive Summary." September 18. <http://www.boeing.com/commercial/cargo/exec_summary.html> September 17, 2003.

Bureau of Labor Statistics, U.S. Department of Labor (2002-03a). "Career Guide to Industries, 2002-03 edition, Trucking and Warehousing." <http://www.bls.gov/oco/cg/cgs021.htm> August 8, 2003.

_____ (2002-03b). "Career Guide to Industries, 2002-03 edition, Air Transportation." <http://www.bls.gov/oco/cg/cgs016.htm> August 8, 2003.

Bureau of Transportation Statistics (2002). "Transborder Surface Freight Data – Annual Summaries." <http://www.bts.gov/ntda/tbscd/reports.html> October 8, 2003.

CNN (2003). "Time in Traffic Increases, Study Finds." September 30. <http://www.cnn.com/2003/US/09/30/congested.highways.ap/index.html> September 30.

Colorado Department of Transportation (2003). "Economic Impact of Colorado Airports." Aeronautics Division. <http://www.colorado-aeronautics.org/aeroecono2003.htm> December 23.

Colorado Motor Carriers Association (2001). "Colorado Trucking Facts." <http://www.cmca.com/TRUCKING.HTM> August 7, 2003.

Colorado Springs Municipal Airport (2003). "Summary of Enplaned Passengers by Airline – August 2003." <http://www.springsgov.com/Units/Airport/Reports/COS0803TrafficRpt.pdf> October 8.

Denver International Airport (2003a). "Dedication of Denver International Airports Sixth Runway." June 20. <http://www.flydenver.com/pr/DIAPR_030620_2.pdf> August 7.

_____ (2003b). "Denver International Airport Passenger Traffic Continues To Surpass 2002 Numbers." May 30. <http://www.flydenver.com/pr/DIAPR_030530.pdf> August 7.

_____ (2003c). "Denver International Airport Total Operations and Traffic – August 2003." <http://flydenver.com/biz/stats/tstats/Aug_2003.pdf> October 8.

Erickson, Jim (2003). "Congested State Roads Earn D+." October 17. *Rocky Mountain News.*<http://www.rockymountainnews.com/drmn/business/article/0,1299,DRMN_4_2353761,00.html> October 20.

ES202 (2003a). <http://www.coworkforce.com/lmi/es202/index.htm> September 21.

_____ (2003b). <http://www.bls.gov/cew> September 21.

Federal Aviation Administration (2002). "Terminal Area Forecast System." July 29. <http://www.apo.data.faa.gov/faatafall.HTM> September 16, 2003.

Focus Group/Survey (2003). Transportation focus group conducted in September.

Griffin, Greg (2003). "Flight Risks?" August 17. *The Denver Post*.

Hansson, Tom, Jurgen Ringbeck, and Markus Franke (2002). "Flight for Survival: A New Operating Model for Airline." December 6. <http://www.strategy-business.com/press/enewsarticle/22462?pg=0> October 7, 2003.

Heimlich, John (2003). "U.S. Airlines: The Big Picture." October 8. Air Transport Association. <http://www.air-transport.org/econ/files/Econ101.pdf> October 13.

International Air Transport Association (2003). "IATA International Traffic Statistics: June 2003." August 4. <http://www.iata.org/pressroom/industry_stats/2003-08-04-01.htm> August 12.

Kesmodel, David (2003). "DIA Exits List of Nation's Top 10 Highest Airfares." October 15. *Rocky Mountain News.* <http://www.rockymountainnews.com/drmn/business/article/0,1299,DRMN_4_2347784,00.html> October 15.

Kesmodel, David, David Milstead, and Heather Draper (2003). "Debt Hamstrings DIA." August 16. *Rocky Mountain News.*

Mountain Wave (2002). "After $7 M Losses in 2001, Airlines Look to the Future." Spring 2002. <http://www.colorado-aeronautics.org/mountwave/pdffiles/spring02.pdf> August 7, 2003.

Patty, Mike (2003). "United, Frontier cut deal on gates." *Rocky Mountain News*, November 10. <http://www.rockymountainnews.com> November 26.

Ports to Plains (2001). <http://www.ports-to-plains.com/home.htm> November 25, 2003.

ProLogis (2003). "Investor Fact Sheet." <http://www.prologis.com/north_america/english/investors/investors.aspx> October 2.

Rebchook, John (2003). "Major Mall Along E-470- Ready to Break Ground." October 9. *Rocky Mountain News.* <http://www.rockymountainnews.com/drmn/real_estate/article/0,1299,DRMN_414_2332373,00.html> October 9.

ReferenceUSA (2003). <www.referenceusa.com>

SW Aviator (2000). "Colorado Airports Look to the Future." Dec/Jan. <http://www.swaviator.com/html/issueD99J00/conews.html> August 11, 2003.

TDC Trade (n.d.). "Danzas Introduces Paperless Trading on Asia-Europe Exports." <http://www.tdctrade.com/shippers/vol25_6/vol25_6_logistics09.htm> September 16, 2003.

U.S. Department of Transportation (2003). "DOT Grants will Help Ensure Safety of Mexican Trucks in U.S." September 13. <http://www.dot.gov/affairs/fmcsa2103.htm> September 15.

WingTips (2003a). "2002 in Review, A Year in the Life of DEN." Vol. 2, no. 1, Winter.

_____ (2003b). "Air Cargo Looks to Asia." Vol. 2, no. 2, Spring.

_____ (2003c). "FedEx Express Doubles Up at DEN." Vol. 2, no. 2, Spring.

_____ (2003d). "Regional Jets Fly High Over Denver." Vol. 2, no. 1, Winter.

AEROSPACE

Industry Overview

This report covers the aerospace industry, its size, composition, growth trends, as well as challenges and opportunities for future growth. Information is drawn from various sources to cover government, defense and commercial aerospace industries, including satellite manufacturing, launch services, telecommunications, global positioning system applications (GPS), and remote-sensing. In addition, we include aircraft and aircraft parts manufacturing in this review.

Prior to 1958, the U.S. space industry existed only through the work conducted by the U.S. Department of Defense, and the National Advisory Committee for Aeronautics (NACA) – the latter being the nucleus of the National Aeronautics and Space Administration (NASA). NASA's space launch program became the genesis of today's commercial space industry.

Initially it was easy to measure the size and impact of the industry as all expenditures could be tracked through government procurement records. As the industry changed, however, measurement has become more difficult. Measurement is complicated by the various definitions of what is included in the industry and how it is segmented. In addition, data on commercial market sectors does not differentiate space applications from other markets. Based on NASA data for FY2000, the size of commercial space markets in the United States (including telecommunications, global positioning system applications, remote sensing, and commercial launch activity) was thought by some to be more than the combined size of the U.S. Government civilian and defense markets (U.S. Department of Commerce 2002). In more recent years, however, defense budgets have increased and commercial markets are declining (Focus Group/Survey 2003).

The growth of the industry has been fueled by the fact that it is now a global industry with commercial markets driven by telecommunications. Although the United States is the leading nation in space, Europe, Japan, Russia, and others have government programs and growing private sector space industries (U.S. Department of Commerce 2002).

World Market Size and Expected Growth

The space industry includes satellites for government, military and civil use including the fast growth commercial sectors of space transportation, telecommunication services, remote-sensing, and global positioning system applications. Overall, the commercial sector of the space industry experienced a 16% annual growth rate between 1996 and 2002 (U.S. Department of Commerce 2001).

In 1999, the commercial space industry generated direct revenues of approximately $68 billion. Over the next 10 years this value was projected to triple, growing to $199 billion in 2010. This growth rate would represent a compound annual growth rate (CAGR) of

11.3% (Space Foundation 2002). Since actual launches in recent years were fewer than anticipated, the actual rate of growth may be less than this projection.

In 2000, estimated turnover for the aerospace industry totaled 214 billion euros globally. The United States had the largest share, with 49.3%, followed by the European Union with 33.8%. Employment totaled an estimated 1.22 million workers. Approximately 49% of the world's aerospace employees worked in the United States, while 35% worked in the European Union (European Association of Aerospace Industries 2001).

The largest and fastest growing segment of the commercial space industry is satellite communications, which includes satellite services, transponder leasing, ground equipment manufacturing, and satellite manufacturing. This segment generated annual revenues of over $67 billion in 2000. This 17 percent growth rate is due to demand for direct-to-home television service, global deregulation of telecommunications, mobile communications, and satellite data communications (U.S. Department of Commerce 2001). A recent survey of satellite manufacturers and service providers at the International Satellite Communications exchange conference identifies homeland security, broadcasting services, and broadband as immediate and long-term industry drivers (Futron 2003).

Another high-growth area is the GPS sector with revenue over $7 billion in 2000 and growth at 19 %. In addition to demand for GPS tracking and navigation tools for land and marine vehicles, additional growth is projected from the emergence of GPS receivers in consumer electronic devices and integration of GPS chip sets into multifunction products. GPS, deployed and operated by the U.S. Department of Defense, consists of 24 satellites that orbit about 11,000 miles above Earth. GPS markets are diverse: aviation, marine surveying, recreation, timing, and in-vehicle navigation. In May 2000 the U.S. government turned off selective availability, a change that greatly improved the accuracy of the received GPS signal. Increased new product development and use are anticipated from the improved accuracy and by U.S. plans to spend billions of dollars over the next five years to modernize the GPS system (U.S. Department of Commerce 2001).

The space transportation segment (satellite manufacturing and launch services) generated an estimated $5 billion in revenue in 2000. This segment experiences large year-to-year variation due to the small number of commercial launches per year, launch vehicle failures, and manufacturing delays (U.S. Department of Commerce 2001).

The fourth growth section, remote sensing, includes raw satellite imagery ($173 million in revenue in 2000), plus value-added sectors of aerial imagery and Geographic Information System (GIS) software and services. The current 14% annual growth rate is expected to increase after 2002 as more commercial platforms come on line and the consumer base expands from historically government users (environmental monitoring, weather forecasting and intelligence) to increasing commercial use enabled by expanded personal computing power and the improved resolution expected from future imaging systems (U.S. Department of Commerce 2001).

The GIS/remote sensing sector includes the new Geospatial Intelligence (GEOINT) activities, which is expected to grow rapidly to fulfill government requirements for timely, relevant, and accurate geospatial intelligence to support national and homeland security. GEOINT is the exploitation and analysis of imagery and geospatial information to describe, assess and visually depict physical features and geographically referenced activities on the Earth. The National Imagery and Mapping Agency (NIMA) has recently changed its name to the National Geospatial-Intelligence Agency reflecting a future focus on the importance and use of GIS and remote sensing for intelligence purposes (U.S. Department of Defense 2003). The military and Department of Homeland Defense are expected to be major customers (Focus Group/Survey 2003).

National Market Size and Expected Growth

The U.S. aerospace industry generated $148 billion in sales in 2002. This was 3.2% below the $153 billion in sales reported in 2001.While sales declined in 2002, industry profits rose to their highest level in three years, an estimated $9 billion. In 2003, industry sales are expected to fall an additional 6.6%, to $138 billion (Aerospace Industries Association 2003).

Since 1986, aerospace sales have generally accounted for between 6% and 9% of all durable goods sales, between 3% and 5% of total manufacturing sales, and between 1.5% and 2.5% of the U.S. GDP. Aerospace sales were 1.4% of the GDP in 2002 (Aerospace Industries Association 2003). More significantly, aerospace industry exports have historically shown a positive balance of trade over the past 35 years, which has helped counter the U.S. trade deficit (Rains 2000). In 2002, the value of aerospace exports (NIACS 33641) totaled $54.5 billion, generating a positive balance of trade of $28.6 billion (Stokes 2003).

Aerospace-related employment in the United States has fallen steadily since 1989. In that year, an estimated 1.29 million people were employed in the industry. In 2002, employment totaled 714,000. This was down 10.6% from the previous year. In 2003, this value is expected to fall another 6.1%, to 673,000 (Aerospace Industries Association, 2003). According to a recent presentation to the National Academies Forum on New Directions in Manufacturing, aerospace manufacturing employment is at its lowest level since World War II.

The terrorist attacks of September 11th had a significant impact on the aerospace industry. The commercial sector, struggling even before the attacks, was devastated. Civil aircraft sales declined sharply in number and value in 2002. Overall sales were down 16% from the prior year. Production of commercial jetliners dropped 27.8% from 2001. Consequently, civil transport aircraft revenues fell 20%. Civil general aviation aircraft and helicopter sales were also down significantly.

On the other hand, the ongoing war on terrorism and the intensified focus on homeland security have given a substantial boost to the military sector. Increased R&D spending, along with Department of Defense procurement, led to a $37 billion increase in sales of

military aircraft, engines, parts, and services. Similarly, missile sector sales increased 18% in 2002. This trend will likely continue as military and defense spending are expected to increase further in the years to come. President Bush's newest proposal for the U.S. Department of Defense budget calls for a spending increase of about 15%, and that figure doesn't include the $78 billion War Supplemental Appropriations bill (Yahoo Business 2003). It is estimated that over the next several years, more than $100 billion will be spent in the military sector of aerospace. In May 2003, Secretary of Defense Donald Rumsfeld said "More than any other country, the United States relies on space for its security and well-being," in the upcoming years the Air Force Space Command will take on broader responsibilities to help "sustain the United States' position as the world's leading space-faring nation"(Colorado Technology Alliance 2003).

The loss of the U.S. space shuttle Columbia on February 1, 2003, was another event that sent shockwaves through the aerospace industry. There was initial speculation that the tragedy would lead to serious changes in the space program, and could devastate the industry. Although it is still too early to tell what the long-term effects will be, this doesn't appear to be the case. In fact, some people believe that the industry will benefit from the increased safety measures, and new technology advancements that will follow the crash.

U.S. Industry Segments

The U.S. aerospace industry can be divided into four main segments: aircrafts, missiles, space, and related products and services.

From 1992-2002, the aircraft segment was the fastest growing in terms of sales, with a CAGR of 0.83%. This was followed by the related products and services segment with a growth rate of 0.67%. The missile segment grew at a rate of 0.51%, and the space segment had a 0.33% CAGR (Aerospace Industries Association 2003).

In 2002, the largest segment was aircraft, with sales of $80.3 billion, 54.2% of all aerospace sales. About 54% of aircraft sales were in the civil market, and 46% were military. Space sales totaled $30.8 billion, 20.8% of the total. Sales for related products and services were $24.7 billion, or 16.7% of all aerospace sales. The smallest segment, missiles, had sales of $12.4 billion, or 8.4% of the total (Aerospace Industries Association 2003).

In 2002 employment in the aircraft segment was 408,000, about 57% of total aerospace employment. A total of 82,000 people were employed in the missiles and space segments, which made up about 11.5% of the total employment. An additional 220,000 people were employed in other aerospace-related jobs (Aerospace Industries Association 2003).

According to the North American Industrial Classification System (NAICS) the Aerospace industry can be further broken down into the following sectors:

- NAICS 336411 Aircraft Manufacturing
- NAICS 336412 Aircraft Engine and Engine Parts Manufacturing
- NAICS 336413 Other Aircraft Parts and Auxiliary Equipment Manufacturing
- NAICS 336414 Guided Missile and Space Vehicle Manufacturing
- NAICS 336415 Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing
- NAICS 336419 Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing
- NAICS 334511 Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing
- NAICS 517410 Satellite Telecommunications
- NAICS 927110 Space Research and Technology

The table below summarizes the covered employment and wage data for all nine aerospace sectors in 2001.

2001 AEROSPACE INDUSTRY EMPLOYMENT AND WAGES

NAICS	Description	Employment	% of Total	Wages (000s)	% of Total
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	148,388	21.3%	$10,323,293	23.7%
336411	Aircraft manufacturing	240,500	34.6	14,945,028	34.4
336412	Aircraft engines and parts manufacturing	94,510	13.6	5,621,660	12.9
336413	Other aircraft parts and auxiliary equipment	97,634	14.0	4,875,432	11.2
336414	Guided Missile and Space Vehicle Manufacturing	53,330	7.7	3,771,651	8.7
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	12,053	1.7	766,680	1.8
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	10,731	1.5	691,321	1.6
517410	Satellite Telecommunications	21,212	3.0	1,305,330	3.0
927110	Space Research and Technology	17,608	2.5	1,199,138	2.8

Source: Bureau of Labor Statistics, CEW data.

The Aerospace Industry in Colorado

According to a recent study conducted for the Space Foundation, "The Colorado space industry is flourishing within the larger, highly competitive, and dynamic global space industry" and "Colorado is well positioned to maintain and increase its market share of space-related activities and investments" (Space Foundation 2000).

According to Covered Employment and Wage data for 2001, Colorado had 10,495 employees working in the nine NAICS sectors defined above. These employees generated about $790.2 million in wages.

However, state employment and wages were estimated to be significantly higher in a recent study prepared for the Space Foundation. Using a broader definition of the industry that includes air transportation, the study estimated that there were more than 100 aerospace companies in the state. In 2001, the industry employed roughly 38,000 people directly. Through the multiplier process it is believed that these jobs created an

additional 75,000 jobs, bringing the total to 113,000 jobs. This value is expected to more than double by the year 2010, giving Colorado 232,000 aerospace jobs (Space Foundation 2000).

The 38,000 direct employees of the aerospace industry in Colorado make an estimated $1.84 billion in wages. The average annual wage for aerospace industry jobs in Colorado is $48,487, 30% higher than the average for all industries in the state (The Commission on the Future of the U.S. Aerospace Industry 2002).

In 2001 Colorado's largest aerospace sectors were air transportation (26,600 employees), guided missiles and space manufacturing (6,500), and search, detection, navigation, and guidance manufacturing (2,900) (Commission on the Future of the U.S. Aerospace Industry 2002).

Total aerospace revenue for Colorado was $3.3 billion in 2001.This number is also expected to grow rapidly, reaching $7 billion by 2010 (Space Foundation 2000).

Colorado Competitive Position

According to a state-by-state analysis of the aerospace and aviation industry using preliminary 2001 data, Colorado is ranked 19th in total aerospace employment, including air transportation (38,000 employees in 2001). California ranked first with 293,700 aerospace-related employees, followed by Texas (184,175), Washington (117,629), and Florida (114,274). Aerospace made up 1.7% of total employment in the state in 2001, the 14th highest concentration in the country. Washington (4.4%) had the highest concentration of aerospace workers, and Kansas (4.3%) was second. Colorado ranked 5th in employment in guided missiles and space vehicles and parts manufacturing, and 8th in satellite communications employment (Commission on the Future of the U.S. Aerospace Industry 2002).

Colorado's average annual wage in the aerospace industry of $48,487 is the 10th highest in the country. The District of Columbia had the best-paid employees ($64,588), followed by Connecticut, ($60,976) and Washington ($57,098) (Commission on the Future of the U.S. Aerospace Industry 2002).

In 2001 Colorado ranked 5th in the nation in guided missiles and space vehicles and parts manufacturing employment, 8th in satellite communications employment, 12th in search, detection, navigation, and guidance manufacturing employment, 18th in air transportation employment, and 30th in aircraft and parts manufacturing employment (The Commission on the Future of the U.S. Aerospace Industry 2002).

The overall decline in satellite communication launches has resulted in reduced business for Lockheed Martin and Boeing, and contributed to the collapse of the market for the Delta II and closure of the Pueblo facility (Focus Group/Survey 2003). Colorado firms participating in defense and government contracts have fared better, receiving a total of $1,138 million in Department of Defense missiles and space procurement in 1999.

Among states receiving space procurement funds, Colorado ranked 4th in total space procurement receipts during 1999 (Space Foundation 2000).

Colorado also has done a remarkable job of procuring NASA funds. In 1999, Colorado ranked 8th, despite the fact that no major NASA facilities are located in the state. Of the states that do not have NASA facilities, Colorado ranked 1st in total funds received from NASA, and 3rd in funds received by educational institutions (Space Foundation 2000).

Strengths and Opportunities for Growth

Colorado has many attributes conducive to a strong and growing aerospace industry with an existing base of companies involved in defense and commercial markets, numerous government and military installations, higher education institutions with world-class aerospace research and engineering programs, and high-tech industries that support commercial space growth sectors. In addition, Colorado's central geographic location makes it a hub for communication, transportation, and redistribution of information, durable goods, and services. Add to that the quality of life in the state, and Colorado becomes a very attractive place to run an aerospace business.

The basic infrastructure for the aerospace industry is already in place. There are more than 100 companies in the state of Colorado that provide materials, equipment, software, and services for the space infrastructure and to end users of space applications. The state is home to many of the industry's leading laboratories, research and testing facilities, and technology centers. In addition, at least 14 Colorado universities offer space-related curricula and/or departments. The state ranked 7th overall in total aerospace engineering R&D expenditures (Denver Metro Chamber of Commerce 2002). In the University of Colorado, Colorado State University, and the Colorado School of Mines, the state has three world-class educational institutions. The University of Colorado at Boulder is a renowned leader in the areas of advanced information technologies, astrophysics and cosmology, astronomy, robotic exploration, planetary studies, and transportation. In fact, in 2000, out of all U.S. universities CU-Boulder ranked 5th in aerospace engineering research and development expenditures. Colorado State University is considered a leader in electric propulsion technologies, and the Colorado School of Mines has long been recognized for offering some of the world's premier engineering programs (Denver Metro Chamber of Commerce 2002)

Industry leaders agree that current workforce needs are met but caution that replacement of older aerospace workers, reaching retirement age in five to ten years, will be a problem for the industry nationally. Colorado could create advantages for the industry here, and attract other companies, by continuing to develop higher education centers that cater to industry needs. Successful examples use internships and worker education programs based on strong partnerships with major companies such as the relationship between LASP at CU Boulder and Ball Aerospace, Lockheed Martin and Orbital Sciences Corporation. A similar program has been developed between University of Colorado at Colorado Springs and Lockheed Martin. Perhaps this program could be expanded to include NORTHCOM Space Command, and companies in the Colorado Springs area.

The current national trend of technology-related jobs going offshore poses a modest threat to the Colorado aerospace industry. As an example, software jobs are more economically performed in countries such as India and Israel. Colorado companies will need systems engineers and workers with the capacity to design and develop new software solutions. Ideally these workers will not only understand software, but the physics needed in aerospace applications (Focus Group/Survey 2003).

Colorado is home to numerous space-related institutions, including the National Center for Atmospheric Research (NCAR), BioServe Space Technologies, the National Oceanic and Atmospheric Administration (NOAA), and the National Institute of Standards and Technology (NIST), the Space Foundation, the Space Science Institute, the Colorado Center for Astrodynamics Research, the Colorado Space Education Initiative, and the Colorado Space Grant Consortium.

Colorado also has a high concentration of high-tech industries that support and collaborate with the aerospace industry. Telecommunications, software, computer storage, photonics, information technology and biotechnology all have a major presence in the state, and are important technologies in the space industry.

Colorado's strong military presence provides another competitive advantage. Military organizations such as the Air Force Academy, U.S. Space Command, NORAD, Air Force Space Command, Buckley Air Force Base, Cheyenne Mountain Operations Center, Fort Carson, Peterson Air Force base, Schriever Air Force Base, and the Northern Space Command are all located within our borders. These organizations support and feed the industry, they foster technological advancements, and they attract new companies to the area. In 1995, the estimated economic impact of Buckley alone was $355 million in Colorado (Colorado Technology Alliance 2003). This number is expected to grow in the upcoming years. With increased defense and homeland security spending, the state's military operations should thrive, giving a boost to the aerospace industry and the entire state economy.

The state could help protect Fort Carson from future budget cuts by advocating now for upgrades that would better support the new, rapid deployment military strategy, perhaps by using the facility as a training center for this new type of fighter (Focus Group/Survey 2003).

Many of the national leaders in the aerospace industry already have major operations in the state. Lockheed Martin Space Systems is headquartered here. Ball Aerospace, Boeing, Computer Sciences Corp., EchoStar, Hughes, Litton Industries Inc., Raytheon, Northrop Grumman (formerly ITT Industries and TRW), Digital Globe, and Space Imaging are a few of the other big name aerospace companies with operations in Colorado. In addition, approximately 100 small and medium-sized Colorado firms support these large firms.

Colorado has been one of the leading states for the production and assembly of launch vehicles. In fact, the U.S.'s three largest and most capable expendable launch systems,

Titan, Atlas, and Delta, used to be manufactured and/or assembled in the state (Denver Metro Chamber of Commerce 2002). This capability has changed drastically, however, as loss of the Boeing plant to Alabama will result in closure of the Pueblo facility in 2004, and the Titan line of launch vehicles is now out of production. This leaves the Atlas V, currently produced by Lockheed Martin in the Littleton area, as the only launch vehicle manufactured in the state (Focus Group/Survey 2003). Lockheed's capabilities, however, are proving a significant economic force with recent awards for 10 Atlas V rockets early on and will perhaps grow to $4.6 billion over a decade (Fillion 2003).

There are future opportunities for Colorado in commercial space systems. The value of commercial systems resides in the ground systems and the value-added products such as sensors in space, and software systems that turn data into a useful product. The core competencies, systems and software engineering, are strong in the state and provide opportunities for the industry to grow in spatial technologies and remote sensing. These sectors could see significant growth with the emergence of military and homeland security interest in Geospatial Intelligence (Focus Group/Survey 2003).

Although some have suggested that Colorado could compete for funds to establish a future commercial spaceport launch capability, others question this idea. Colorado may offer some advantages over humid coastal areas including the dry climate that reduces wear on equipment, and the benefits of launching at a higher elevation with less dense atmosphere. However, these advantages need to be weighed against coastal advantages of safer launching over oceans and the increased angular velocity of the earth near the equator (Focus Group/Survey 2003).

In the future, the military will increasingly rely on space for fighting any war using satellites, space radar and GPS for precision control of weapons and unmanned vehicles in any part of the world. Colorado is well positioned to play a major role in providing information assurance for these systems, i.e. providing a high level of assurance that information is valid and reliable, and that the systems are secure (Focus Group/Survey 2003).

Clearly, Colorado's aerospace industry is ready to take off. The foundation is in place. The state has a highly educated workforce and a concentration of support industries. The military presence, and the numerous world-class university programs, research labs, testing facilities, and industry leading companies give Colorado a competitive edge.

Weaknesses and Barriers

The industry as a whole provides several challenges. The industry may be growing rapidly now, but Rick Ambrose, vice president and regional executive for Lockheed Martin Space Systems, Information Systems and Solutions, cautions, "The space industry as a whole moves in cycles…bumps are typical of this market, and they will undoubtedly be encountered and should be expected" (Colorado Technology Alliance 2003).

The aerospace industry is highly competitive. Colorado does not yet have the national or international reputation for being a space state. Colorado needs to better market its capabilities as an aerospace center. Currently, states like California, Texas, Florida, Alabama, and Alaska are all aggressively pursuing growth and increasing their shares of the market. Many of these states offer substantial financial incentives to recruit companies. They have lower corporate property and inventory taxes, and many have lower labor costs than Colorado. Additionally, these states have a major advantage over Colorado in terms of government support for the industry. Many of these states have offices whose sole responsibilities are to support the industry, attract new companies, capture more federal funding, and market the capabilities of their industry. These agencies coordinate the activities of the various groups involved in the industry and help create the synergy needed to grow and thrive.

Another obstacle facing the industry, in Colorado and elsewhere, is the traditional secrecy associated with the defense activity. This limits the cooperation between the military and the private sector, and hinders industry progress.

There are also tough federal restrictions placed on the exports of space technologies, which makes it difficult and sometimes impossible for U.S. companies to do business overseas. For example, implementation of the International Traffic in Arms (ITAR) rules in 1999 restrict the sale of U.S. manufactured launch engines to foreign launch vehicle companies while foreign competitors are free to supply international markets for commercial launch systems (Foust 2003). In pressing for change in the way ITAR is implemented, the U.S. Institute of Electrical and Electronics Engineers (IEEE-USA) asserted that U.S. market share of contracts for new communications satellites dropped from about 70% to below 35% between 1999 and 2001(Sauthoff 2001).

ITAR is also creating difficulties in hiring, as programs subject to these rules can only allow access by U.S. citizens or green card holders, thereby limiting the use of foreign expertise. In addition, hiring tends to go in cycles, with many years between the cycles, resulting in broadly spaced age distributions. With the downsizing in the past years, hiring has been restrained. This has resulted in a large group of experienced employees who are approaching retirement—a condition that seems endemic to this industry owing to the strong up and down economic cycles. These retirements will create opportunities for new hires, as well as reemployment of retired workers wishing to continue working on a more limited basis. Compounding this issue is a decline in enrollment in space-related engineering programs. In sum the stability of the workforce, and lost opportunities for apprentice-like training between experienced workers and new hires, is a serious problem.

In addition, aerospace companies in Colorado could potentially have a difficult time attracting the IT and other high-tech workers they need. Because Colorado is such a technology-oriented state, aerospace competes with photonics, biotech, telecom, and computer storage industries over the high-tech labor pool.

Growth Strategies

Fortunately, there are ways to overcome some of these barriers, and increase Colorado's share of the aerospace market.

A focus group responding to this study, recommended more cooperative action of the state, industry, and the Congressional delegation to enthusiastically market our advantages, work aggressively to capture federal dollars, and address regulatory and policy issues. Such coordination between federal and state officials was subsequently initiated at an October 2003 roundtable convened by U.S. Senator Wayne Allard, Lieutenant Governor Jane Norton, and Tim Fritz, Director of the Colorado Office of Aerospace and Aeronautics.

Colorado could also capitalize on its aerospace-related educational programs to increase the pool of highly trained, highly skilled aerospace employees within the state. Joint efforts by educational institutions and industry are needed to identify curricula at all educational levels to interest Colorado youth, with relevant outreach programs in science and math at an early age. The ideal would be a fully integrated pre-K-16 educational system that introduces youth to career opportunities in aerospace at a very early age and provides engineering, science, math and space technology preparation from pre-school through doctoral level education. Development of the workforce needed to replace older, retiring aerospace veterans, would not only support growth of existing Colorado firms, but would also give the state a significant advantage in attracting additional aerospace companies to the state.

A stronger government-industry-academia partnership could foster interaction between the state's aerospace industry and companies with capabilities in high-technology areas such as telecommunications, photonics, and remote sensing. Such interaction could lead to increased use of in-state suppliers, research partnerships to develop next generation capabilities, and strengthen the aerospace cluster.

The state could use the advantages of its central location to play a significant future role as the command center for homeland security including everything from first responder to military command. Colorado already has major advantages in that NORTHCOM and a new Transportation Security facility are already located in Colorado Springs, and new investments are being made to the Center for Disease Control in Ft. Collins. In order to be competitive in this arena, Colorado needs to find solutions to state budget problems to finance improvements in basic infrastructure. Important infrastructure components include a state-of-the art broadband network in order to receive and process information, and a transportation infrastructure to quickly move people around, e.g. highways that enable smooth traffic flow and more airline flights from Colorado Springs to serve the aerospace industry cluster in that community (Focus Group/Survey 2003).

BIBLIOGRAPHY

Aerospace Industries Association (2003). *2002 Year-End Review and 2003 Forecast.* <http://www.aia-aerospace.org/stats/yr_ender/yr_ender.cfm>

Colorado Technology Alliance. *Aerospace Defense Industry Overview – State Takes Off as a Leader in National Space Industry.* <http://www.coloradota.org/companies/industry.asp?bcid=1&BcName=Aerospace%2FDefense>

Commission on the Future of the U.S. Aerospace Industry (2002). *U.S. Aerospace and Aviation Industry: A State-by-State Analysis*, pp. 19, 82, 84. October.

Denver Metro Chamber of Commerce (2002). *Creating Colorado's Space Priorities – White Paper.*

European Association of Aerospace Industries (2001). *The European Aerospace Industry – Facts and Figures 2000.* < http://www.aia-aerospace.org/pubs/links/aecma2000.pdf >

Fillian, Roger (2003). "Lockheed on a Winning Streak." *Rocky Mountain News*, December 11.

Focus Group/Survey (2003). Aerospace focus group and survey conducted in August.

Foust, Jeff (2003). "Main Engine Cutoff." *The Space Review*, February 17. <http://www.thespacereview.com/article/3/1> November 24.

Futron (2003). "ISCe 2003 Survey Reveals Satellite Executives' Outlook." August 21. <http://www.futron.com/news/pressrelease/latestpressrelease.htm> December 5.

National Academies Forum on New Directions in Manufacturing (2003). *The Value of Manufacturing.* <http://www7.nationalacademies.org/bmaed/tracypresentation.pdf>

Sauthoff, Ned R. (2001). Letter to George W. Bush, President of the United States, from IEEE-USA, August 30. <http://www.ieeeusa.org/FORUM/policy/2001/01aug30b.html> November 24.

Space Foundation (2002). *Colorado's Strategic Plan for Space.* <http://www.coloradospace.org/resources/docs/colorado_space_plan.doc>

Stokes, H. Kemble, Jr. (2003). "U.S. Exports of 50 Major Products." Office of Trade and Economic Analysis, International Trade Administration, U.S. Department of Commerce, November, pp. 57, 58.

<http://www.ita.doc.gov/td/industry/otea/trade_perspective/ProductXQ303.pdf> December 5.

U.S. Department of Commerce (2001). *Trends in Space Commerce.* Office of Space Commercialization.

_____ (2002). *Space Economic Data.* Office of Space Commercialization, December, p. 10.

U.S. Department of Defense (2003). *NIMA Changes Name to National Geospatial-Intelligence Agency*. News Release, The Pentagon, Washington, D.C., November 24. <http://www.defenselink.mil/releases/2003/nr20031124-0684.html> December 5.

U.S. Department of Labor (2003). *Covered Employment and Wages.* Washington, D.C.: Bureau of Labor Statistics.

Yahoo Business (2003). *Aerospace and Defense Industry Profile.* <http://biz.yahoo.com/ic/ae.html>

DEFENSE AND HOMELAND SECURITY

Industry Overview and Market Size

The defense industry is composed of private sector companies that provide key products and services to support the U.S. military. Even though the industry experiences growth and decline based on political and military contingencies, it represents a substantial piece of the American economy.

Market size is somewhat difficult to measure, as the defense industry is actually comprised of pieces of many different industries including aerospace, research and technology, telecommunications, transportation, contract services, and manufacturing. The most accurate way to gauge the size of the industry is to look at the budget of the U.S. Department of Defense (DoD). The FY2003 budget stands at $364.6 billion, representing a 10.85% increase compared to FY2002. This growth trend is expected to continue under the current administration, with a proposed budget for FY2004 of $379.9 billion (U.S. Department of Defense 2003). Over the next six years, the DoD is estimating budget increases of roughly 5% per year, which would put the FY2009 budget at $483.6 billion. These projections do not include supplemental budget allocations for the war or reconstruction of Iraq, or for future unforeseen military conflicts.

The DoD claims that it is America's oldest, largest, and most successful "company." In addition to external procurement of goods and services, this government department employs roughly 2.3 million military personnel and 636,000 civilians, both in this country and in over 146 countries worldwide. The FY2003 military budget of $364.6 billion dwarfs that of the largest U.S. private sector company, Wal-Mart, whose budget is approximately $271 billion.

The defense industry, as a whole, has become more prominent in the last few years as the terrorist attacks of September 11th and the ongoing military involvement in Iraq and Afghanistan have reinforced the need for national security among the American public. With these ongoing conflicts and homeland security concerns, current defense contractors are enjoying increased business, opportunities are created for additional companies to meet newly identified needs, and prospects are that the nation's defense industry will continue to thrive.

National Industry Leaders

Lockheed Martin Corporation, The Boeing Company, Northrop Grumman Corporation, Raytheon Company, and General Dynamics Corporation are perennial leaders in the defense industry, bringing in billions of dollars and accounting for major portions of the $364.6 billion budget. In 2002, these firms were awarded contracts worth a combined $56.3 billion. The two biggest contractors, Lockheed Martin and Boeing, received DoD contracts of $17 billion and $16.6 billion, respectively. Boeing makes up 20.7% of the aerospace and defense industry, and Lockheed follows closely with 16.8% market share. Below is a chart of the top 10 defense contractors in 2002.

TOP 10 DEFENSE INDUSTRY CONTRACTORS (2002)

Rank	Contractor	Awarded Contract (Billion $)	% of Total DoD Contracts
1	Lockheed Martin Corporation	$17.0	10.0%
2	The Boeing Company	16.6	9.7
3	Northrop Grumman Corporation	8.7	5.1
4	Raytheon Company	7.0	4.1
5	General Dynamics Corporation	7.0	4.1
6	United Technologies Corporation	3.6	2.1
7	Science Applications International Corp.	2.1	1.2
8	TRW Incorporated	2.0	1.2
9	Health Net, Inc.	1.7	1.0
10	L-3 Communications Holdings, Inc.	1.7	1.0
Total		$67.4	39.5%
Total DoD Contracts		$170.8	100.0%

Source: U.S. Department of Defense

Drivers and Barriers

The changing political and national security landscapes are the biggest drivers of the defense industry. As most American companies struggled to deal with the slumping economy and massive impact of 9/11, defense companies flourished. The creation of the U.S. Department of Homeland Security (DHS), and the decision to go forward with Operation Iraqi Freedom, produced many opportunities for the hundreds of defense contractors in the United States.

The Department of Homeland Security came into existence in June 2002 as a result of the September 11th terrorist attacks. As defined by the White House, Homeland Security is "a concerted national effort to prevent terrorist attacks within the United States, reduce America's vulnerability to terrorism, and minimize the damage and recover from attacks that do occur" (U.S. Department of Homeland Security 2003). To accomplish these three objectives, Congress has allocated $36.2 billion to the DHS for FY2004. Some key components of the budget include:

- $500 million to assess the nation's critical infrastructure, such as nuclear power plants, water facilities, telecom networks, and transportation systems, and work to ensure that any vulnerabilities are addressed.
- $350 million in new funding for research, development, and testing of homeland security projects, such as nuclear and bioterrorism detection technologies.
- $373 million for border security and trade initiatives, including technology investments along the border (e.g., radiation detection and X-ray machines).
- $3.5 billion for the Office of Domestic Preparedness to train and equip first responders, including $500 million for assistance to firefighters and $500 million for state and local law enforcement anti-terrorism activities.

Technology is another huge factor driving the defense industry. Billions of dollars are spent every year to develop new weapons systems, update old ones, and reorganize the

defense infrastructure. The portion of the defense budget that addresses research, development, testing, and evaluation (RDT&E) has increased significantly in FY2003, from $48.7 billion in 2002 to $56.8 billion in 2003. A further increase is planned for 2004 with an estimated $61.8 billion allocated to RDT&E (U.S. Department of Defense 2003). The Defense Advanced Research Projects Agency (DARPA) will see $3 billion in funding, and the Department of Energy (DOE) will receive $8.5 billion in defense-related research funding. The National Institutes of Health is projected to receive $26.9 billion for R&D, which represents a 2.7% increase over 2003 levels, but a 117% increase in the area of bioterrorism research. (American Association for the Advancement of Science 2003) The Department of Homeland Security is proposed to receive nearly $1 billion in research funding in 2004, with most ($874 million) of the money going into the Directorate of Science and Technology, up nearly 68% from 2003 levels. A report by the American Association for the Advancement of Science in September 2003 lists the following breakdown of requested research money within the Directorate of Science and Technology:

- $70 million for university-based centers of excellence in homeland security, and fellowships for scientists and engineers to work within DHS;
- $60 million for development and prototyping of antimissile devices for commercial aircraft;
- $75 million for rapid prototyping activities helping to speed the deployment of new technologies by first responders and DHS employees;
- $127 million for development of radiological/nuclear countermeasures;
- $199 million for development of biological countermeasures;
- $52 million for development of chemical countermeasures;
- $10 million for protection against explosive attacks;
- $94 million for threat and vulnerability assessments;
- $21 million for investigation of emerging threats.

In addition, the DHS budget will include a request for $88 million to fund construction of the National Biodefense Analysis and Countermeasure Center in Fort Detrick, Maryland.

One of the major military technology initiatives of the last few years has been the deployment of the nationwide missile defense program. The DoD's 2004 budget provides over $9 billion to support the program, with a large amount going toward research and development for both ground and sea-based systems. Program leaders are confident that these systems will provide a limited defense against intercontinental ballistic missiles by late 2004. Other technologies driving growth in the defense and homeland security areas are remote sensing and global imaging. These systems allow users to gather detailed pictures of the earth and use them for mapping, national and regional security, and natural disaster/emergency response. As a result of September 11th, the need for detailed global imagery has increased substantially, creating new demand and business opportunities for companies involved in remote sensing and global imaging. Part of the $36.2 billion allocated to the Department of Homeland Security will help to encourage the development of the remote sensing/global imaging industry.

Another big contributor to the health of the defense industry is the willingness of the U.S. government to spend major dollars on defense. The Bush administration has clearly shown that defense is an important part of its policy, and as President Bush and Congress continue to emphasize both national security and the war on terrorism, the industry should see prolonged success. This is evident in Bush's September 7, 2003 address to the nation, in which he announced a request to Congress for an additional $87 billion to cover the cost of the growing military and restructuring needs in Iraq. The new request will bring the total amount spent on the Iraq war to roughly $166 billion. (White House 2003). While these funds are specific to the war effort and reconstruction, rather than research and deployment of new defense systems, companies providing equipment and supplies will benefit. Furthermore, the national commitment to finance defense at home and abroad, will continue to create opportunities for the industry.

In the ongoing effort to cut costs, the DoD is continuing to downsize the U.S. military and outsource many internal functions to private military companies (PMCs). As this trend continues, it creates more industry opportunity. In the past, functions like accounting and finance, health care, housing, and information systems have been the main targets for outsourcing. Now, many private sector firms are being tasked to actually get involved on the battlefield and provide logistics and support functions to the troops like food, water, and fuel. According to *Military Officer Magazine*, there are essentially three types of modern PMCs: military provider firms, military consulting firms, and military support firms (Kurlantzick 2003). Military provider firms offer battlefield training and, in some cases, they will enter combat. Military consulting firms offer training and advice to troops, but don't get involved on the battlefield. Military support firms provide logistics, transportation, and technical services. Currently, the DoD uses roughly 700,000 full and part-time contractors, and in a June 2003 address, Defense Secretary Donald Rumsfeld spoke of plans to turn over an additional 320,000 DoD jobs to civil service or contractor employees (Garamone 2003). This represents a clear movement towards the increased outsourcing of the U.S. military, something that thousands of private defense businesses will likely continue to take advantage of in the next few years.

There are also barriers and risks to participation in this industry. First of all, the industry is impacted by changes in government policy, regulation and budget allocation. What goes up can, and probably will, go down, due to changes in the legislative and executive branches of government, and in response to world conditions. The industry has experienced past downturns, which severely impacted companies that supplied goods or services specific to the government customer. During a past downturn in defense budgets and procurements, the government offered companies in this industry assistance to redesign defense products (no longer in demand) to address a commercial market. This strategy was employed in an attempt to retain the supplier capabilities that would be needed to respond to future demand and defense requirements.

Secondly, the industry is impacted by the loss of manufacturing capability within the United States as companies move production off shore to utilize lower-wage workers and remain cost competitive in a global economy. As a result, while defense contracts may go

to U.S. suppliers, the resulting production jobs may not benefit local economies in this country.

In addition, this industry is highly competitive with high barriers to entry, including:

- The size of government procurements which favor larger company suppliers;
- The highly regulated and complex procurement process;
- The low profit margins dictated by "low bidder" selection;
- Contract payment terms; and,
- Established product specifications, which create barriers for new product offerings.

The government has made efforts to try to level the playing field for small firms by requiring prime contractors to establish small business subcontract objectives, by providing research opportunities through the Small Business Innovation Research (SBIR) program, and by providing procurement preferences for small and disadvantaged companies and for small companies located in economically distressed areas or "Hub-Zones." The DoD's Small and Disadvantaged Business Utilization program has the goal of assisting small businesses to win 23% of the total DoD prime contracts, and 40% of the DoD subcontracts in 2003 (Office of Small and Disadvantaged Business Utilization 2003).

Colorado's Competitive Position

With all this money being earmarked for defense and homeland security, where does Colorado stand? The state is well positioned for business activity in the defense and homeland security markets. Historically, the former nuclear weapons program at Rocky Flats and the North American Aerospace Defense Command (NORAD) in Colorado Springs gained Colorado recognition as a player in national defense systems. In addition, some of the big national defense contractors have operations in Colorado. In 1997 (most recent data available) the top five defense contractors in Colorado received contracts worth a total of nearly $1.2 billion, with Lockheed Martin Corporation bringing in over $973 million (Colorado Office of Economic Development and International Trade 2003). Colorado is also home to a number of military bases (Buckley, Peterson, and Schriever Air Force Bases, and Fort Carson Army Base) and the U.S Air Force Academy in Colorado Springs.

Strengths

Colorado has a number of strengths that should help to attract and support defense and homeland security-related business.

An important advantage is the massive telecommunication and information infrastructure build up by companies like Qwest, IBM, and Level 3 Communications. A robust telecom infrastructure is necessary for the nation's defense and homeland security programs to succeed. As intelligence and information architecture receive greater attention from the

military, Colorado will be able to take advantage of its strong position in telecom and information systems. In fact, ISR Systems Group, a division of Lockheed Martin based in Colorado, was recently chosen (October 2003) to join a team of contractors awarded a $157 million from the U.S. Air Force to upgrade and integrate a number of intelligence systems.

In addition, the state is generally recognized as a center of excellence for space systems support, with companies like Lockheed Martin and Ball Aerospace at the forefront. Large and small Colorado companies provide the satellite, remote sensing, space imaging, and communications technologies utilized by defense systems. Indeed, Colorado is home to two growing companies that deal specifically with global imaging and remote sensing. DigitalGlobe, located in Longmont, and Space Imaging, located in Thornton, are leaders in the emerging field and will boost the state's position within the industry.

In addition, major government organizations in Colorado Springs attract companies to locate near their major customers, most notably, U.S. Northern Command (NORTHCOM), Air Force Space Command and the Space Warfare Center. In particular, Air Force Space Command provides market opportunities for Colorado's large defense contractors and emerging homeland security technologies. Air Force Space Command will be an important catalyst for industry to provide global situational awareness capabilities that meet defense requirements. Future growth for the industry will depend upon the amount of funding allocated for development of new systems; however, opportunities are expected in GPS III, space-based radar, transformational communications, and operationally responsive launch (Focus Group/Survey 2003).

NORTHCOM is also expected to create new opportunities for companies able to support its unique mission. Although DoD restructuring lost Colorado Springs the U.S. Space Command to Omaha, NE, it was quickly replaced by NORTHCOM, which was formally established on October 1, 2003. Based at Peterson AFB, this command will support federal agencies such as the FBI and Federal Emergency Management Agency, as well as civil authorities in times of emergency. It will combine all aspects of military homeland defense including NORAD (Hess 2002). In order to address NORTHCOM's needs, industry needs to understand this unique mission and identify market opportunities within its command and control, common operating picture, and data fusion requirements (Focus Group/Survey 2003).

Development of the nation's missile defense requirements is expected to be another driver for the Colorado industry. The Joint National Integration Center near Colorado Springs provides a state-of-the-art capability for the Missile Defense Agency (MDA) in testing, modeling, simulation, and analysis, as well as the control node for the Ballistic Defense Network. It provides missile defense related analysis, system level engineering, integration and test and evaluation support for development, acquisition, and deployment of air and missile defense systems and architectures (Joint National Integration Center 2003).

Network Centric Operations (NCO) is another new capability being developed and adapted to the needs of the military and homeland security. NCO is an environment where collaboration between platforms, systems, and devices, such as satellites, aircraft, or PDAs, is available to move critical information between sensors and effectors, such as fighter aircraft, ground vehicles, ships, satellites, reconnaissance platforms, soldiers, and decision-makers, to create unprecedented situational awareness. It is based on interoperability between networks using a common information and communication architecture (Boeing 2003). NCO systems will also be important in combat, defense of our homeland and the ability of first responders to minimize property damage and loss of life during manmade or natural disasters. Colorado innovative small and large firms will find opportunities for many technologies that support development and deployment of the NCO capability (Focus Group/Survey 2003).

Although homeland security is not directly part of the defense industry as we know it, various new requirements and funding for this area will stimulate additional economic growth for Colorado companies. Homeland security-related operations in Colorado received a boost in July 2003, when nearly $9.5 million in federal funds was finally received to be allocated to the state's first responders as part of the 2003 State Homeland Security Grant Program. According to the Office of the Governor of Colorado, the money will be used to purchase equipment, train personnel, identify and protect critical infrastructures, and conduct and evaluate training exercises that simulate terrorist attacks. In the near future, Colorado is expected to receive another $25 million in Part 2 of the grant program, pending approval by the U.S. Department of Homeland Security. This will support growth in various nondefense areas such as consultants, fire departments, police departments, and other public safety organizations. Industry leaders have suggested that some of this money could be spent to integrate educational and training programs for firefighters, police, etc., into the state's many public and private colleges, universities and technical schools. Some progress is already being made at Colorado State University. It was announced in October 2003 that the school received a $22.1 million grant from the National Institutes of Health. The money will be used to build a biodefense and infectious disease research center. It will be one of nine such biodefense labs in the country, and will employ 60-100 people when it is finished in 2005.

Another strength is the state's diverse university and industry technological capabilities in bioscience, photonics, telecommunication, software, advanced materials, and nanotechnology that support technical requirements of developing new defense and homeland security systems. For example, Colorado has many small, research-capable companies that obtain federal funding to conduct advanced research for federal agencies under the Small Business Innovation Research (SBIR) program. Since DoD has the largest budget to fund extramural R&D, this agency offers a variety of SBIR-funded research opportunities. Since 1983, Colorado companies have received 711 DoD Phase I SBIR awards with a total dollar value of $49,317,041, and 271 DoD Phase II SBIR awards with a total dollar value of $209,628,695 (TECH-Net 2003). The SBIR program grants the small company rights to patent their technologies, resulting in growth opportunities to sell the resulting technology product or service through a government procurement contract, and/or to develop a commercial application of the technology.

Since the military buys everything needed to support local bases and military personnel from commissary goods to smart weapons, there are opportunities for small companies to participate as subcontractors to large primes. In order to participate in government procurement, however, small companies may need initial assistance to overcome the barriers to entry previously cited. In addition, if small manufacturers in rural communities had access to technical assistance to help them identify and bid on appropriate government contracts, some rural and economically distressed areas could take advantage of government purchasing preferences based on Hub-Zone designations that currently cover Alamosa, Baca, Bent, Conejos, Costilla, Crowley, Dolores, Huerfano, Jackson, Kiowa, Las Animas, Lincoln, Montezuma, Otero, Phillips, Prowers, Rio Grande, Saguache, San Juan, Sedgwick and Washington counties; Indian Reservations, and portions of Adams, Arapahoe, Boulder, Delta, Denver, Elbert, El Paso, Fremont, Jefferson, La Plata, Larimer, Logan, Mesa, Pueblo and Weld (Small Business Administration 2003).

At a recent defense industry focus group meeting in Castle Rock, Colorado, conducted as part of this project, participants offered a number of other strengths on which they believe the state could capitalize (Focus Group/Survey 2003). These included:

- **Quality of Life**, which can attract a highly educated workforce.
- **Affordability**, especially when compared to other major defense states like California.
- **A young and highly educated workforce** that is willing to stay in Colorado and invest time and money into the state.
- **Geographic location** of the state. Its central location can be a benefit in terms of transportation and communication, and also security, as it is not located on a port of entry. Additionally, its many wide open, unpopulated plains offer an ideal space for live fire exercises for many branches of the military.

Weaknesses

Panel members also noted some major weaknesses and threats that must be addressed in order for Colorado to gain the most from future opportunities in defense and homeland security.

First is the need for expanded and improved education and training to meet future requirements in defense and homeland security. Like other states, Colorado has a need to provide training for first responders, emergency medical and security personnel. In addition, with NORTHCOM's presence in Colorado Springs, there is going to be an increasing opportunity for qualified and highly technical homeland security workers in the coming years. While the University of Denver has recently begun a degree program in the area of homeland security, there are simply not enough resources going toward the training of individuals throughout the state. Additionally, engineering programs in the state's universities have not been able to keep pace with the rapid development of defense-related technologies. There is a clear need for improvement in order to produce

graduates that possess the technical skills specific to these new technologies, and trained systems engineers that are capable of understanding defense-related architecture. Panel members suggested the state's schools look to places like Carnegie Mellon and George Mason as ideal models of such systems-engineering programs (Focus Group/Survey 2003).

Another big problem facing Colorado is the lack of aggressive representation in the fight for federal dollars. Focus group members stated that representatives from other states are consistently fighting for, and winning, large sums of money, enabling them to go after the development of homeland security and defense initiatives to benefit their states. They believe Colorado representatives have not even been entering these battles.

For the defense industry to really thrive in Colorado, there simply needs to be a higher mass of defense-related companies. Colorado can strengthen this cluster by more aggressively competing to attract new, larger businesses to the state. This may require more initiative from the state's political leaders. Discussions with a number of defense industry leaders concluded that one way to spur this kind of business development may be for the state to pursue additional NASA research funding and programs with the intent of locating a NASA research center in Colorado (Focus Group/Survey 2003). In addition, future market opportunities presented by NORTHCOM and the Joint National Integration Center, could be used to attract companies with appropriate technologies to locate near these facilities.

If the state is interested in pursuing the idea of attracting military training installations to rural Colorado, the state's telecommunications infrastructure would need to be more fully developed. Whereas the federal government would not likely bear the cost of such a development, an expanded broadband system could be a competitive advantage for the state.

One future threat to the defense economy in Colorado is the possible Base Realignment and Closure (BRAC) of Fort Carson army base. The closure of the base would force over 15,000 employees to look for new jobs (Colorado Office of Economic Development and International Trade). However, Fort Carson's most valuable assets, its training ranges, should be enough to keep the base running for at least a few more years. But if the military begins to cut back on the number of soldiers enlisted, as some experts predict will happen, Fort Carson may find itself in the crosshairs of BRAC once again.

Finally, panelists commented on something that seems to be a resounding statement among industry leaders throughout Colorado: the state is simply putting too much emphasis on quality of life as a major recruiting draw, and is ignoring the fact that financial incentives are usually the most important factor in bringing in new business. While quality of life is clearly a major strength in Colorado, it cannot attract new business entirely on its own.

Summary

The defense industry is a tremendously important component of the U.S. and Colorado economy. It is constructed from a myriad of different industries, including aerospace, biotechnology, telecommunication, software, and manufacturing. Defense installations provide civilian jobs and support local retail and service businesses. Defense procurement provides millions of jobs for America's workforce. This sector has managed to thrive in a time of economic instability. Military budgets are increasing steadily and will likely approach $500 billion within the next five or six years, creating a significant opportunity for companies with products and services needed by the U.S. military.

Colorado certainly stands to benefit from the upswing in the defense and homeland security requirements. The state is already home to a number of major defense-related organizations, including NORAD, U.S. Northern Command, Air Force Space Command and the U.S. Air Force Academy, as well as big defense contractors like Lockheed Martin and Ball Aerospace. These major customers, along with Colorado's high technology capabilities, quality of life, relative affordability, highly educated workforce, and strategic geographic location, creates a strong foundation from which the state can realize future economic benefits.

Colorado's high technology industries and research entrepreneurs will continue to find opportunities to develop and provide new products and technical capabilities to meet the needs of a highly mobile and specialized armed forces, as well as to help the country counter terrorist threats at home and abroad. The state could increase the economic impact of this private sector research by providing support services to assist small firms in commercializing their technology within the state (Eye 2002).

The role of Colorado's military installations in the nation's defense and homeland security mission will continue to attract and support a defense-related economy in the state. In addition, the current defense industry, the massive telecommunications backbone, and an excellent reputation in the space industry, will help attract more defense and homeland security jobs to the state.

Major policy changes are required if the state is to achieve its full potential in the defense and homeland security area. The robust telecom infrastructure that has been built up throughout the past few years should be extended into the rural areas of the state. Additionally, Colorado's colleges and universities must find ways to meet future workforce requirements with engineering programs that keep pace with emerging defense technologies, and development of specific homeland security training programs. Then, to compete with other states, Colorado's representatives need to be more aggressive in the fight for federal dollars. Finally, state legislators have to realize that it is imperative to provide financial incentives in order to compete in attracting major defense businesses to Colorado.

BIBLIOGRAPHY

American Association for the Advancement of Science (2003). *AAAS Analysis of R&D in the FY 2004 Budget.* <http://www.aaas.org/spp/rd/prev04p.htm>

Boeing (2003). *The Next Frontier-The Knowledge Age*. Strategic Architecture. <http://www.boeing.com/ids/stratarch/about_nco.html> December 4.

Colorado Office of Economic Development and International Trade (2003). *Colorado's Defense Contractors.* <http://www.state.co.us/oed/bus_fin/defcont.html> <http://www.state.co.us/oed/bus_fin/recommend.html>

Eye, Karen and G. Horvath (2002). "Economic Outcomes for Colorado Companies—A Survey of Colorado SBIR Award Winners." May.

Garamone, Jim (2003). *Civilian Personnel System 'Not Cutting It,' Rumsfeld Says.* DefenseLINK, U.S. Department of Defense, June 3. <http://www.defenselink.mil/news/Jun2003/n06032003_200306037.html>

Hess, Pamela (2002). *New Command will Protect U.S.* United Press International, April 17. <http://www.upi.com/view.cfm?StoryID+17042002-025410-2852r> December 4, 2003.

Joint National Integration Center (JNIC) (2003). About the JNIC. <http://www.jntf.osd.mil/general/about.asp> December 4.

Focus Group/Survey (2003). Defense/homeland security focus group and survey conducted in September.

Kurlantzick, Joshua (2003). "Warfare Inc." Military Officer Magazine. May. <http://www.moaa.org/magazine/May2003/f_warfare.asp>

Office of Small and Disadvantaged Business Utilization (2003). *Small Business Program Goals for FY 2002-2003.* U.S. Department of Defense. <http://www.acq.osd.mil/sadbu/programs/goals.htm>

Small Business Administration (2003). Areas of Colorado That Are Qualified as HubZones. <http://map.sba.gov/hubzone/hzqry.asp?state=co> October 21.

TECH-Net (2003). Statistics of SBIR awards- search for DOD awards to Colorado companies. <http://tech-net.sba.gov/tech-net/search.html> October 21.

U.S. Department of Defense (2003). *100 Companies Receiving the Largest Dollar Volume of Prime Contract Awards - Fiscal Year 2002.* <http://www.dior.whs.mil/peidhome/procstat/p01/fy2002/top100.htm>

_____ (2003). *Fiscal 2004 Department of Defense Budget*. <http://www.whitehouse.gov/omb/budget/fy2004/defense.html>

U.S. Department of Homeland Security (2003). *The National Strategy for Homeland Security*. < http://www.whitehouse.gov/homeland/book/nat_strat_hls.pdf>

White House (2003). *Address of the President to the Nation.* September 7. <http://www.whitehouse.gov/news/releases/2003/09/20030907-1.html>

TELECOMMUNICATIONS

Telecommunications is an important industry that contributes jobs and revenues to the economy. It is also a key component of the infrastructure that enables overall economic growth, creating new businesses and transforming business operations, through the use of "information technology." Information technology (IT) consists of computers, the software used to operate them, the telecommunications systems that link them, and the resulting web technology – the Internet, web sites, and web-based programs (Sommers 2003).

World Market Size and Expected Growth

According to the International Telecommunication Union, in 2002 there were over 2.2 billion telephone subscribers in the world, more than 1.1 billion main telephone lines, and close to 1.2 billion mobile cellular subscribers (International Telecommunication Union 2003). The year 2002 marked the first year that there were more cellular users than main telephone lines. This trend will likely continue as growth in the cellular sector is expected to greatly outpace the growth of main telephone lines in the years to come.

Additionally, in 2002 there were an estimated 615 million personal computers worldwide, or one computer for every 10.8 people. Internet users numbered 580 million, or 9.7% of the population (International Telecommunication Union 2003).

From 1992 to 2002, the number of main telephone lines increased from 572 million to 1.13 billion, a compound annual growth rate (CAGR) of 7.04%. The number of mobile cellular subscribers skyrocketed from 23 million in 1992 to 1.16 billion in 2002, a CAGR of 47.94%. During this time period the number of personal computers jumped from 155 million to 615 million, a CAGR of 14.78%. The number of Internet users world-wide grew at a CAGR of 55.54%, growing from 7 million users in 1992 to 580 million users in 2002. These numbers are expected to continue their rapid growth into 2003 and the years following (International Telecommunication Union 2003).

Total revenue for the world telecom industry in 2002 was $1.295 trillion. Approximately $1.02 trillion of that, 78.8%, was in the services sector, while the other 21.2%, $275 billion, came from the equipment sector (International Telecommunication Union 2003). The total revenue for the telecom industry has grown at a CAGR of 8.36% from 1992 to 2002. The services sector has grown at a slightly faster rate than the equipment sector. In 2003, the industry is expected to continue its expansion, with total revenue forecasted to be nearly $1.4 trillion (International Telecommunication Union 2003). According to the Telecommunications Industry Association, revenues are expected to reach $1.9 trillion by 2006.

National Market Size and Expected Growth

In 1995, there were approximately 160 million main lines and 34 million cellular subscribers in the United States. In 2002, there were 190 million main telephone lines,

and over 140 million mobile cellular subscribers. This represents a CAGR of 2.5% for main lines and 22.6% for cellular. In addition there were an estimated 178 million personal computers, or 1 computer for every 1.6 people. There were also 155 million Internet users, or 53.8% of the U.S. population (International Telecommunication Union 2003). Although these data show some growth in telephone lines over the past seven years, more recently local telephone access lines have not grown. This flat or decline in telephone line usage reflects customer movement to wireless replacements, over Internet services, and to high-speed services instead of second lines for fax or dial-up Internet lines (Focus Group/Survey 2003). According to research conducted by Plunkett Research, Ltd., in June 2001 there were over 9.6 million high-speed Internet lines (defined as over 200 kbps in at least one direction). This represents an increase of 120% compared to June 2000. This accelerated growth is expected to continue, with estimates of 40 million high-speed subscribers by 2006 (Telecommunication Industry Association 2003).

According to Covered Employment and Wage (CEW) Data, the U.S. telecommunications industry consisted of 42,213 firms in 2001. These firms employed 1.29 million workers and generated over $73 million in wages. The average telecom employee earned $56,476. This is 54% higher than the national average wage. Employment in the telecom industry is expected to increase by 12% over the next 10 years. This is slightly less than the 15% growth rate projected for all industries combined (U.S. Department of Labor 2003).

In 1996, Congress passed the Telecommunications Act of 1996. This act was designed to increase competition within the telecom market. The legislation allowed for competitive local-exchange carriers (CLECs) and Interexchange Carriers (IXCs), along with cable companies, broadcasters, gas and electric utilities, and wireless service operators to offer local and toll calling previously only offered by the Regional Bell Operating Companies (RBOCs, often referred to as the "baby bells"). It also forced the RBOCs to open their networks to their competitors. Along similar lines in October, 2003, a U.S. appeals court ruled that cable companies will also have to grant their competitors access to their high-speed networks. At the same time, "baby bells" were allowed to sell cable and TV services and phone equipment, and also to provide long distance services. The act also decreed that the "bells" would not have to share any new broadband networks that they may build. In response to the competition resulting from these provisions, "baby bells" have already increased spending significantly and may need to invest even more if they decide to build fiber-to-the-home networks in order to compete in the future.

Since the Telecommunications Act of 1996 was passed, the industry has received $1.3 trillion from investors. However, since March of 2000, the industry has lost more than $1 trillion in market value. The telecom collapse was at the center of the economic recession that began in 2001 (Yahoo Business 2003). In the past two decades, U.S. telecom firms have spent more than $30 billion constructing over 90 million miles of fiber optic cables. As much as 90% of this network capacity remains unused (Yahoo Business 2003). As a result of this extensive spending, many telecom firms have struggled with debts, mass layoffs, and drastic decreases in capital spending.

In 2002 total revenue in the U.S. telecommunications market was $681 billion, up 3.5% from 2001. Large increases in wireless services, services in support of equipment, and high-speed Internet access offset the 15.4% drop in equipment spending (Telecommunication Industry Association 2003).

In 2003, the TIA expects the market to begin a recovery. Total revenues are forecasted to grow 8%, to $736 billion. This growth will be led by the specialized services category, a sector that consists of high-speed Internet access, unified messaging applications, and videoconferencing and audio-conferencing services. Revenue in this sector is estimated to increase 37% in 2003, and will continue to grow at a CAGR of 26% through 2006. With increased revenues in this sector, companies will begin spending more on equipment. Revenue in the equipment sector is expected to rebound, rising at a 7.1% CAGR over the next four years (Telecommunication Industry Association 2003). The wireless segment of the industry is expected to experience revenue growth at a 9.6% CAGR over the next four years (Telecommunication Industry Association 2003).

Of particular interest in the wireless sector is a revolutionary new technology called Wi-Fi. Wi-Fi, short for wireless fidelity, is a wireless local area network (WLAN) that is capable of delivering information at speeds up to 11 Mbps in the 2.4-GHz band, with a range of about 300 feet. A small box can distribute broadband Internet and a card connected to your PC, laptop, cellular phone, or PDA can receive it. About 12 million Wi-Fi packages were sold in 2002, and sales are expected to double in 2003 (Anderson 2003). Research company Pyramid has predicted that there will be almost 700 million people using Wi-Fi services by 2008 (M2 Communications 2003). Laptops are already beginning to have Wi-Fi cards built in and public Wi-Fi networks are springing up across the country. Right now, many people can go to airports, cafes, hotels, or city parks with their laptops and connect to a Wi-Fi network for free. As the technology improves, and security concerns are quelled, private enterprises should begin installing Wi-Fi networks. The opportunities presented by this technology are endless. David Reed, the MIT Media Lab adjunct professor, calls Wi-Fi "expandable and scalable without bound" (Anderson 2003). Because the photons that make up radio signal can pass through each other, the airwaves are unlimited and can be shared by all. Although it is still too early to tell exactly what impact Wi-Fi will have, the technology could potentially revolutionize the entire telecommunications industry. Some people are comparing it to the birth of the Internet, the rise of local area networks, or the arrival of the Web browser. According to Teresa Meng, electrical engineering professor at Stanford, "Five or ten years from now, we won't worry about communication with wires" (Anderson 2003). Overall, the wireless LAN market is expected to grow from $1.5 billion in 2002 to $3.1 billion by 2007, according to market research firm Dell'Oro group (PBI Media 2003).

Another area of potential growth in telecom is web conferencing services. In the aftermath of September 11th, the ongoing threat of terrorist attacks, and the various other international conflicts, business travel is being reduced. The slumping U.S. economy is also causing businesses to cut costs wherever possible. All this is good news for the web conferencing market. Demand is already beginning to increase. In Europe, the market was valued at EUR12.6 million in 2002, and is predicted to rise to EUR237 million by

2009 (M2 Communications 2003). Web conferencing services could take off in the United States as well.

Another major trend is the increased movement to Voice over Internet (VoIP). Speaking at a telecommunications conference in September, Jeff Pulver of Pulver.com indicates that technologies like broadband, Wi-Fi and satellite have triggered an inexorable shift of voice traffic to alternative networks. With at least 100,000 people using VoIP today, estimates are that telcos will see up to 40% of fixed-line traffic leak away to other systems in five to seven years. Analyst group In-Stat/MDR believes there will be 7 million VoIP phones in circulation by 2007. To counter this potential leakage of revenues, U.S. and European telcos are beginning to introduce their own IP communication services (electricnews.net 2003) (Charny 2003).

Overall, total revenue in the U.S. telecom industry is expected to increase at a 9% CAGR from 2003 to 2006, reaching $936 billion (Telecommunication Industry Association 2003).

U.S. Industry Segments

According to the North American Industrial Classification System, the Telecommunications industry can be broken down into the following sectors:

- NAICS 5171 – Wired Telecommunications Carriers
- NAICS 5172 – Wireless Telecommunications Carriers
- NAICS 5173 – Telecommunications Resellers
- NAICS 5174 – Satellite Telecommunications
- NAICS 5175 – Cable and Other Program Distribution
- NAICS 5179 – Other Telecommunications

The following chart summarizes the employment data for the U.S. Telecommunications industry.

TELECOMMUNICATIONS INDUSTRY EMPLOYMENT

NAICS	Description	2002 Employment (000s)	% of Total Telecom	Employment CAGR 1993-2002
517	Total Telecommunication	1,200.9	---	2.7%
5171	Wired Telecom Carriers	662.4	55.2%	0.7
5172	Wireless Telecom Carriers	195.9	16.3	14.9
5173	Telecom Resellers	185.7	15.5	1.0
5175	Cable and Other Program Distribution	128.0	10.7	6.0
5174/ 5179	Satellite Telecommunications/ Other Telecommunications	28.9	2.4	7.5

Source: Bureau of Labor Statistics, Current Employment Statistics (CES) data.

In 2002, the largest subsector in the telecom industry was wired telecom carriers, which made up over 55% of total telecom employment. This was followed by wireless telecom

carriers, telecom resellers, and cable and other program distributors. The satellite and other telecom subsectors combined for just 2.4% of total telecom employment.

From 1993 to 2002, employment in the telecom industry has grown at a CAGR of 2.7%. The fastest growth has been in the wireless subsector, which has grown at a 14.9% CAGR. The wired telecom carriers subsector has had the slowest growth, with a CAGR of 0.7%.

It should also be noted that there is significant employment in several manufacturing industries related to telecommunications, including NAICS 3342 – Communications Equipment, NAICS 335313 – Switchgear and Switchboard Apparatus, NAICS 335314 – Relay and Industrial Controls, NAICS 33592 – Communication and Energy Wires and Cables, and NAICS 33593 – Wiring Devices. Following the trend of manufacturing in general, employment in the majority of these industries has declined steadily over the last 10 years.

Colorado Industry Trends

Background

For years, Colorado has been a major player in the area of telecommunications. In the late 19th century, as the phone system expanded throughout the country, Denver became the hub of the nation's longest north/south telephone line. Since then, Denver has continued to be a key location for telephone companies. Due to the area's geographic location, and strong military presence, Colorado became a leader in the field of satellite communications in the 1940s. This continued during the cold war and laid the groundwork for the tech boom in the 90s. Denver was also the birthplace of cable television, more than 50 years ago, and the city has held its position as a cable center. Today, Denver is home to The Cable Center, an independent, global institution that works with the cable industry. These three developments gave rise to the term "Convergence Corridor" to describe Colorado as the place where telecommunications, satellites, and cable television come together. This, along with the quality of life in Colorado, the concentration of telecom-related industries, especially photonics and software, and the highly educated workforce, makes the state an attractive place to locate a telecommunications business.

Historically, the strength of Colorado's telecom industry has been in setting up and running cable and telephone networks. Telecom equipment manufacturing, although present, has never been prominent in the state. This trend is expected to continue as the state's telecommunications industry builds on its strengths in satellite and cable network services.

Employment and Wages

In 2002, Colorado's telecommunications industry employed 39,700 people, representing over 3.3% of the total telecom employment in the United States. These 39,700 telecom

employees make up over 1.8% of Colorado's total employment. Nationally, telecommunications comprises just over 0.9% of all jobs. Location quotients (LQ) are commonly used to measure the concentration of an industry in a state relative to the nation. An LQ greater than 1 means the state has a relatively high concentration in that industry. The Telecommunications LQ for Colorado was 1.97 in 2002.

In 2002, there were 1,010 telecom companies in the state. These firms paid out a total of $2.69 billion in wages. Average wages in the telecom industry for 2002 were $67,842, this was 79% higher than the state's average wage for all industries combined, and 20% more than the national average for telecom employees.

From 1993 to 2002, employment in the telecom sector has doubled in Colorado, with a CAGR of over 6.7%. Telecom employment growth in Colorado has been nearly two and a half times faster than that of the nation.

Recent Developments

However, over the last couple of years, telecommunication companies in Colorado have struggled mightily. The telecommunications industry collapse has been blamed as part of the reason the state's economy is so weak today. Bankruptcies, mergers, and acquisitions have resulted in the loss of thousands of jobs. Between January of 2001 and March of 2002, an average of 585 communications jobs was lost each month (Business Research Division 2002). These cuts continued through the end of 2002, and into 2003. Qwest, AT&T, WorldCom, Sprint, and many other telecommunications companies have all announced huge layoffs since 2001. Financial and legal struggles have also plagued the industry. Many people cite excessive optimism, excess capacity, lack of adequate funding, decreased demand, and poor management as sources of telecom's woes.

How bad has the telecom collapse in Colorado actually been? According to employment and wage data from the Colorado Department of Labor, in the first quarter of 2001 there were 1,154 telecom companies in the state, employment totaled 48,893, and wages exceeded $871.2 million. Since then, the number of companies has dropped by 16%, to 968 in the fourth quarter of 2002. Employment fell to 37,585, a 23.1% decrease, and total wages fell 28.4%, to $624.2 million. Average wages have also fallen 7%, from $71,277 in Q1 2001 to $66,430 in Q4 2002.

It is important to note that while there has been a significant downturn in the telecommunications industry over the last couple of years, overall, the industry has still grown dramatically since 1993. Employment rose sharply during the 90s and then fell considerably in 2001, but remained well above employment levels of the early 90s.

Future Outlook

What will lead to the revival of the telecom industry in Colorado? Initially, it is presumed that as the economy as a whole starts to recover, the telecommunications industry will benefit. Additionally, a recent article in the *Denver Business Journal*, pointed to the

emergence of new technology, both within the telecom industry and in related areas that are expected to stimulate growth in the industry. New technologies, particularly in the area of photonics, are promising for telecommunications. Moreover, as technologies in areas such as digital media improve, demand for telecom services and products should increase. However, technology will only drive growth if it is useful, applicable, and beneficial. The article warns that relying on the latest and greatest technology to save the industry is unrealistic. The real turnaround might take place in bankruptcy court. Companies that cannot survive will file for bankruptcy, and will unload their assets. Surviving companies will be able to buy these assets at significant discounts, enabling them to grow and thrive, thereby leading the way to recovery (Bryer 2002).

Colorado industry experts are generally optimistic about the future of telecom in Colorado. Mass layoffs in the industry have created a large group of skilled, experienced employees looking for work. With the labor pool already in place, Colorado will be an attractive place for new or relocating companies. Additionally, companies that laid off large portions of their workforce are now dealing with the problems of being greatly understaffed. As customer service becomes a bigger concern, many of these companies will have to re-hire many of the positions they eliminated. Furthermore, new technologies such as web conferencing services, voice over IP and cable, broadband wireless, and Wi-Fi, are expected to stimulate demand in the industry. The passage of the Homeland Security Act of 2002 has also made funds available for security-related telecom products and services. While this has not fueled growth in the industry yet, it offers significant potential. If these markets can be capitalized on, the industry should recover in the state (Focus Group/Survey 2003).

Growth Barriers

Several barriers will need to be overcome in order for growth to occur. Many businesses find Colorado's tax structure overly complicated and burdening. Additionally, state regulatory decisions can often negatively affect the industry. It also appears that state development efforts may currently be focused away from telecommunications in an effort to diversify the economy. Another issue is lack of funding for universities and subsequent cutbacks on telecommunications programs and faculty, which hurts the educational foundation that is needed to generate skilled employees, and in turn, attract new companies to Colorado (Focus Group/Survey 2003).

Some telecommunication-based service companies are increasingly relocating their operations, especially call centers, in more affordable areas outside the state and overseas. This trend is eliminating some local jobs. While these barriers impede business, none of them are insurmountable (Focus Group/Survey 2003).

Growth Strategies

If Colorado's telecommunications industry can overcome some of the barriers summarized above, then it will open the door for growth. The state legislature can work to create a more business-friendly atmosphere, and a simplified tax structure. With

increased state funding for higher education, higher tuition rates, and help from private businesses and donors, the universities in the state could renew and improve their telecommunications programs. As the industry recovers and state government recognizes its future potential, new economic development efforts targeted to telecommunications could capture additional growth from the industry and from general business production enabled by a strong telecommunications infrastructure (Focus Group/Survey 2003).

Colorado's central location in the United States and time zone are both attractive to call-centers. While wages in the Denver/Metro area are too high to attract call-centers, they could feasibly locate in some of the state's rural areas. As broadband technology becomes available to the rural areas of the state, the concept of a virtual call center, where employees can work from their homes, could be a potential growth area for Colorado, given the state's high quality of life (Focus Group/Survey 2003).

Additionally, the state already has a high concentration of knowledgeable, well-trained individuals, who know the industry. Many of these individuals are looking for work, due to the recent layoffs. Add to this the strength of Colorado's software and photonics industries and the state's investment in broadband access, and the state becomes an appealing location for new or relocating companies.

Telecommunications and Widespread Economic Growth

In addition to the economic potential of growth in the telecommunications industry, improvement of the state's telecommunications infrastructure has the potential to generate economic growth in all industries, from agriculture to retail, and to extend that growth to all areas of the state. Information technology is impacting regional economic development strategies in ways that change as the technology and its uses change. For example, IT is creating these opportunities and challenges for economic development:

- As companies are able to access and utilize telecommunications infrastructures, both technology-based and traditional firms are utilizing IT to design and manufacture products, purchase materials and services, cut costs, out source functions, and link to customers.
- IT enables large companies to segment functions to different locations throughout the United States and abroad, creating opportunities for communities with broadband access to attract functions that best fit its resource base, e.g. financial services, data processing, distribution, production, R&D, or sales.
- IT also creates new criteria for firm relocation decisions. Adding broadband capacity to a skilled labor force and good business environment, can give communities an edge in recruitment of businesses.
- IT helps firms do business internationally and to outsource key functions to gain efficiency, profitability, or competitiveness. As a result, communities must now compete globally for firms, portions of firms, and employment opportunities (Sommers 2003).

As the technology continues to improve, the idea of the "virtual office" is becoming a reality. It is increasingly easy and inexpensive for employees to work at home. This means a person living in Durango does not have to relocate to Denver. It is feasible to work for a Front Range company, and still reside on the Western Slope. As awareness of these opportunities grows, businesses will benefit with increased productivity and globalization, the state's rural counties will benefit with economic diversification and job growth, and the telecom industry will benefit with increased revenue.

In an effort to make these opportunities available to people in the state's rural areas, Colorado has embarked on the Multiuse Network (MNT) Project. The state contracted with Qwest Communications International Inc. to build a high-speed data network stretching to each of the state's 64 counties. By providing Internet access to every county in the state, the project takes the first step in the "last-mile" solution. The last-mile issue now becomes making broadband Internet access available to every household and business within these counties. By making high-speed, broadband Internet available to rural areas at affordable rates, the state will foster growth in small businesses, and benefit local governments. New businesses will be more likely to locate in these areas, and new jobs could be created. Broadband technology has the potential to jumpstart rural economies. As of September 2003, 62 of the 70 planned ANAPs (aggregated network access points) are completed, with the additional 8 scheduled to be completed by the end of the year. As long as the state continues to support this and similar endeavors, Colorado will reap the economic benefits (Colorado Department of Personnel and Administration 2003).

Summary

Colorado's telecommunications industry is at a major crossroads. The industry experienced rapid growth through the 90s, and the state became known as a major telecommunications center. However, in 2001, the telecom industry began its downward spiral. In the ensuing months, thousands lost their jobs as companies struggled with bankruptcy and legal troubles. Now, with both state and national economic recoveries on the horizon, the industry is poised to turn around. While the growth levels seen in the 90s will likely never be replicated, the future appears to be bright. Colorado's large pool of unemployed telecom workers; concentration of software, photonics, and other telecom-related industries; and quality of life can attract new companies. Existing companies should benefit from reduced competition, the affordable assets made available through bankruptcies, and exciting new technological advancements. By eliminating and/or working around some of the barriers that impede growth, the recovery should be expedited.

In addition, expansion of the state's telecommunication infrastructure would be beneficial to both new-economy industries and traditional industries. Advanced telecommunications services can help businesses improve quality, efficiency, speed, and service. Expansion of current efforts by the state to provide "last mile" access to broadband, will bring these benefits to Colorado's rural communities and help equalize economic opportunity in all areas of the state.

BIBLIOGRAPHY

Anderson, Chris (2003). "The Wi-Fi Revolution." *Wired Magazine*. May. <http://www.wired.com/wired/archive/11.05/unwired/wifirevolution_pr.html>

Bryer, Amy (2002). "Ailing Telecom Industry Needs a Path to Recovery." *Denver Business Journal*. September 30. <http://www.bizjournals.com/denver/stories/2002/09/30/story2.html>

Business Research Division (2002). *2003 Colorado Business Economic Outlook.* University of Colorado at Boulder.

Charny, Ben (2003). "California to regulate VoIP providers." CNET News.com, September 30. <http://news.com.com/2102-7352_3-5084711.html?tag=st_util_print> (November 13, 2003).

Colorado Department of Labor and Employment (2003). *ES202 Employment and Wage Data.* <www.coworkforce.com/lmi>

Colorado Department of Personnel and Administration (2003). Division of Information Technologies. *The Multi-Use Network Project.* <http://www.colorado.gov/dpa/doit/mnt/>

Electricnews.net (2003). "Shift to voice over IP underway," electricnews.net, September 25. <http://www.theregister.co.uk/content/5/33028.html> November 13.

Focus Group/Survey (2003). Telecommunications focus group and survey conducted in September.

International Telecommunication Union. *Key Indicators of World Telecommunications.* <http://www.itu.int/ITU-D/ict/statistics/>

M2 Communications, Ltd. (2003). *Pyramid Expects Wi-Fi User Growth to 2008.* Telecomworldwire. July 28.

_____. (2003). *Web Conferencing Market at E231m in 2009, Report.* July 17.

Maloney, Nikki (2002). "Denver…The Convergence Capital: An Overview of What's Driving Denver's High Tech Boom." *Technology Community.* July/August. <http://www.colorado.edu/cubac/archive/tcom29.html>

PBI Media, LLC (2003). *$3.1B.* Communications Today. August 8.

Plunkett Research, Ltd. (2003). *Telecommunications Industry Statistics.* <http://www.plunkettresearch.com/telecommunications/telecom_statistics_3.htm>

Sommers, Paul and D. Carlson (2003). *What the IT Revolution Means for Regional Economic Development*. The Brookings Institute. February.

Telecommunication Industry Association (2003). *2003 Telecommunications Market Review and Forecast.* <http://www.tiaonline.org/media/press_releases/index.cfm?parelease=03-14>

U.S. Department of Labor (2003). *CES and CEW Data.* Bureau of Labor Statistics. <www.bls.gov>

Yahoo Business (2003). *Telecommunications Services Industry Profile.* <http://biz.yahoo.com/ic/42.html>

BIOSCIENCE

The bioscience industry is comprised of a diverse group of companies employing life-science technologies to develop and commercialize new therapeutics and diagnostics, instruments and devices, services, and products, for improving human health, food production, and the environment. In addition to firms classified as "biotechnology" (those that use cells and biological molecules for applications in medicine, pharmaceuticals, research and testing, industry, environment, and agriculture), this broader definition includes medical devices and instruments as an important element of the industry sector in Colorado. The medical device segment of this sector in Colorado has not been extensively studied and both source and secondary materials are scanty. Primary research will be required to fully profile the current economic contributions and future economic growth potential of this segment. As a result, many of the references and studies cited pertain to the more limited biotechnology sectors.

National and International Trends

Biotechnology Sector

The mapping of the human genome completed in June 2000 was a revolutionary breakthrough expected to generate new bioscience discoveries in medicine and diagnostics for years to come. Currently human medicine, diagnostics, and therapeutics account for 95% of biotechnology revenues (Cortright 2001).

Biotechnology is a global industry driven by international research collaborations and increasing investor focus on the quality of the intellectual property rather than on location. In addition, companies develop international alliances to access capital, market penetration, and expertise. A major driver toward globalization is the need to bring products to market faster, necessitating vertical integration through strategic alliances and outsourcing to other firms for timely acquisition of specific technical and business components. In addition, an increasingly competitive financing environment is motivating more industry consolidation, which is expected to strengthen the financial condition of remaining firms (Ernst and Young 2003b).

In spite of declines in the overall global economy, global biotechnology revenues increased 15% in 2002 to more than $41 billion. At the same time, investment in R&D increased 34% to more than $22 billion. Biotechnology research continues to produce new innovations that are translated into new products for the marketplace (Ernst and Young 2003b).

According to data from Standard and Poor's and the U.S. Department of Commerce, the current global market for medical devices is approximately $165 billion and has a projected growth rate of 5-10%. Pharmaceuticals sales in 2000 totaled approximately $150 billion (Carnegie Mellon 2001).

Based on data from Dun & Bradstreet for the period 1998 to 2002, U.S. employment in the biosciences grew by 120,679 jobs or 11% (Battelle Memorial Institute 2003).

Both within the United States and globally, the biotechnology sector has been particularly hard-hit by the market downturn of the past few years. The table below illustrates this for the U.S. biotechnology sector. Employment in the industry has declined approximately 12% over the last four years and currently is 142,900. Somewhat surprisingly, the number of firms has increased 15% and is currently at 1,466. The sharp declines in the stock market can be seen in both the sharp drop in market capitalization, the total value of publicly traded biotech companies at market prices, and the small number of IPOs in the last two years. While revenues in the sector have increased, so have net losses (Ernst and Young 2003a). Similar results are seen in the global biotechnology market. The United States is the top biotechnology country in terms of the total number of public and private firms (Ernst and Young 2003b).

U.S. BIOTECHNOLOGY INDUSTRY

	1999	2000	2001	2002
Number of employees	162,000	174,000	142,800	142,900
Number of firms	1,274	1,379	1,457	1,466
Number of IPOs	11	56	4	4
Market capitalization (public) (in billions)	$353.5	$330.8	$290.4	$189.5
Revenues (in billions)	22.3	25.0	29.6	33.6
Net Losses (in billions)	5.6	5.8	6.8	11.6

Sources: Ernst and Young (2001), *Focus on Fundamentals: The Biotechnology Report* and Ernst and Young (2003), *Resilience: Americas Biotechnology Report 2003* (Summary).

One result of the decline in stock market values is that it more clearly highlights the stratification among biotechnology firms. Companies with products on the market and experienced leadership are doing much better than newer firms with products in the early stages of development and little funding. The number of biotechnology firms in the market is expected to result in increased consolidation in the industry through merging, cutting employees and costs, or exiting from the industry (Ernst and Young 2003a).

Another consequence of the decline in the stock market is that public offerings, a significant source of funding for biotechnology firms, are gone. At the same time, because of increased consolidation in the pharmaceutical industry there are fewer companies to partner with, another major source of biotechnology funding. This means there will be increased competition for a declining pot of venture capital funding (Ernst and Young 2003a).

In the United States the industry continues to face lengthy testing and clinical trials for new drug development, which increase costs and lengthen time to market. In addition, political and societal pressure for containment of medical and pharmaceutical costs creates uncertainties and risks for companies and investors. Government regulates everything from patent policy, to approval of safety and efficacy, to conditions for manufacturing pharmaceuticals, advertising to consumers, and coverage in national health-care programs (Cortright 2001).

The development and commercialization of new biopharmaceutical products is risky, uncertain, lengthy, and expensive. Even though NIH funds about 25,000 research projects and an average of 5,500 new biotechnology patents are granted each year, only about 100 biotech-related drugs have actually reached market in the past 30 years and the top 10 of these account for nearly all of the sales. Biotech firms need to cover the cost of expense laboratory facilities and legal fees to protect intellectual property even before commercial prospects can be ascertained (Cortright 2001).

Medical Devices and Instrumentation

In 2001, the U.S. medical device industry generated approximately $47 billion. Of this, 65% was produced by large companies with over $500 million annual revenues, 25% was produced by medium-sized firms ($100 to $500 million annual revenues), and 10% was produced by small companies with less than $100 million annual revenues (Followwill 2002).

The U.S. industry size and composition, as profiled below, indicates a total of 5,267 firms with 363,058 employees in 2001. Medical technology is a source of high paying jobs with workers earning 49% more than other private sector employees (Followwill 2002).

PROFILE OF U.S. MEDICAL DEVICES MARKET (2001)

SIC	Sector	Firms	Employees	Est. sales (bil)
3841	Surgical medical instruments	1,171	136,291	$20.8
3842	Orthopedic, prosthetic surgical appliances/supplies	2,006	96,319	13.4
3843	Dental equipment/supplies	778	27,797	4.0
3845	Electromedical, electrotherapeutic apparatus	471	62,384	9.6
3851	Ophthalmic goods	841	40,267	3.8
	Total	5,267	363,058	$51.5

Source: (Followwill 2002) Source: Harris Infosource, defined by SIC codes

The United States is the world's largest producer of medical devices with 9 of the top 10 medical device companies based here. In addition, much of the recent growth is in the north central United States, an area that experienced a 53% increase in the number of medical device firms from 1997 to 2001 (Followwill 2002).

Time to market is much shorter for medical device development and deployment with an estimated three to five year timeframe, providing a more attractive option for venture funding (Focus Group/Survey 2003). In 2001, venture capital funding for medical device companies was $1.6 billion with an average deal size of $10.5 million (Followwill 2002).

Trends in the valuations of U.S. venture-backed companies show a steady increase in valuations for the medical device sector:

MEDIAN PRE-MONEY VALUATION BY INDUSTRY GROUP ($mil)

Annual totals	1997	1998	1999	2000	2001	2002
Biopharmaceuticals	$15.0	$19.0	$20.0	$25.3	$22.0	$15.1
Medical Devices	$12.1	$11.5	$13.4	$18.6	$18.4	$20.6

Source: (Venture One 2003)

Growth Opportunities

The commercial potential of bioscience discovery over the coming decade is enormous. Biotechnology companies are just beginning to utilize the potential of new understanding of the human genome for the development of preventive therapies, vaccines, and therapeutics.

Beyond health care, biotechnology encompasses many growth applications in agriculture, industry, and environment. The interrelationships of bioscience with other emerging technologies will be a significant growth trend in the future. New products and applications will be made possible through the convergence of biotechnology with devices, information technologies, photonics, and nanotechnology. Some examples of these growth areas include:

- Bioinformatics – Advances in information technology provide the storage and computational power needed to manipulate large data sets such as the human genome. Research areas include molecular modeling, genomics, proteomics, and physiomics.
- Industrial – biotechnology uses enzymatic reactions in manufacturing processes to replace current noxious chemicals that produce hazardous waste. For example, biotechnology processes are being applied to production of detergents, starches, food, pulp and paper, and textiles. In addition to clean production processes that reduce pollution, biotechnology also works to increase efficiency and reduce production costs. In 2001, Cargill Dow and DuPont began producing compostable biopolymers from the sugars in field corn. This bioplastic is competitive with petroleum-based plastics and polyesters in both price and performance. The biopolymer can be used to produce packaging materials, clothing, and bedding products. Biofeedstocks can also be used to create energy for the production process (Biotechnology Industry Organization 2003b).
- Agriculture – biotechnology is applied to improved food and animal production through genetic engineering to increase traits such as resistance to pests, disease or drought, weather and soil condition, and to increase crop yields, improve flavor or nutrition. According to the National Center for Food and Agricultural Policy's 2002 report, in 2001 the eight transgenic crop varieties adopted by U.S. growers increased yields by 4 billion pounds, saved growers $1.2 billion in production costs and reduced pesticide use by 46 million pounds. Biotechnology-based animal health products and services is estimated to be $2.8 billion and expected to grow to $5.1 billion by 2005. Biologics are used to detect, treat, and prevent diseases, improve animal breeding, increase nutritional value of feed, and

stimulate growth for livestock, swine, and poultry production (Biotechnology Industry Organization 2003a).

- Nanotechnology – Biotechnology advances using enzymes, proteins, and small organic molecules are applied to synthesis and assembly of very small-scale materials and devices with applications in a variety of industries such as semiconductor, computer, and information technologies (Ernst & Young 2000).
- Environmental Biotechnology – Living organisms such as microbes, fungus, and bacteria are used for hazardous waste clean up, sewage treatment, to identify and filter manufacturing waste, and to remove pollutants from water and soil. Biotechnology is also used to monitor and diagnose harmful organic pollutants, including applications that detect explosives at old munitions sites (Biotechnology Industry Organization 2003b).

The biggest market for medical devices is cardiovascular with a worldwide market of $14.7 billion. Predicted future growth sectors include cardiovascular, orthopedics, minimally-invasive applications, drug delivery, plastic surgery, pain management, neurology, and applications for chronic conditions such as diabetes, arthritis, cancer, AIDS, and obesity. The future also involves the convergence of devices with other technology advances in information technology, biotechnology, drugs, and medical imaging (Followwill 2002).

Like other areas of healthcare, the medical device sector will be impacted by higher costs and Medicare budget limitations and lengthy reimbursement processes. In addition, concerns about bioterrorism have made the infection control and disposables market more important. With a chronic labor shortage of nurses, devices that reduce labor requirements, improve healing, automate nursing functions, and save costs will also have a market advantage (Followwill 2002).

Colorado's Bioscience Industry

Bioscience is a small but growing part of Colorado's economy. In 2002, Colorado had 604 bioscience establishments or business locations. This translates roughly into 200 companies of which about 60 are biotechnology, 100 are medical device companies, and 20 are pharmaceutical and some are "other." Between 1995 and 2002, the number of bioscience firms increased 35% in Colorado, compared to 29% nationally. In 2002, Colorado employed 17,681 individuals in bioscience jobs, 0.76% of Colorado's private sector employment. Although a small share, this was a 4.3% increase from 1995 (Battelle Memorial Institute 2003) (Focus Group/Survey 2003).

Bioscience jobs on average pay significantly more than other private sector jobs. The chart on the next page compares average annual earnings in bioscience industry segments with average earnings for the private sector as a whole.

COLORADO AVERAGE ANNUAL EMPLOYEE EARNINGS (2000)

Industry Sector	Average Annual Employee Earnings
Research and Testing (Biotechnology)	$64,331
Drugs and Pharmaceuticals	54,473
Medical Devices	47,018
Organic and Agricultural Chemicals	42,423
Entire Private Sector	37,553

Source: Battelle 2003, page 2.

Currently, the largest component of Colorado's bioscience industry is medical devices, employing 11,973 representing 68% of Colorado's employment in bioscience. Between 1998 and 2002, however, the state experienced a 5% employment decline in this segment while the nation's medical device industry grew at 2% (Battelle Memorial Institute 2003).

Drugs and pharmaceuticals are the 2nd largest sector of Colorado's biosciences, employing 2,782. Organic and agricultural chemicals are the smallest sector, employing 576 (Battelle Memorial Institute 2003).

In terms of total number of firms, biotechnology is a small but fast growing component of the Colorado bioscience industry. Depending again on definition, there are approximately 30 (Fletcher 2003) to 60 (Focus Group/Survey 2003) biotechnology companies in Colorado with the majority of them private. Colorado's employment in biotechnology grew by 95% between 1998 and 2002, compared to 34% employment growth nationally over this timeframe (Battelle Memorial Institute 2003). However, similar to national trends, market capitalization of Colorado public firms fell significantly over the past year (48% compared to 35% nationally). Also similar to national trends, a number of Colorado's biotechnology firms have merged with other firms (Fletcher 2003).

Colorado's bioscience industry is composed primarily of small firms. Many biotechnology firms are in the research and development stage; which is the fastest growing segment of Colorado bioscience. The industry is highly concentrated geographically in the Denver-Boulder-Greeley CMSA, which account for 80% of the state's bioscience employment and 73% of its firms (Battelle Memorial Institute 2003).

Colorado's Competitive Position

A number of studies have identified factors required for a successful bioscience sector These factors include: strong academic research institutions that are conducting basic research in biosciences and are actively engaged with industry; the presence of local venture capital for all stages of business cycle; access to specialized facilities and equipment in close proximity to universities; a highly skilled workforce; a stable and supportive public policy structure; federal or other R&D support and successful transfer of government-funded research to commercialization.

Biotechnology Sector

While Colorado has strong academic research activity in the biosciences, which is a prerequisite for a successful biotechnology cluster, it is not sufficient. In addition, a successful biotechnology center must have the ability to commercialize research discoveries. This requires an entrepreneurial culture and a flow of venture capital to new biotechnology businesses. In the United States, levels of research activity (patenting and NIH grants) have been fairly widespread; however, commercialization has been highly concentrated. The nine metropolitan areas leading in biotechnology account for 88% of biotech venture capital and 96% of dollar value of research alliances. States that are trying to create a biotechnology center need policies to stimulate venture capital and encourage local entrepreneurship. As there is no evidence that biotechnology firms relocate, states should focus on developing local biotechnology firms, keeping in mind that at least a decade of investment will be required before there is payoff (Cortright 2001).

In spite of world-class research, a biotech R&D tax credit, and the Fitzsimons campus, Colorado's biotechnology industry is affected by the global industry trends toward consolidation. In the late 1990's, several Colorado companies were acquired by out-of-state companies. As a result, smaller entrepreneurial companies now make up the industry in Colorado. Colorado needs to build a critical mass of companies, and a high-profile biotechnology anchor firm, in order to attract investors. Additional state tax breaks and investment resources are needed to compete with other states (Peterson 2000).

Colorado biotechnology has a unique relationship with the California industry which is working to its advantage in several ways. These relationships have resulted in companies that have established operations in each state, and have also encouraged California venture funds to invest in Colorado companies. And, even though some Colorado companies have been acquired by California firms, when the jobs remain here, this actually results in capitalization of the Colorado operation (Focus Group/Survey 2003).

One significant barrier to transfer and commercialization of health science technology, however, remains the difficulty in obtaining pre-seed and seed funding. New leadership of technology transfer at the health sciences center recognizes the need for changes to increase the transfer and commercialization of biomedical research. These changes include more attention to protection and selection of patentable intellectual property and encouragement of researchers to pursue additional research that addresses the technical questions pertinent to the commercial application of the technology. These changes are intended to create more value and increase the possibility of licensing and transfer to a commercial venture (Focus Group/Survey 2003).

In spite of widespread interest in the industry by states, the overall economic impact of biotechnology on local economies is unclear. While biotechnology is a growing industry that pays high wages, overall employment in this sector is not that large. For example, for the nine current major biotechnology areas, total employment in pharmaceutical manufacturing and life sciences research is 3.5% of all manufacturing employment. Only

two of these areas have employment equal to 10% of manufacturing employment. Furthermore, most biotech firms will not grow to a large size; instead, biotech firms typically make alliances with pharmaceutical firms. Therefore, the ancillary benefits of producing and marketing biotech products will occur in areas that are pharmaceutical centers rather than biotech research centers (Cortright 2001).

Within the United States, Colorado is not among the states rated as primary biotechnology centers: San Francisco bay, Boston, Baltimore/Washington, the New York /New Jersey metropolitan area, San Diego, Raleigh, Seattle, Los Angeles, and Philadelphia. A recent Brookings study classified the Denver-Boulder-Greeley CMSA as having a "median level" of biotechnology research and commercialization. Twenty-eight other metropolitan areas shared the median level designation while thirteen areas were ranked higher (Cortright 2001). This ranking, however, was based on a biotechnology definition that did not include medical devices, one of Colorado's larger sectors.

Of those metropolitan areas classified as being at the "median level" of biotechnology research and commercialization, the Denver-Boulder-Greeley CMSA compares favorably. It had the 2nd highest share of overall NIH funding in 2000 (1.8%). It was the 4th highest in the number of patents received from 1990-1999. It is one of the three areas outside the nine major biotech centers to employ more than 1000 people in this sector. Based on membership in Biotechnology Industry Organization (BIO), the trade association for biotechnology firms, DBG had 1.9% of all biotechnology firms, the highest share of any of the median areas. Significantly, it had the highest share of venture capital funding of the median areas (1.6%). In addition, of these areas it had the second highest valued research and development alliances between pharmaceutical and biotechnology firms, indicating promising research. There was a significant increase in the value of such arrangements between 1996 and 2000 (Cortright 2001).

Bioscience

The recently completed state strategic plan used a broad definition that included biotechnology and medical devices. The report identified a number of comparative advantages that Colorado holds in creating a strong bioscience area.

- First, Colorado has a highly educated and skilled workforce. Almost 35% of Colorado's population 25 years or older hold a bachelor's degree, making it the highest ranked state. In 1999, Colorado had the 2nd highest share of scientists and engineers.
- In addition, Colorado has strong bioscience research capability in universities and federal facilities. In FY 2002, university sciences brought in $559.7 billion in research funding making it 18th among the states.
- Colorado also has a strong bioscience infrastructure with a research park for bioscience companies to work in collaboration with universities and a specialized bioscience incubator for start-up companies.

- The state's current high-technology manufacturing sector provides the capacity to support the bioscience industry from initial research and development through manufacturing and sales.
- Other identified comparative advantages include an entrepreneurial economy and attractive business climate (Battelle Memorial Institute 2003).

In addition, the plan identified a number of areas of weakness for Colorado as compared to traditional bioscience centers:

- Lack of strong collaboration between academia, bioscience industry, and public sector;
- Failure to realize the full potential of university research transfer and commercialization;
- Gaps in pre-seed/seed funding;
- Colorado doesn't have a critical mass of companies, which may discourage relocation of other bioscience companies;
- No history of sustained investment in technology development;
- An early stage bioscience industry base composed of many small firms engaged in research and testing;
- No strong public sector initiatives in support of the bioscience industry; and
- Finally, Colorado lacks a national image as a bioscience center potentially hindering current firms from relocating to Colorado (Battelle Memorial Institute 2003).

Colorado Growth Opportunities in Biosciences

The strategic plan noted Colorado's highly diverse research base and recommended a focus on research strengths that intersect with the state's bioscience and other high-technology industries. In the near term, the following areas were suggested as targets for development:

- Pharmaceutical biotechnology: Commercial applications in drug development and drug delivery systems.
- Medical devices and bioengineering: Commercial applications include implantable materials, bioscaffolds, tissue engineering, orthopedics, drug delivery, intelligent devices, diagnostic instruments, and biosensors. This focus area would build on Colorado's existing industry and on strengths in biomaterials and BioMEMS/nanotechnology.
- Plant and agricultural biotechnology: Applications include transgenic plants with pest/pathogen resistance, pharmaceuticals via plant pathways, bioprocessing of "farmaceuticals", and environmental monitoring and bioremediation.
- Biosecurity: Applications for biosecurity include vaccines, diagnostics, drugs and therapeutics, and environmental monitoring. Currently CSU and the CDC labs in Fort Collins have proposed creating a regional center of excellence in bioterrorism and infectious disease (Battelle Memorial Institute 2003).

Over the longer term, the state could create areas of specialization to include metabolics, computational biology, and bioinformatics, as well as biomedical lasers and optics (Battelle Memorial Institute 2003).

Colorado's economy already benefits from the application of ag-bio in improved crop and animal production. Now, with the recent permitting of a small experimental plot, Colorado is showing some receptivity to the development of plant pharmaceuticals. Public policy decisions that welcome this industry could be pivotal in attracting early experimental, then commercial scale, crops to the state's rural areas. There are current opportunities and need for research beyond crop production to address issues in transportation and manufacturing process required. Growing bio-pharmaceutical crops is a controversial area. Stakeholders in Colorado and adjacent states will need to address a variety of concerns including the potential for contamination of other crops (Focus Group/Survey 2003).

Summary

The economic potential of bioscience industries is apparent in the large number of states competing for dominance in these industries. In the United States alone, no fewer than 40 regions have targeted at least $18 billion to attract biotechnology companies. Like Colorado, a number of regions have created plans to create or maintain bioscience clusters. The recently completed Colorado strategic plan to develop the industry is a necessary and positive step toward using the state's significant research assets for future economic growth.

Over the past several years, the Colorado bioscience industry has begun to address its identified weaknesses and build on its strengths. There have been significant improvements in the collaboration and interaction between industry, research institutions, and government. Recent trends demonstrate growing cooperation and coordination among various sectors of the industry to involve biotechnology, medical devices, and ag-bio in the industry associations.

The newly completed strategic plan reflects this broader industry definition. The report identifies four focus areas that could maximize the economic potential from the intersection of research assets with industry strengths. These areas are pharmaceutical biotechnology, medical devices and bioengineering, plant and agricultural biotechnology, and biosecurity. These areas take advantage of identified global growth sectors and the convergence of bioscience with other Colorado high-technology industries. The priority areas also recognize the economic strengths of the medical device and ag-bio sectors.

Colorado industry and academic leaders believe strongly that the state needs to focus first on "growing its own" rather than spending a lot of resources on trying to recruit larger companies to the state. Primarily this is because Colorado is not competitive with other states that are offering large incentives and funding to attract bioscience firms. One opportunity in recruitment would be to encourage companies that are headquartered elsewhere but have some existing operations in Colorado, to expand their Colorado

operations. In addition, the state can continue to draw on its relationships with California to attract operations and financing here. Another strategy could be to try to recruit a large division of a major company, rather than the company headquarters. The advantages of having these larger company operations in the state, is to create a pool of talent with potential for spin-off entrepreneurial ventures and to create a market for needed industry support services (Focus Group/Survey 2003).

Another problem specific to recruitment of biotechnology/pharmaceutical companies is that the state still lacks some of the services necessary to support larger biotechnology firms, e.g. services in clinical trials, product manufacturing, fill and finish, and distribution. Here we have some smaller consulting firms that can grow as the industry grows, as well as the potential to better leverage and build on the clinical trial resources that exist within the CU Health Sciences Center, National Jewish, Children's Hospital, Veterans Administration, and Denver Health. This barrier does not exist for medical device firms where the Colorado sector is well established and has regulatory support, consulting and other service providers (Focus Group/Survey 2003).

State financial investments in the Fitzsimons development complex are designed to support the transfer of commercially viable medical research, produce educated medical personnel, and provide for the incubation of start-up companies. This facility both encourages relocation of biotechnology operations to the state, and nurtures development of start-up companies within the state.

The biggest challenge to "growing our own" is the need for seed funding which has been exacerbated during the economic downturn. Colorado could help address this need by reforming the CAPCO funding mechanism and perhaps targeting this funding to specific industries like biotechnology. This could provide funding for companies that are already established and have a product ready for market (Focus Group/Survey 2003).

In the earlier pre-seed and seed financing stages, establishment of a private seed fund could make a tremendous difference in growing this industry. Such a fund may be viable if some subsidy of administrative costs were available. The financing issue isn't as pronounced for medical device firms because they have a shorter product development timeframe and can, therefore, reach profitability faster and provide the return on investment that investors and venture capitalists look for (Focus Group/Survey 2003).

Geographically, most bioscience companies will locate in the Front Range near research centers and major airports. Even the service providers that support the bioscience cluster, will locate near the metropolitan area close to their customers. The exception could be in the ag-bio area where development in other areas of the state could be supported by Colorado State University research and the statewide extension service. Medical device companies may be more flexible to locate wherever their CEO wants to live. And, while theoretically, such a company could set up manufacturing any place, they would need access to an educated labor force that understands the regulatory environment unique to the industry (Focus Group/Survey 2003).

Workforce development is one area that requires the statewide participation of higher education. Currently several higher education institutions are creating bioscience programs in their business schools and academic departments. Increased coordination and more accountability to industry would make these efforts more effective (Focus Group/Survey 2003).

In summary, Colorado has many strengths in the bioscience industry that can be used to generate both near term and long term economic benefits. Continued collaboration involving state government, industry, and academia is needed to implement a focused strategy that will maximize the return on investment of scarce human and financial resources.

BIBLIOGRAPHY

Battelle Memorial Institute (2003). *Colorado's Place in the Sun: A Bioscience Future, an Action Plan to Grow Colorado's Bioscience Cluster*. Colorado Office of Innovation and Technology. <http://www.oit.state.co.us/resources/docs/Colorado_Final_Report_04-03-01.pdf>

Battelle Memorial Institute and State Science and Technology Institute (2001). *State Government Initiatives in Biotechnology 2001*. Biotechnology Industry Organization. September. <http://www.bio.org/tax/battelle.pdf>

Biotechnology Industry Organization (BIO) (2003a). "Agricultural Production Applications." Biotechnology Industry Organization. <http://www.bio.org/er/agriculture.asp> August 27.

_____ (2003b). "Industrial and Environmental Applications." Biotechnology Industry Organization. <http://www.bio.org/er/industrial.asp> August 27.

Carnegie Mellon University, Center for Economic Development (2001). *Southwestern Pennsylvania Industry Cluster Analysis*.

Colorado Biotechnology Council (2001). *Report to the Governor*.

Cortright, Joseph and H. Mayer (2001). *Signs of Life: The Growth of Biotechnology Centers in the U.S*. The Brookings Institution, Center on Urban and Metropolitan Policy, January. <http://www.brookings.edu/urban > August 28, 2003.

Ernst & Young (2003a). "Resilience: Americas Biotechnology Report 2003 – Summary." <http://www.ey.com> August 27.

_____ (2003b). "Ernst & Young Biotechnology Reports Foresee an Industry Poised for Profitability." <http://www.ey.com/global/Content.nsf/US/Media_-_Release_-_06-12-03DC > August 28.

_____ (2001). *Focus on the Fundamentals: The Biotechnology Report*.

_____ (2000). *Convergence: The Biotechnology Industry Report*. pp. 13-31.

Fletcher, Amy (2003). "Experts Predict biotech boom in Colorado." *Denver Business Journal*. <http://www.bizjournals.com/industries/health_care/biotechnology/2003/06/23/denver_story3.html>.

Focus Group/Survey (2003). Bioscience focus group and survey conducted in July.

Followwill, Dorman (2002). “The Future of Healthcare.” Frost and Sullivan presentation to Colorado Medical Devices Association. September 10.

Peterson, Eric (2000). “What biotech Needs to Grow.” *Colorado Biz*. May.

Venture One (2003). “Valuations for U.S. Venture-Backed Companies (1997-2Q03).” Investment figures based on proprietary research conducted by VentureOne.

NANOTECHNOLOGY

Nanotechnology is an enabling technology with applications across many industry sectors important to Colorado including telecommunications, optics, biotechnology, pharmaceuticals, data storage, aerospace, defense, energy, and environmental. It is the science that allows manipulation of atoms to form molecules and create new materials from the beginning with desired new and novel properties. In this technology scientists work with matter that is one-billionth of a meter (1 nanometer), or 1/75,000th the size of a human hair. At this scale, different laws of physics come into effect, material properties change, and whole new material behaviors come into existence.

Many predict that nanotechnology will be the next economic revolution changing the way almost everything is designed and produced. This science will not only change current products but will be used to create new and currently unimagined capabilities. Applications are likely to include:

- Materials with desirable properties such as high strength, chemical sensing, or optical switching designed in from the start.
- Information technologies such as quantum computing and computer chips that store trillions of bits of information on a device as small as the head of a pin.
- Medical advances including improved drug and gene delivery, biocompatible materials for implants, and sensors for disease detection.
- Environmental benefits such as water purification, artificial photosynthesis of clean energy, and pollution control systems (National Science Foundation 2003).

National and International Trends

The commercial potential of nanotechnology research is becoming apparent as new material properties are used to improve existing products. Some examples are UV protectant cosmetics, scratch resistant coating on glasses, and coatings on textiles for stain and wear resistance. Although still in an initial, exploratory stage, nanotechnology is already creating real business advantages for companies and promises significant economic benefits for those communities and nations that manage to foster its scientific and commercial development. Companies, communities, states, and nations are committing significant investments now in hopes of sharing in its future potential rewards.

The race for economic dominance based in nanotechnologies is global. There are some 1,700 companies in 34 nations currently involved in commercial development of nanotechnology. In addition to the United States, countries with major early investment in the field include Japan, Denmark, and Europe (UK, Germany, and France). Other nations with interests and scientific competencies in nanotechnology include Australia, Canada, Switzerland, Ireland, Italy, Spain, Sweden, Israel, Russia, Korea, and Singapore.

The U.S. government initiated the National Nanotechnology Initiative (NNI) in FY2001 to develop national priorities and fund interdisciplinary research and education important

to national nanotechnology goals. Federal budget support for nanotechnology R&D reached $697 million in FY2002 with $774 million requested for FY 2003 and $849 million for FY2004. Federal funding supports fundamental, basic, research conducted in ten federal departments and agencies, as well as research by individual university researchers, industrial participation and small business initiatives, and the establishment of large science and technology (S&T) research centers. These S&T centers include Nanoscale Science and Engineering Centers (NSEC), National Nanofabrication Users Network (NNUN) and the Network for Computational Nanotechnology (NCN) at Purdue (National Science Foundation 2003).

Specialized scientific research centers are highly sought after by states wishing to build the infrastructure needed to generate, attract and retain nanotechnology companies. Such centers are key to the development of scientific prominence, education of the specialized workforce required, and to the attraction of the industrial partners seeking to commercialize the technology. Some major specialized nanotechnology research centers in the United States, and their university, government and, industry partners are listed in Appendix A.

The diversity of nanotechnology applications is apparent by the federal departments and agencies involved: Department of Defense, Department of Energy, Department of Justice, Department of Transportation, Environmental Protection Agency, NASA, National Institutes of Health, National Science Foundation, and U.S. Department of Agriculture. Current national priorities are research in nanotechnology as an efficient manufacturing process; solutions to detection of biological, chemical, radiological, and explosive elements; education of the skilled workforce; involvement of industry; and development of instrumentation and standards (Roco 2002).

Growth Opportunities and Requirements

Nanotechnology is currently in use as materials and coatings for metals, fibers, and cosmetics. "The National Science Foundation projected the annual global market for nanotechnology products and services to reach $1 trillion by 2015" (*Small Times* 2003a).

Phillip Bond, Undersecretary of Commerce for Technology, compares this market estimate to total U.S. GDP of approximately $10.4 trillion, i.e. a market equal to about 10% of the entire U.S. economy today. If this prediction holds true, Bond estimates the number of jobs created would be about 7 million (Bond 2003).

Initial applications are already creating competitive advantage and market expansion for existing products. Some examples:

- Use of nanowhiskers by Nano-Tex to produce stain resistant fabric;
- Advanced Powder Technologies' sunscreen product with UV protection superior to zinc oxide;
- Nanocomposites in the running boards of SUVs;

- NanoBio, with products like NanoDefend which can be used to decontaminate clothes and surfaces, and NanoGreen, which can be used on skin;
- Nanotechnology applied to tennis balls to double useful life and to tennis rackets to reduce torsion (Bond 2003); and
- Thin film coatings used for eye glasses, and computer and television screens to prevent scratching.

Nanotechnology companies are highly sought after. A study of biotech and nanotech companies in Texas reveals that 36 firms had been offered opportunities to relocate to other areas of the country. Companies reported key considerations to their location choice to be availability of laboratory space with clean room facilities, access to technical resources, incentives for general office facilities such as a business incubator, and having similar businesses and suppliers in the area (Higgenbotham 2003).

While nanotechnology holds promise for significant future economic benefit, it is still very much a science which faces several barriers to successful deployment, including:

- A highly guarded and protective stance on intellectual property that restricts knowledge sharing;
- Lack of shared facilities for use by smaller companies in product development;
- Concerns raised by environmental groups about potential toxicity of future nanomaterials;
- Increasing regulatory requirements for medical applications and potentially in other application areas;
- Lack of sustained funding for development and commercialization; and
- Insufficient number of young researchers and scientists with appropriate training in the United States (LuxCapital 2003).

Workforce development for a future nanotechnology industry will require a national investment in education and retraining. In the past four years, more than 1,700 jobs have been created from venture capital funding in nanotechnology. It is estimated that 40,000 U.S. scientists are capable of working in nanotech; however, 800,000 U.S. workers will be needed to support the National Science Foundation (NSF) predictions of a $1 trillion nanotech industry by 2015 (LuxCapital 2003). In order to realize full advantage from this new science, researchers must work across disciplines or know how to work with others in the interfaces between the disciplines, and think in totally new ways (Siegel 1999). While in the near term, the industry will need to rely on training for workers currently employed in other high-technology industries, national leaders call for innovative programs in K-12 and higher education that prepare students to function as researchers, innovators, and executives for these future companies.

Estimates of time to market, from proof of concept in the laboratory to product sale, is 7 to 10 years. Scale-up from laboratory discovery to commercial application involves technical, manufacturing, and business issues. Whether research is conducted in university or corporate labs, researchers must consider commercial applications early in the process. Some institutes hope to accelerate this process by offering commercialization

assistance to laboratory researchers. In the electronics industry, for example, producing a molecular device that works in real-world conditions is a technical barrier that must be overcome (Rice 2003). In addition to solving technical problems, new products must address business feasibility issues. In order to be competitive in the market, the new products developed must have material properties desired by large-volume markets, and new manufacturing processes will need to be developed to produce these products at low costs.

The status of most nanotechnology development is still too early and the time to market and return on investment is too long to attract most venture funding (Rice 2003). Increased venture funding, however, is being generated by growing awareness, government and corporate investment in R&D, and media attention. While total venture capital declined from 2001-2002, venture investment in nanotech increased (by 251% in electronics, 211% in industrial products, and by 313% in life sciences/nano-biotechnology). Since 1999, $900 million in venture capital has gone to nanotech companies, with $386 million invested in 2002 (LuxCapital 2003).

Colorado Competitive Position

The State of Colorado Technology Alliance (CTA) has recognized the need to position the state in the nanotechnology arena. The CTA web site quotes the national director of the NanoBusiness Alliance in stating that, "Colorado has all the assets to be among the global leaders in nanotechnology as well as an indomitable strength and spirit of entrepreneurialism."

Colorado has several competitive advantages, including leading research at universities and federal laboratories, nascent industry group of companies founded on nanotechnology, a well-educated workforce, high-technology industries that will be users of nanoscience, and a dry climate conducive to nanofabrication (Focus Group/Survey 2003).

One little known advantage for Colorado is the state's dry climate. Nanomaterials have high surface areas and will absorb water from the air, making a dry climate a huge advantage. Texas and New Mexico are already recognizing this advantage and promoting it to recruit startups (Focus Group/Survey 2003).

Research capabilities are one of the major requirements for economic growth based in nanotechnology. One major research asset for Colorado is the National Renewable Energy Laboratory Nanotechnology research areas at NREL have energy, medical, and electronic applications:

- Chemical Sciences research will connect solar photons to fuels, chemicals, and electricity toward using quantum.dot solar cells;
- Electronic Materials research targets improvements in thin film photovoltaics as nanoscale enables high efficiency and lower cost;

- Carbon Nanotubes research will enable hydrogen storage materials, rechargeable lithium batteries, ultracapacitors, and fuel cell components;
- Biotechnology research is developing protein micro organisms and self-assembling proteins, quantum.dot lasers, and light emitting diodes; and
- Solid state theory that will have multiple applications. (Bull 2003)

Another research asset is the National Institute of Standards and Technology, Boulder, and scientists at JILA, an institute for interdisciplinary research and graduate education in the physical sciences, operated jointly by NIST and the University of Colorado at Boulder. The Quantum Physics Division at NIST and the new W.M. Keck Optical Measurement Laboratory at JILA provide unique laboratory resources for nanotechnology research. The Quantum Physics Division involves 848 NIST researchers in a variety of nanotechnology activities including:

- Production and characterization of nanoscale structures relevant to quantum-limited electronics, nanodots for complex semiconductors, and biological fluorescent labeling;
- Plasma processing of films to enhance the efficiency of photovoltaic devices;
- Investigation of surface processes on films used in ultra-miniature electronic devices; and
- Pump-probe spectroscopic technique to investigate ultra-fast carrier relaxation in semiconductors.

In addition to JILA research, the University of Colorado researchers work in a variety of areas including microfluidics, MEMS (micro-electromechanical systems), and bio-MEMS (diagnostics on a chip). Currently, the university system has not identified and supported any specialty area for nanotechnology research. Instead researchers are entrepreneurial, with priorities guided more by individual research interests, and available funding from federal and/or industry sources. Current laboratories in engineering can support some research areas, however, specialized research facilities may be needed to support advanced research and be competitive with other states. For example, to conduct research in bio-MEMS it is optimal to have silicon fabrication and biotechnology laboratories together in a super containment environment. Universities where states have provided funding for new specialized research centers will have the edge (Focus Group/Survey 2003).

Given Colorado's investment in biosciences and the exceptional facilities at the University of Colorado, Health Sciences Center at Fitzsimons for research and business incubation, nanobiotechnology is one area where the state could develop a competitive advantage. Biotechnology industry leaders agree that more interaction and coordination between researchers with nanotechnology and biotechnology competencies is needed. The University of Colorado proposal to merge the Denver campus with the Health Sciences Center could foster increased collaboration between strong biotechnology and engineering capabilities needed to develop bio-nanotechnology specialties (Focus Group/Survey 2003).

Future medical applications of nanobiotechnology include:

- Tiny machines that roam the body, finding and destroying viruses or cancer cells;
- Superfast drug discovery at a fraction of today's cost;
- Ultraspecific drug targeting;
- Biosensors (for pollutants); and
- Medical devices that use biomotors with moving parts no larger than a protein (Mehr 2002).

Colorado State University competencies address various industry interests: With current funding from National Institutes of Health, CSU researcher David Dandy is working to develop a new type of biosensor that could be used to diagnose illness, identify disease, and detect biological terrorism agents. Peter Dorhout is working on developing nanowires that could be used in electronic applications like magnetic storage or capacitors. According to Dorhout, CSU has an instrumentation facility that could form the basis for development of a nanotechnology research center (Kegg 2003).

Colorado already has a small number of companies with established nanotechnology research competencies and products in this new field. One of these firms is a spin off from research at the University of Colorado, one relocated here from Arizona, and at least one developed technologies from Small Business Innovation Research (SBIR) R&D funding. Companies are small with from one to 54 employees located in Littleton, Longmont, Denver, Westminster, Northglenn, Fort Collins, and Colorado Springs. The partial list in Appendix B is compiled from various reference sources.

In addition, most large corporations are making investments in nanotechnology research. For example, IBM, Kodak, Lockheed Martin, and Hewlett-Packard have a presence in Colorado and are making corporate commitments to nanotechnology research. These investments could merely result in overall future corporate competitiveness and stability, or could present new opportunities that would expand their existing Colorado operations. IBM Microelectronics has created a small group within its semiconductor division to work with nanotechnology start-ups with prototypes to address manufacturing issues and explore new trends. In time, nanotechnology processes are expected to create storage devices that are small in size and large in capacity, and that can be manufactured at much lower cost. Development of the technology is predicted to result in new manufacturing materials within five years. Then researchers will have to invent new manufacturing techniques in order to commercialize the technology. Within 10 years or so, it is predicted that nanotechnology will be used commercially in sensors and other types of chips enhancing semiconductors made of silicon. Full development, however, is a longer term proposition projected to take "massive investment, intensive research and a couple of decades" (Kanellos 2002).

In the United States, Colorado is among the top states in the number of nanotech companies:

TOP STATES IN NANOTECH INDUSTRY

Rank Based on Number of Nanotech Firms		Rank Based on Density of Nanotech Firms	
Rank	**State**	**Rank**	**State**
1	California	1	Massachusetts
2	Massachusetts	2	New Mexico
3	Texas	3	Rhode Island
4	New Jersey	4	Connecticut
5	New York	5	New Hampshire
6	Michigan	6	*Colorado*
7	Ohio	7	California
8	*Colorado*	8	New Jersey
9	Illinois	9	Michigan
10	Connecticut and Virginia	10	Arizona

Source: Stuart 2003

Small Times magazine, a leading source of business news and information about nanotechnology industry, ranked Colorado 12th among states in the race to become the economic center of the industry. States ranking higher included California (1), Massachusetts (2), New Mexico (3), Arizona (4), Texas (5), Maryland (6), New York (7), Illinois (8), Michigan (9), Pennsylvania (10), and Washington State (11). Rankings were based on factors such as research talent; industry, venture capital, innovation, work force, and costs. California was ranked at the top based on having the critical mass to attract researchers, companies, and VC cash. Colorado was listed among the "states to watch" (i.e., those with nanotechnology foundations that could challenge the leading regions) (*Small Times* 2003).

An article on a 2002 conference sponsored by the NanoBusiness Alliance concludes that, "The state has the basic components to stake a claim in the future of small technology, but there's a lot of work to do before Colorado catches up to early adopters such as New York, California, Massachusetts, or Texas. The state's universities have a great batting average in getting federal funds to support nanotechnology-related research. It has a well-established semiconductor industry in Colorado Springs and a small but solid venture capital community, which has in the past supported early-stage technology projects. Colorado just hasn't put the pieces together" (Sprackland 2002).

Working to change that is the recently organized Colorado Nanotechnology Initiative (CNTI). CNTI, initiated May 1, 2003, has a stated mission to share technical assistance, address technology transfer issues, support nanotechnology education from youth to higher education, and address the social implications of nanotechnology. Through meetings organized by CNTI, researchers from Colorado's universities are beginning to coordinate their efforts to seek funding for a center for nanotechnology that could strengthen the state's position in nanotechnology research and preparation of an educated workforce to support nano-based industry growth in the state. CNTI estimates that Colorado will need $10 to 12 million in private investment over the next 3 to 5 years to help target nanotechnology and secure national funding. Through CNTI efforts, six university presidents have signed a general letter of intent to initiate nanotechnology programs within their institutions, however, state cuts in higher education budgets are one barrier to actual implementation of such programs. (Focus Group/Survey 2003).

The NanoBusiness Alliance (www.nanobusiness.org) was the first trade association founded for the emerging industry of nanotechnology. With 250 member companies, the association has offices in New York City, Washington, DC, and (as of April 2002) Denver. The Colorado office was established to create a voice for the industry in Colorado and the western United States.

An April 2003 report, issued by the Colorado NanoBusiness Alliance summarizes some key findings on nanotechnology as a regional economic development driver (Kundahl 2003). The findings include the following:

- Though all the current state and regional nanotech initiatives are less than 3 years old, winners are already emerging. Federal and corporate money is following established nanotech centers and being added to centers that have already received funding from other sources;
- Nanotechnology hubs have been built on top of traditional technology hubs and leverage existing support networks and infrastructure;
- These hubs gain notoriety either through excellence in university research and/or the establishment of large world-class facilities or institutes in addition to creating specific organizations to promote the hub internationally;
- All hubs are built around a specific research area;
- The recruitment of an eminent researcher coupled with a world-class facility populated by a critical mass of researchers helps build immediate notoriety and this, in turn, attracts further investment and resources to the hub;
- Most nanotechnology hubs ensure that the various participants in nanotechnology research – academia, industry, and government – concentrate on specific areas of research that are aligned with the local industry environment;
- Hubs place equal importance on both fundamental and applied research; and
- State financial support coupled with industry participation is key.

In addition, the report urges the state to take action now if it is to claim its share of the nanotechnology economic future. The report recommends:

- Organize and develop a plan and announce a state initiative focused on current strengths in university research, corporate strengths, and economic realities: aerospace, biotechnology, materials, defense, environmental and energy, information technology, etc.;
- Aggressively lobby and seek federal funds;
- Work with corporations as partners and align university research with Colorado existing industry base;
- Encourage universities to create multidisciplinary programs tailored to nanotechnology with a curriculum that draws from physics, chemistry, biology, engineering, et al and adequately equip and provide the appropriate infrastructure;
- Develop collaborations with other states, government labs, and foreign governments;

- Organize a public/private nanotechnology partnership office led by the state government;
- Promote Colorado's efforts domestically and abroad through marketing program of events, newsletters, website, and other outreach;
- Create state industrial programs to support nanotechnology activity and commercialization;
- Fund feasibility studies, and develop incentives for entrepreneurs and investors, incentives to attract and retain companies, incentives to create manufacturing facilities, and incentives to attract private nanotechnology research centers; and
- Develop commercialization tools as well as facilities and infrastructure (Kundahl 2003).

The report offers the following analysis of the market opportunities applicable to Colorado:

- Nanomaterials and nanobiotechnology are dominated by small companies. The most current commercial opportunities for these sectors lie in the commercialization of a product in nanoparticle form for the chemical and pharmaceutical industries;
- Nanoelectronics sectors have large corporate participants. Opportunities are mostly centered on nanotubes, quantum dots, and NEMS for the information technology and telecommunications sector;
- Further demand in the nanomaterials sector will lie within nanocomposites and nanoporous materials;
- In nanobiotechnology and nanoelectronics the most important opportunities will remain in their traditional sectors (nanoparticles for bio and quantum dots, NEMS, and nanotubes for electronics);
- Over the next decade, life science, aerospace, defense, and information technology have the highest number of applications; however, in terms of market potential, most opportunities lie in life science, materials, agriculture, aerospace, and construction which are strong sectors in Colorado; and
- For aerospace in particular, the field is just beginning to take shape. Development will lie in nanocomposites and structural materials while nanoparticles will prevail in coatings (Kundahl 2003).

Speakers at a July 24, 2003, Jefferson County Economic Forum made several recommendations on how Colorado could proceed to capitalize on its nanotechnology assets:

- Colorado needs to focus on areas where in-state research strengths match in-state industry strengths, i.e. energy, defense/aerospace, medical, telecommunications, electronics, and semiconductors;
- First class university research with facilities available and accessible for industry use, and an improved technology transfer function, are key requirements for future state economic growth based in this technology;

- The state needs to build a future labor force with programs that include early introduction to the sciences in K-12, technician training specific to nanotechnology manufacturing at the community college level, and a higher education program that supports research scientists at the Ph.D. level;
- To attract companies here the state needs to move away from simply telling people what a good place this is in which to live. It needs to build a strong base of educated employees, support services for the industry, and a base of companies in the industry; and
- It is important to help emerging nanotechnology companies gain access to capital by teaming with strategic investors and angel investors that have a long term horizon for return on investment.

Edward Moran, director of product innovation at Deloitte & Touche in New York, echoes this last recommendation: "Colorado must have a spectrum of finance options, including vital access to seed capital, in order to create a nano friendly environment" (Sprackland 2002).

Summary

Colorado has the research capability, industry presence, workforce, climate, and high-tech industries needed to foster economic growth from nanotechnology. The future economic potential of investment in the development and commercialization of nano-based technologies appears to be enormous. The extent to which that economic potential is realized, however, may well depend on the level and continuity of human and financial resources committed to this sector.

There is broad agreement that all sectors (researchers, higher education, industry, government, and economic development) need to be involved in building the infrastructure and coordinated approach to support this technology. While voluntary efforts of the NanoBusiness Alliance and Colorado Nanotechnology Initiative have begun to develop this collaboration, state leadership is called for to develop, sustain and elevate a collaborative effort. As a first step, the state could do what they're doing for biotechnology: establish a strategic direction and fund a state coordinator to guide nanotechnology economic development (Focus Group/Survey 2003).

In addition, some incentives will be needed if Colorado is to compete with other states that are gaining advantage with early financial support to create centers of excellence in research and to offer tax incentives to attract industry. In the absence of a state incentive program, there is the danger that other states will lure young nano-based firms from Colorado. Suggestions for relocation efforts include influencing major corporations that already have Colorado operations to move their nanotechnology research to the state, e.g. Level 3's optic research, and Lockheed Martin's nano probes and satellite research. Other possible relocation candidates that could strengthen the industry are Viewpoint Data Labs, Orem, Utah (3-D nano modeling), and Microtec-d.com of Duisburg, Germany (MEMS) (Focus Group/Survey 2003).

In order to realize economic growth from nanotechnology, Colorado should build on its existing strengths: a base of nanotechnology companies, a highly educated workforce, other high-technology industries, and scientific research activity.

In order to foster economic growth from existing nanotechnology firms, and prevent out-migration of emerging firms, state and/or local economic development agencies should provide support services and business incubation programs for commercialization of research, and for start-ups. Some suggest targeting incentives and services initially to retain and attract MEMS/NEMS and renewable energy companies. These areas are thought to match state research strengths, and have near-term market applications with potential to secure the investor and venture financing needed for growth.

Colorado's highly educated technical workforce provides a current advantage in the creation and attraction of companies developing and producing products based in nanotechnology. In order to maintain this advantage, Colorado will need to reinvest in its educational system including science and math education in K-12, technician training in community colleges, and university programs with specialties in nanosciences. In the future, cross-disciplinary programs will become increasingly important.

Colorado's other high-technology industries can be a catalyst for growth. This growth can be accelerated by initiating interaction between nanotechnology researchers, and companies in other Colorado high-technology industries that will utilize this enabling science to create their next generation competitive products and services. Within the next five years, Colorado will expect to see some growth from the use of nanotechnology to improve existing products. The first economic growth could come from coating and nano-powders. Within ten years, Colorado could see significant growth from several application areas: aerospace/defense, biotechnology and drug delivery, information technology/microelectronics, as well as energy and nano-associated fuel cells and batteries (Focus Group/Survey 2003).

Research capability will drive economic growth from this enabling technology. In order to place Colorado in the most competitive position, everyone (government, academia, and industry) should strive to obtain funding for an advanced research center. Meanwhile, as the state economy improves, the state and higher education could target specific areas for state-funded university-industry research collaborations that will utilize university research expertise and facilities to advance in-state product development. In addition, Colorado needs to develop proactive technology transfer programs dedicated to keeping technologies in Colorado (Focus Group/Survey 2003).

Most economic growth is expected to occur in close proximity to research centers in the metro area and along the Front Range from Colorado Springs to Ft. Collins. Grand Junction, Durango, and Pueblo areas could also benefit as existing firms use this science to develop and produce improved new products.

BIBLIOGRAPHY

Bond, Phillip J. (2003). "Technology Administration Keynote Address." Undersecretary of Commerce for Technology, speech delivered at the National Nanotechnology Initiative in Washington D.C. April. <http://www.ta.doc.gov/speeches/PJB_030404.htm> May 14.

Bull, Stan (2003). Associate director of Science and Technology, National Renewable Energy Laboratory. Presentation at Jefferson County Business Forum. July 24.

Focus Group/Survey (2003). Nanotechnology focus group and survey conducted in July

Higginbotham, Stacey (2003). "Biotech, Nanotech Need Aid. Survey Indicates Government Money, Space Needs Are Vital to Region's Hope for Industry Hub." *Austin Business Journal,* March. <http://www.bizjournals.com/industries/health_care/biotechnology/2003/03/24/austin_story4.html> March 24.

Kanellos, Michael (2002). "IBM Thinks Big about Nanotechnology." *CNET News.com* <http://news.zdnet.co.uk> May 12, 2003.

Kegg, Amy (2003) "CSU Set to Enter the Fray for Nanotechnology Funds." *Northern Colorado Business Report,* April. <http://www.smalltimes.com/print_doc.cfm?doc_id=5835> May 13.

Kundahl, Griffith A. (2003). "No Small Task." Colorado NanoBusiness Alliance, April. <http://www.nanobusiness.org/Colorado_Hub/CO_hub_home.htm> May 13.

LuxCapital LLC (2003). "The Nanotech Report 2003- Investment Overview and Market Research for Nanotechnology." Key findings, pp 11, 31.

Mehr, Ian J. (2002) "Nanobiotechnology-Commercial Opportunities from Innovative Concepts." <http://www.drugandmarket.com/9072> May 1, 2003.

National Science Foundation (2003). "NSF Fact sheet, Nanotechnology." April. <http://www.nsf.gov/od/lpa/news/03/fsnano_03.htm> May 12.

Rhoades, Glenn (2003). CEO and founder, Colorado Nanotechnology Initiative. Presentation at Jefferson County Business Forum. July 24.

Rice University (2003). "Nanotechnology: From the Laboratory to New Commercial Frontiers." Final Report on the Southern Regional Workshop, National Nanotechnology Initiative, pp 11, 50-54, 61. February 28.

Roco, M.C. (2002). "National Nanotechnology Investment in the FY 2003 Budget Request by the President." February 13. National Science Foundation, National

Science and Technology Council subcommittee on Nanoscale Science, Engineering and Technology. <http://www.nsf.gov/home/crssprgm/nano/2003budget.html> May 12, 2003.

Siegel, Richard W. (1999). "Nanostructure Science and Technology: R&D Status and Trends in Nanoparticles, Nanostructured Materials and Nanodevices." World Technology September. <http://www.wtec.org/loyola/nano/00_es.htm> May 13, 2003.

Small Times (2003). "Small Times Magazine Names Top 10 Small Tech Hot Spots." *Small Times,* March 12. <http://www.smalltimes.com/document_display.cfm?document_id=5641>

Sprackland, Teri (2002). "Colorado is Just Waking Up to Nanotechnology's Possibilities." *Small Times*, April 29. <http://www.smalltimes.com/document_display.cfm?document_id=3625&keyword=Zettacore&summary=1&startsum=1>

Stuart, Candace (2003). "California, Massachusetts Locked in BiCoastal Clash for Supremacy." *Small Times*, March 12. <http://www.smalltimes.com/document_display.cfm?document_id=5640>

APPENDIX A – NATIONAL NANOTECHNOLOGY INITIATIVE – U.S. R&D CENTERS

Six Nanoscale Science and Engineering Centers funded September 2001

Center	Institution and Contact	Partners
NSEC: Integrated Nanopatterning and Detection Technologies http://www.nsec.northwestern.edu	Northwestern University Chad Mirkin (847) 467-5162 camirkin@chem.nwu.edu	Argonne National Lab Harold Washington College University of Illinois, Urbana University of Chicago Chicago Museum of Science and Industry Lawrence Livermore National Laboratory NASA Dupont Exxon Mobil Rohm and Hass Motorola IBM Unilever
NSEC: Nanoscale Systems in Information Technologies http://www.cns.cornell.edu/	Cornell University Robert Buhrman (607)255-3732 rab8@cornell.edu	Brigham Young University Colgate University University of New Mexico Pomona College
NSEC: Science of Nanoscale Systems and their Device Applications http://www.nsec.harvard.edu/	Harvard University Robert Westervelt (617) 495-3296 westervelt@deas.harvard.edu	Massachusetts Institute of Technology Princeton University of California-Santa Barbara Boston Museum of Science Brookhaven National Lab Oak Ridge National Lab Sandia National Lab Delft University, The Netherlands University of Tokyo
NSEC: Electronic Transport in Molecular Nanostructures http://www.cise.columbia.edu/nsec	Columbia University James Yardley (212) 854-3265 jy307@columbia.edu	Barnard College CUNY City College Rowan University Lucent IBM
NSEC: Nanoscience in Biological and Environmental Engineering http://cnst.rice.edu/cben	William Marsh Rice University Richard Smalley (713) 527-4845 res@cnst.rice.edu	Oak Ridge National Lab TDA Research Inc Geosciences Environmental Lab, France
NSEC: Directed Assembly of Nanostructures http://www.rpi.edu/dept/nsec	Rensselaer Polytech Institute Richard Siegel (518) 276-8846 rwsiegel@rpi.edu	U. Illinois, Urbana Los Alamos National Lab. Morehouse College Mount Holyoke College Smith College Spelman College Williams College ABB Albany International IBM Eastman Kodak Philip Morris State of New York

OTHER U.S. NANOTECHNOLOGY R&D CENTERS

Center	Institution and Contact	Partners
National Nanofabrication User Network (NNUN)		
Network for Computational Nanotechnology		
Nanobiotechnology Center	Cornell University	
Albany Institute of Nanotechnology http://www.albanynanotech.org/	University at Albany - SUNY	
California NanoSystems Institute (CNSI) http://www.cnsi-uc.org/mainpage.html	U of California, LA (UCLA) (310) 267-4838 U of California, Santa Barbara (805) 893-4130 Professor Evelyn Hu, Acting Director Professor J. Fraser Stoddard, Co-Director	
Nanotechnology Center	Purdue University	
University of South Carolina NanoCenter http://www.nano.sc.edu/welcome.asp	University of South Carolina	
Institute of Nanoscience	The Naval Research Laboratory	
Nanomanufacturing Research Institute http://www.nano.neu.edu/	Northeastern University, Boston, MA (617) 373-3294	
Center for Nano Science and Technology http://www.nd.edu/~ndnano/title.htm	Notre Dame University Wolfgang Porod (574) 631-6376 Alan C. Seabaugh (574) 631-4473 NDnano@nd.edu	

APPENDIX B – COLORADO NANOTECHNOLOGY COMPANIES (PARTIAL LIST)

Company	Nanotechnology Competencies	Application Areas
ALD NanoSolutions Westminster	Atomic layer deposition: Activating Nanolayers, Passivating Nanolayers Functional Nanolayers	Materials applications in defense, biomedical and electronics
HiperSem, Inc. Northglenn	System-on-a-chip	Hi performance semiconductor solutions
Cenymer Corporation Longmont	Polymer precursors to diamond and diamond-like carbon coatings	
IonTech, Inc Fort Collins	Subsidiary of Veeco: advanced manufacturing equipment	Atomic force microscopes, optical interferometers, stylus profilers, optical inspection systems and magnetic testing devices
ITN Energy Systems Littleton	Nanomaterials	Gas separation membranes to enable coal to hydrogen energy, and solid cells
Nanomaterials Research, LLC Longmont	Novel process for manufacturing nanopowders, precision nanofabrication of components using self-assembly systems and carbon nanotube-based products.	R&D and manufacture of gas sensors, electronic components, and nanofabricated devices (ceramic MEMS)
NanoPierce Connection Systems, Inc – Denver and Colorado Springs	Connection technology	Microelectronics
NanoProducts Corp Longmont	Design and manufacture of nanoscale materials and produce nanoscale particles (nanotechnology building blocks) in commercial volumes	
TDA Research, Inc Wheat Ridge	Catalysis and advanced materials and manufacture of computer controlled testing equipment	Environmental catalysts, sulfur sorbents and self-heating meals
ZettaCore Denver	Molecular structures in electronic storage for advances in memory density and lower power consumption	Portable devices such as laptops, PDAs, cell phones, cameras, Internet appliances, desktop and server computers

SERVICES

The services sector has historically been the largest and most diverse component of the U.S. economy. With the emergence of a technology-based, global economy, the services sector in the United States has become even more dominant. In 2000, the sector employed roughly 48.7 million people, or 37.5% of total U.S. employment. The sector includes a wide variety of services representing a broad range of employment skills and pay ranges from high salaried engineers, lawyers, and scientists, to low-wage workers in hotels. Personal, business, repair, amusement, recreational, health, legal, engineering, and educational services are all included under the broad heading.

In exploring growth opportunities for the state, this section of the report will focus on three service areas: financial services (an industry which is not typically classified within the services division), research and development, and health care. We also look briefly at the potential of call centers to create jobs in rural areas. In addition, a separate section of this report is specific to growth opportunities in tourism.

Financial Services

The financial services sector of the economy is made up by banks, insurance companies, financial investment companies, and other related activities. The sector is relatively small in terms of employment, but is vitally important to the nation's economy.

According to Plunkett Research, Ltd., the total value of U.S. household financial assets in 2002 was nearly $30.1 trillion. This is 75% higher than 1992, and is nearly 400% above the value in 1982. Total consumer credit in 2002 was $1,721.9 trillion through November. Consumer credit has increased by 120% since 1992, and 450% since 1982.

According to the Insurance Information Institute and the Financial Services Roundtable, the financial services sector contributed 9% to the U.S. gross domestic product (GDP) in 2001. When real estate transactions are included, the financial services sector accounted for nearly 21% of the GDP. In 1992, these percentages were 6.6% and 18.1%, respectively. In 2001, the GDP grew 2.6% from the prior year, while the GDP of the finance and insurance sector grew 6.1%, and finance, insurance, and real estate grew 5.1%.

National Employment and Wages

In 2002, there were approximately 5.8 million people employed in the finance and insurance sector. This represents 4.46% of total nonfarm employment, down slightly from 4.54% in 1993. Average wages for the sector were $62,700. This is 70.7% higher than average wages for all industries combined.

From 1993 to 2002, total employment in the finance and insurance sector grew at a compound annual growth rate (CAGR) of 1.6%, slightly less than the 1.8% CAGR for total U.S. nonfarm wage and salary employment.

The largest subsector in the industry is credit intermediation and related activities, which makes up 46.1% of total finance and insurance employment. This is followed by insurance carriers and related activities (38.2%); and securities, commodity contracts, and financial investments (13.8%). Since 1993, the securities, commodity contracts, and financial investments subsector has been the fastest growing portion of the finance and insurance industry, growing at a CAGR of 5.2%. The subsector experiencing the next fastest growth was funds, trusts, and other financial vehicles. The monetary authorities – central bank subsector has experienced negative employment growth since 1993.

NATIONAL FINANCE AND INSURANCE EMPLOYMENT

NAICS	Description	2002 Employment (000s)	CAGR vs. 1993	% of Total 2002 F&I
523	Securities, Commodity Contracts, and Financial Investments	800.8	5.2%	13.8%
525	Funds, Trusts, and Other Financial Vehicles	85.6	3.8	1.5
522	Credit Intermediation and Related Activities	2,682.3	1.4	46.1
524	Insurance Carriers and Related Activities	2,223.1	0.7	38.2
521	Monetary Authorities – Central Bank	23.1	-0.1	0.4
	Total Financial and Insurance Services	5,814.9	1.6%	100.0%

Source: Bureau of Labor Statistics. CES data.

National Trends

Following the prosperity of the 90s, the finance and insurance industry has had a tumultuous couple of years. First came the bursting of the dot-com bubble. This was followed by a series of accounting scandals at some of the largest, highest-profile companies in the nation. Decreased public confidence in markets, along with decreased revenues and profits sent the stock market into a downward spiral, and the nation fell into an economic recession. After rising from 2,629 at the end of 1994 to 7,053 in September of 2000, the New York Stock Exchange fell to 4,724 in March 2003. Similarly, the NASDAQ jumped from 735 at year-end of 1994 to 4,410 in February 2000, only to fall to 1,242 in October 2002. However, in 2003, signs of recovery have appeared. Stocks are slowly climbing upwards. At September's end the NYSE was 5,748 and the NASDAQ was 1,856. Layoffs in the investment banking and stock brokerage sectors have subsided, and property and casualty insurance underwriters are recovering. On the other hand, consumer debt is extremely high, $8.45 trillion in 2002, up 10% from 2001. There were 1.61 million personal bankruptcy filings in the 12 months ending June 30, 2003, an all-time high, and up 30% from the previous 12 months (Plunkett Research 2003b).

Consolidation and diversification have brought about the greatest changes in the U.S. financial services industry in recent years. In 1999, legislators passed the Gramm-Leach-Bliley Act. This act repealed the Glass-Steagall Act of 1933, and opened the door for cross industry mergers and consolidation. Banks are acquiring insurance agencies and securities firms, and insurance companies are opening banks. Most major financial services companies today do business across sectors, and are increasingly offering their customers one-stop-shopping for financial services. This consolidation is allowing the big companies to become even bigger. From 1995 to 2001, the asset share of the top 10

property/casualty insurance firms has increased from 30% to 45%. The top ten life insurance firms have increased their share from 34% to 44%. The ten largest banks in the United States have increased their asset share from 34% to 40%, and the ten largest savings institutions have increased their share from 21% to 38% (Insurance Information Institute and Financial Services Roundtable 2003). Meanwhile, the number of firms in the sector is falling. There were approximately 25,000 banks in the United States before World War I, this number has fallen to 7,887 in 2002. In 1987 there were 9,515 securities brokers and dealers, in 2002 there were 6,766. The number of life insurance underwriters also fell from 2,200 in 1985 to 1,506 in 2001. Property/casualty insurers, numbering 3,163 in 2002, are expected to experience a similar fate, falling by 30% over the next decade (Insurance Information Institute and Financial Services Roundtable 2003).

While the number of banks may be decreasing, their presence is continuing to expand. Branch banking has become much more prevalent in an effort to improve customer convenience. In 2002 there were approximately 65,500 branches at the nations 7,887 banks. This is up 7% from the number of branches in 1998. Some branches are experiencing profitability within a year of opening, much quicker than the norm in the past (Thompson Media 2003). Branches are opening in supermarkets, online banking services are expanding, and ATMs are spreading around the globe (800,000 of them in 2001) and evolving from cash-dispensing machines to financial service depots (Plunkett Research 2003b).

Many banks and financial firms are adding nonbanking services, such as stock brokerage, insurance brokerage, trust services, mortgage banking, and retirement products, to the list of services they offer in hopes that the fees generated from these nontraditional services will increase revenues. Some of these services can be reliable sources of income during periods of poor stock market performance. One area that financial institutions are focusing on is financial planning. Many individual investors are looking for professional help after the market crash of the early 2000s, and banks are targeting these individuals. Another targeted area is the establishment of private banking relationships with wealthy individuals. These services target households with $10 to $25 million, and charge high fees in exchange for personalized service for all their financial needs (Plunkett Research 2003b).

Intense competition in the property and casualty insurance industry kept premium rate increases low during the 1990s, however with increased claims, many firms struggled to make profits. In 2001, the industry reported its first ever loss, nearly $7 billion. Consequently, rates have increased since 2001, and are expected to continue to rise in the coming years. This increase has led to a recovery for property and casualty underwriters who gained profits of nearly $3 billion in 2002 (Plunkett Research 2003b). The future of the stock and bond markets will have a significant impact on determining the outlook for insurance firms as most of their profits come from the investments they make with received premiums.

The securities industry has been plagued by dismal market performance. The year 2000 marked record revenue and profits at U.S. stock brokerages, $245 billion and $21 billion,

respectively. However, in 2001 revenues fell by over 25% to $195 billion, while profits fell by over 100% to $10.4 billion. In 2002, revenues and profits fell an additional 28%, to $152 billion and $8.1 billion respectively. The source of this revenue is shifting from principal transactions and commissions, to interest revenue. In 1980, commissions and principal transactions combined to make up 58.5% of total industry revenues, while interest comprised just 10.8%. In 2002, interest made up 35.2% of revenues, while commissions and principal transactions formed just 28.3% (Securities Industry Association 2003).

With U.S. stocks struggling, many investors turned to foreign stocks, and real-estate investments. Online services are also growing. Offshoring is becoming increasingly popular in the industry, as firms are saving money by sending call centers and other back-office tasks overseas to low-cost workers. A final trend in the financial services industry is reduced IT spending in the U.S. securities industry. After increasing every year since the 1970s, tech spending was down in 2002, and looks to decline modestly in 2003 as well (Thompson Media 2003).

Colorado Competitive Position

Colorado is not generally known as a national financial services center, in part because there are few major financial services firms headquartered in Colorado. Although the state is a regional money center, it does not draw a large portion of the national market. In 2001, financial services made up an estimated 7.3% of the Gross State Product, slightly below the national average of 8.9% (Insurance Information Institute and Financial Services Roundtable 2003). This ranked Colorado 27th in the nation. In March 2003, there were 179 financial institutions in Colorado, which had total assets of roughly $49.9 billion (FDIC 2003). During the five-year period from 1997-2002 the number of institutions has been consistently falling by 5-10 each year. This decline is consistent with the national trend of consolidation. Total assets were down 2.9% from March 2002, but remained 29.8% higher than the 1999 value (FDIC 2003).

Most of the financial institutions in the state are concentrated in the Denver metro area. In March 2003, 29.1% of the state's financial institutions, and 62.7% of assets were located in Denver MSA. Colorado Springs had 8.9% of the institutions and 4.4% of the assets, and Fort Collins had 3.9% of the institutions and 7.2% of the assets. Roughly 48.6% of the state's financial institutions were located outside of MSAs, yet these institutions only held 18.0% of total assets (FDIC 2003).

In 2001 direct premiums written in Colorado totaled $6.75 billion, roughly 1.8% of the nations total (Rocky Mountain Insurance Industry Information Association 2003). While this value was more than twice as large as the rest of the Rocky Mountain region combined, it was significantly lower than the nation's largest market – California ($44.1 billion).

Colorado's strengths in the financial services industry are mainly in the area of mutual funds. Denver in particular has long been recognized for the concentration of mutual

funds. The city is home to more than a dozen mutual fund families, including Janus, Invesco, Dreyfus Founders, Marisco, Icon, and Westcore (Moore 2003). In 2000, Denver ranked 5th in the country in the amount of mutual fund dollars managed (Svaldi 2003b). However, mutual funds across the nation have taken a major hit in recent years, as the stock market spiraled downwards. Denver's mutual fund industry, which grew largely as a result of its aggressive investing, was hit especially hard. Since 2000, assets at the area's largest mutual fund companies have fallen drastically, which has led to decreased revenue, and resulted in significant layoffs. In August, 2003, Denver had fallen to 9th in the country in mutual fund dollars managed. In addition, the future of the mutual fund industry will be negatively impacted by recent discovery of "late trading" irregularities which has undermined confidence in mutual funds in general.

Colorado Employment and Wages

In 2002, the finance and insurance sector employed 102,400 people in Colorado. Location quotients are commonly used to measure the concentration of an industry in a state, relative to the nation. A location quotient greater than 1 means the state has a higher than average concentration of that industry. Finance and insurance accounts for 4.7% of total nonfarm employment in Colorado. Nationally, finance and insurance makes up 4.46% of total nonfarm employment. Therefore, Colorado's location quotient for finance and insurance is 1.1.

From 1993 to 2002, employment showed a CAGR of 2.8% in the finance and insurance industry, slightly less than the state average of 3.0%. Finance and insurance employment was 4.7% of total state nonfarm employment in 2002 compared to 4.8% in 1993.

Average wages in the industry were $55,000, 45% higher than the state average wage, but 12% lower than the national average for finance and insurance.

The largest subsector in Colorado is credit intermediation and related activities, with 46.4% of all finance and insurance employment. This is followed by insurance carriers and related activities (38.3%).

From 1993 to 2002, the securities, commodity contracts, and financial investment subsector experienced the fastest growth, with a CAGR of 6.6%. NAICS 521 – monetary authorities – central bank and NAICS 525 – funds trusts and other financial vehicles experienced strong negative growth during that period.

COLORADO FINANCE AND INSURANCE EMPLOYMENT

NAICS	Description	2002 Employment (000s)	CAGR vs 1993	% of Total 2002 F&I	Location Quotient
523	Securities, Commodity Contracts, and Financial Investments	14.9	6.6%	14.6%	1.1
522	Credit Intermediation and Related Activities	47.5	3.7	46.4	1.1
524	Insurance Carriers and Related Activities	39.2	3.2	38.3	1.1
	Other (NAICS 521 and 525)	0.8	-22.2	0.8	.4
	Total Financial and Insurance Services	102.4	2.8%	100.0%	1.1

Source: Bureau of Labor Statistics. CES data.

Financial services has been one of the areas hit hardest by the recent economic downturn. Since September of 2001, over 1800 positions have been cut. Merrill Lynch, Janus, Invesco, Bancorp, TIAA-CREF, and American Century Investments, among others, have all announced significant lay-offs affecting their Colorado work force. Furthermore, the jobs being cut in this sector are high-paying positions.

Growth Opportunities

There is a belief that the recent layoffs by some of Denver's biggest mutual fund companies may actually drive growth in the state's financial services industry in the long term. In 2002, the number of employees in the securities, commodity contracts, and other financial investments and related activities industry fell by over 14%. Wages in this sector fell by over 19%. However, at the same time, the number of firms rose 5.7%. This suggests, that mass layoffs are prompting the laid-off workers to start their own companies. This is a trend that could lead to growth or recovery in this area. There is a large pool of talented mutual fund managers in the Denver Metro Area. According to John Schroer, a hedge fund manager at Itros Capital in Cherry Creek, "There is a lot of talent in Denver that drives the ability to grow" (Svaldi 2003a).

Denver is also establishing itself as a national center for hedge funds. With stocks in a bear market, many investors have turned to hedge funds, which use alternative strategies to make money. Hedge funds, which are organized as partnerships rather than investment companies, face less regulation than mutual funds, and use very aggressive strategies which often allow them to make money even when the stock market is declining. Since 2001, a number of hedge funds have sprung up around the Denver metro area. Many of these companies are being started by former mutual fund managers. Many people expect hedge funds to grow significantly in the next several years, as the demand for alternative investment strategies grows. Schroer believes that "What you are going to see is Denver grow as a city for alternative investment management" (Svaldi 2003a). A return of a bull-market could spell doom for hedge funds, but some experts believe that investors will remain hesitant to reenter the traditional market, and the demand for alternative investment strategies such as hedge funds will continue to grow.

Barriers

As consolidation of financial services continues, Colorado is faced with a number of challenges. Currently, the financial services industry is concentrated on the coasts. Colorado does not yet have the critical mass necessary to compete with cities like New York and Boston. The industry's major firms are headquartered outside of Colorado. These firms are becoming larger and larger, and smaller institutions are disappearing. Moreover, the services these firms are offering are rapidly expanding. The big players in the industry are beginning to offer one-stop shopping. This means people can have all financial needs met at one firm, which is often headquartered outside of Colorado. Compounding the problem is the fact that technology advancements are making it much easier for this to happen. Today, someone living in Colorado can easily take care of all their financial services at a bank located in California. The super-regional banks are beginning to dominate the Colorado market. In 2000, super-regional banks had a market share of 28.3% in Colorado (Federal Reserve Bank of Kansas City 2003). These banks have superior information systems infrastructure and visibility. Super-regional banks have also developed a specialized set of services to address the needs of small businesses, such as offering SBA loans, treasury services, purchasing cards, and international services. Smaller local banks cannot compete head-on with these giant banks. At the same time, small banks have been able to survive by targeting niche markets, focusing on customer service, greater flexibility, lower fees, and the ability to react to changes quickly.

Currently Colorado faces several challenges in attracting large financial service firms to the state. Firms are deterred by the high wages and cost of living in the area. Additionally, with technology increases, large companies no longer need to come to Colorado; they can service the region from either coast.

On the other hand, as telecommunications makes distance of less importance to location, it could also help offset another disadvantage Colorado faces in the securities industry, which is its distance from the U.S. Stock Exchanges, located in New York, Boston, Philadelphia, Cincinnati, Chicago, and Los Angeles. Obviously, these areas have been able to attract financial service firms much easier than Colorado.

The finance programs at Colorado's universities and colleges do not currently compete with those at some of the high-caliber higher education institutions concentrated on the east coast, and California, causing the industry to import a large portion of financial services employees. If state budget cuts for higher education continue, this could further impact the availability of a qualified labor force for the finance industry.

Research and Development Services

Organized corporate research efforts began in Europe's chemical dye industry in the mid 19th century. Research and development quickly spread to the United States and by 1900 roughly 40 corporate research facilities were operating in the country. Growth was stimulated by a growing middle class, and increased demands for new products. U.S.

involvement in World War II fostered rapid growth in R&D, which would continue for decades to come. The space race and the Cold War further spawned research efforts funded by the federal government. In 1962, the federal government subsidized nearly 60% of America's corporate research. Since then, federal government investments in research performed by industry have steadily risen, while corporate investments in R&D have grown very rapidly. As a result, in 2002 the federal government share of investment in corporate research was approximately 30%. There are now 15,000 corporate research laboratories in America, which employ 750,000 people and invest about $300 billion in R&D each year. There are also approximately 20,000 additional U.S. firms conducting significant levels of research and development outside of dedicated labs (Plunkett Research 2003a).

Small businesses are encouraged to conduct innovative research through the Small Business Innovation Research (SBIR) and Small Business Technology Transfer Research (STTR) programs. Federal agencies are required to set aside a percentage of their external R&D budgets and issue annual solicitations for small business competition. Selected research projects receive Phase I awards to establish feasibility. Successful projects may be invited to apply for Phase II funding to support up to two-years of research to complete proof-of-concept or prototype. Companies are expected to apply research results to a commercial application thus stimulating economic growth from new products and technologies.

In addition to corporate research, R&D conducted by federal laboratories and universities also creates jobs and economic growth both nationally and locally.

National Employment and Wages

In 2002, over 6.7 million people were employed in the professional and technical services sector of the U.S. economy, which includes research and development. Between 1993 and 2002, the professional and technical service sector of the economy grew at a CAGR of 4.0%. All subsectors experienced positive growth, with computer systems design showing the largest growth. In 1993 this sector accounted for 4.2% of total nonfarm employment. By 2002, the sector accounted for 5.1% of total nonfarm employment.

In 2002, approximately 537,300 people were employed in the scientific research and development subsector. Since 1993, this sector has grown at a CAGR of 1.0%. Average wages in this sector were $68,800, 87% higher than the national average for all industries combined.

NATIONAL PROFESSIONAL AND TECHNICAL SERVICES EMPLOYMENT

NAICS	Description	2002 Employment (000s)	CAGR vs 1993	% of Total 2002 P&T
5417	Scientific Research and Development	537.3	1.0%	8.0%
5411	Legal Services	1,111.8	1.6	16.6
5418	Advertising and Related Services	441.9	2.0	6.6
5412	Accounting and Bookkeeping Services	867.1	3.2	12.9
5413	Architectural and Engineering Services	1,251.1	3.4	18.6
5419	Other Professional, Scientific, and Technical Services	488.4	3.7	7.3
5414	Specialized Design Services	122.9	4.3	1.8
5416	Management, Scientific, and Technical Consulting Services	731.8	7.4	10.9
5415	Computer Systems Design and Related Services	1,162.7	10.2	17.3
	Total Professional and Technical Services	6,715.0	4.0%	100.0%

Source: Bureau of Labor Statistics. CES data.

National Trends

According to the National Science Foundation, funding of industrial research and development in 2001 totaled nearly $200 billion; $182 billion came from private companies and other nonfederal funding sources, while $17 billion came from the federal government.

Prior to 1983, the vast majority (95%) of industrial research and development was taking place in manufacturing industries, however over the past 20 years, research and development has become much more prevalent in nonmanufacturing industries. In 2001, nearly 40% of all R&D performed by industry was in nonmanufacturing areas. The nonmanufacturing industries receiving the largest portions of company funded R&D investment were software publishing, scientific R&D services, and computer systems design and related services. Scientific R&D services, architectural, engineering and related services, and computer systems design and related services received the largest portion of federal government funding. On the manufacturing side, motor vehicles, trailers and parts, communications equipment, and semiconductor and other electronic components received the largest portions of the company funds. Federal funding went primarily to navigational, measuring, electro-medical, and control instruments, and aerospace products and parts.

In the future, experts are looking to biotechnology as a major area of emphasis and growth in research and development. As of mid-2003, there were already approximately 153 approved drugs that were developed using biotechnology, and 350 additional drugs that were in clinical trials. Biotechnology is rapidly changing the way we treat illness and disease, and is expected to continue to grow. However, following the tech crash of 2000, funding to commercialize research discoveries has become an issue. In 2000, new investment in U.S. biotech firms was $32 billion. In 2001, investment in biotech fell to $12 billion, and in 2002 it totaled roughly $10 to $12 billion (Plunkett Research Ltd. 2003). Future venture funding depends largely on the ability of biotech companies to reduce time-to-market and successfully move new drugs into the marketplace. (See the Biotechnology Section of this report).

Another area of potential growth in research and development is nanotechnology. In 2003, Congress approved $849 million in funding for nanotech research, over 40% higher than the $604 million approved in 2002 (Plunkett Research 2003a). Investment from the private sector is growing as well. (See the Nanotechnology Section of this report.)

Other areas of potential growth in R&D include defense and homeland security, and renewable energy technologies, which are also discussed in other sections of this report.

Cooperation has been a recent trend driving growth in research and development. Labs are sharing knowledge, corporations sponsor research consortia, and suppliers are collaborating with each other on the R&D of their components. Additionally, partnerships between corporations and universities are continuing to grow.

Colorado Competitive Position

Colorado has long been a center for research and development. The University of Colorado-Boulder, the University of Colorado-Health Sciences Center, Colorado State University, and the Colorado School of Mines receive millions of dollars in research funding each year. These university research programs can contribute a healthy amount to the Gross State Product. For example, CU contributes $16.64 to the Colorado economy for every $1 the school receives in general state funding (University of Colorado 2003). University research has also been shown to be a big promoter of new firm development. In a 2002 study by BJK Associates, the authors concluded that as research expenditures at universities increase, new firm birth rates in the area also increase. Not only do universities contribute highly educated and skilled workers to the labor force, but they also generate new inventions that lead to the formation of firms.

In addition to the research universities in the state, a number of federal research facilities, including the National Renewable Energy Laboratory (NREL), the National Institute of Standards and Technology (NIST), the National Oceanic and Atmospheric Administration (NOAA), and the National Center for Atmospheric Research, and the National Telecommunications and Information Administration (NTIA), are located in the state. Combined, these federal labs are projected to contribute nearly $2 billion to the Colorado economy from 2001 to 2005 (University of Colorado Business Research Division 2003). Overall, Colorado ranks ninth in the nation in federal and academic research and development (Governor's Office of Innovation and Technology 2003).

Colorado's highly educated entrepreneurial business sector has proven extremely successful in securing federal funding for research through the SBIR and STTR programs. From 1983 to date, 1691 SBIR Phase I awards with a total dollar value of $111,658,952, and 617 Phase II awards valued at $312,612,038, have been received by Colorado firms. In addition, companies received 29 awards totaling $2,361,298 in the STTR program, which requires a partnership between the small business and a university or private research organization. In 2002 alone, Colorado firms received 205 Phase I and 89 Phase II awards, ranking fourth among states.

Employment and Wages

In 2002, 141,000 people were employed in the professional and technical services sector of Colorado's economy. In 2002, companies in these sectors employed 6.5% of the states employees, compared to 6.1% in 1993. The location quotient (1.3) suggests that this sector has relatively high concentration in Colorado. Between 1993 and 2002, the professional and technical sectors showed a CAGR of 3.5%, slightly faster than the state average of 3.0%.

COLORADO PROFESSIONAL AND TECHNICAL SERVICES EMPLOYMENT

NAICS	Description	2002 Employment (000s)	CAGR vs 1993	% of Total 2002 P&T	Location Quotient
5415	Computer Systems Design and Related Services	35.8	7.6%	25.4%	1.8
5413	Architectural and Engineering Services	35.8	4.2	25.4	1.7
	Other(NAICS 5414, 5417, 5418, 5419)	53.7	1.6	38.1	1.3
5411	Legal Services	15.7	1.1	11.1	0.8
	Total Professional and Technical Services	141.0	3.5%	100.0%	1.3

Source: Bureau of Labor Statistics. CES data.

According to ES202 data for employment and wages, in 2002, there were 10,547 employees in research and development. Average wages for these employees was $73,800, 94% higher than the state average, and 7% higher than the national average for research and development workers.

Growth Opportunities

Mirroring the national trend, one area of research and development that experts believe will experience major growth in Colorado is Biotechnology. The biotechnology and biomedical industries employ over 153,000 people in Colorado, located mostly in Denver, Boulder, Fort Collins, and Colorado Springs (Colorado Edge, 2003). There are a number of large biotech research institutions in Colorado, including the CU Health Sciences Center, American Medical Association, Colorado State University, National Jewish and Medical Research Center, and Colorado Institute for Research in Biotechnology. The University of Colorado Health Sciences Center (UCHSC) and the University of Colorado Hospital (UCH) are in the process of completing major expansions on the Fitzsimons campus in Denver. These expansions include the building of the Colorado Bioscience Park Center in Aurora, which was completed in 2000, and the building of two major research complexes to be completed in 2004 and 2007.

Another significant opportunity for Colorado's research and development industry is the emergence of Colorado State University's Bioterrorism Lab. The school received a $22.1 million grant in October of 2003. The research center is scheduled to be completed in 2 years, and will employ 60-100 people (Beauprez 2003). One of just nine labs of its kind in the country, the CSU lab should be able to garner a large portion of the R&D dollars made available by the Bush administration to combat bioterrorism. The BioShield Act proposes to make $5.6 billion available through 2013 to buy drugs, devices, and

biological products to treat, identify, and prevent bioterrorist attacks. The lab could serve to attract some of the nation's brightest researchers to Northern Colorado, and make the region a national center in the biodefense area.

In a recent focus group meeting held by the Leeds School of Business, participants discussed some trends, opportunities, and weaknesses in the Colorado R&D industry. One opportunity for growth is the university system in Colorado. Participants said that the cooperation between universities and the private sector, along with early-stage government funding, would promote more research and development, specifically in the high-tech sector that is already prevalent in the state. However, the participants also stated that Colorado universities have to improve a great deal in order to compete with other major R&D schools like UCLA and Stanford University. Specifically, the Colorado universities need to make an effort to encourage the growth of an entrepreneurial culture within the schools.

The continuing ability of Colorado's small companies to win and perform on SBIR and STTR research awards brings additional research dollars to the state and presents an opportunity to create new products, technologies, and high-technology companies. In order to maximize economic benefits, however, companies need business and market assistance and access investment and venture funds to complete the commercialization process (Eye 2002). Various public and nonprofit organizations currently play a role in assisting in the commercialization of technology developed by universities and private companies, including Colorado Technology Incubator (CTEK), ITU Ventures, Colorado BioVenture Center, Rockies Venture Club, Colorado Institute for Technology Transfer and Implementation (CITTI) in Colorado Springs, and the CU-Business Advancement Center. A more coordinated state effort, with sufficient funding, could increase the economic impact realized from commercialization of new technologies developed within the state.

Barriers

In a depressed economy, R&D is often one of the first things to go. This has been a major barrier to R&D growth in Colorado in the past few years. Budget cuts at the federal level are threatening to reduce operations at research institutes such as NOAA and NIST, and at Colorado's public universities. State budget priorities have also impacted this sector as funding for university-industry research seed grants and operational support for the Colorado Advanced Photonics Technology (CAPT) center were eliminated in the last legislative session.

The lack of available venture capital locally also impedes the economic growth that could result from R&D. While Colorado companies have done a remarkable job of procuring venture capital, the state itself is not a major source. Entrepreneurs with new technologies often need to leave the state in order to secure seed and pre-seed financing. Experts are hoping that as the Colorado economy slowly recovers, venture capital will become more readily available.

Health-Care Services

The U.S. health-care services market is worth nearly $1.4 trillion. Easily the largest in the world, this is roughly twice the size of the European health-care services market (Hoovers 2003). Health-care spending in 2000 was 14% of the GDP. Total U.S. health-care spending is expected to rise to $2.6 trillion in 2010 (Plunkett Research 2003c).

The availability of health-care services in the community affects the economy first in the retention of health-care expenditures estimated nationally at more than $3,000 per capita per year in 1997. This figure represents local resources as well as government reimbursements and direct support for local health-care institutions. In addition, the existence of local hospitals and health-care services is an important consideration in attracting and retaining businesses and the jobs they bring to the economy (Ormond 2000).

National Employment and Wages

In 2002, over 13.5 million people were employed in the health-care and social services sector of the national economy. This represents 10.4% of total nonfarm employment, up from 9.5% in 1993. Average wages in the sector were $34,402, 6% below than the national average.

The largest subsector in the industry is ambulatory health-care services, with 34.2% of total health-care employment. This is followed by hospitals (30.7%). The smallest subsector is social assistance (14.8%).

Overall, the health-care and social services sector experienced a CAGR of 2.8% from 1993 to 2003, slightly below the national average CAGR of 1.8%. The social assistance subsector grew the fastest, at 5.0%. The hospital subsector experienced the lowest compound rate of growth (1.2%).

NATIONAL HEALTH CARE AND SOCIAL SERVICES EMPLOYMENT

NAICS	Description	2002 Employment (000s)	CAGR vs 1993	% of Total 2002 HC&SS
624	Social Assistance	2,003.5	5.0	14.8
621	Ambulatory Health Care Services	4,633.4	3.5	34.2
623	Nursing and Residential Care Facilities	2,743.2	2.9	20.3
622	Hospitals	4,253.1	1.2%	30.7%
	Total Health Care and Social Assistance	13,533.2	2.8%	100.0%

Source: Bureau of Labor Statistics. CES data.

In addition, most health insurance plans now have case management and disease management programs making them large employers of health-care personnel/professionals such as nurses, pharmacists, psychologists, and social workers. Also, medical call centers employ a growing number of health professionals (Focus Group/Survey 2003).

National Trends

The cost of health care is rapidly rising, leading to increased competition in the industry, and a continued focus on cost containment. In 2001, health-care spending was 14.1% of the nation's GDP, and it is expected to reach 17.7% by 2012 (Blendon 2003). Health insurance premiums rose by over 9% in 1998, and by an additional 9% the following year. In 2002, cost increases were as high as 20%. Employers that provide health insurance as an employee benefit are unable to keep up with such rapidly rising costs. Faced with increased costs, employers are forced to choose between several options. They can cut health-care benefits entirely, absorb all the cost increases, or pass the increases off to their employees. The latter appears to be the most popular solution as employers are increasingly asking their employees to pay a larger portion of the bill. Consequently, 14.3% of Americans lack health-care coverage altogether (Plunkett Research 2003c). This number could rise even higher as health-care costs are expected to increase significantly in the next several years. Total health-care spending in the United States is forecasted to increase at an average annual rate of 6.8% through 2010.

Many people blame the cost of prescription drugs as the cause for the rapid increase in health-care costs. Prescription drug costs have increased more than 10% every year since 1995, 17% in 2001 (Plunkett Research 2003c). Medicaid cutbacks, government mandates and regulations, nursing shortages, technology advancements, and increased patient demand for flexibility in their health-care plans are also contributing to rising costs. In the future there could be increasing conflict between the public's interest in utilizing new technologies and drugs and the fact that many of these are only partially covered by insurance. There are many new pharmaceuticals in the pipeline with 89 new drugs approved by the FDA and almost 4,000 clinical trials being conducted in 2002. The lack of comprehensive coverage for these new treatments may discourage pharmaceutical companies from developing products that are clinically beneficial but not financially advantageous (Blendon 2003).

Increased litigation costs are also fueling the rise in health-care costs. An estimated 7% of the increase in health-care costs can be directly attributed to litigation and risk management (American Association of Health Plans 2003). Damage awards and attorney fees in malpractice suits are skyrocketing. In 1985 fewer than 1 out of every 100 medical malpractice claims resulted in awards greater than $1 million, today it is nearly 1 in 8. Moreover, between 1996 and 1999 the average jury award in theses cases has increased 76% (National Restaurant Association 2003). Consequently, costs for medical malpractice insurance are going way up. Threats of litigation are also causing doctors to use unnecessary tests and treatments, which are further adding to the rising costs.

In the future, rising health-care costs may force a fundamental change in consumer behavior. A large portion of the medical care provided in the United States is unnecessary. According to the American iatrogenic Association (AiA), more than 50 million unnecessary antibiotic prescriptions are written for patients outside of hospitals each year. This represents roughly 60% of total antibiotic prescriptions. Moreover, the IOM Roundtable estimates that 20-50% of surgical operations are unnecessary, and 50%

of X-Rays for back-pain patients are unneeded. A reduction in needless doctor visits, optional procedures and other excessive uses of health-care services may be the only way to counter the rising costs.

In the next decade, as the baby-boomers age, health-care services in the United States will become an even more important issue. In 2011, the first of the 76 million baby boomers will turn 65. By 2025, an estimated 62.6 million Americans, 18.5% of the U.S. population will 65 or older, an 80% increase from 2000. The number of people over the age of 85 is expected to rise 73% over the same period (*Modern Healthcare* 2003). The effect this will have on the U.S. health-care industry is up for debate. Historically, as people age, their use of health-care services has increased. Health-care spending rises by an average of $40 annually each year a person ages between 18 and 50. Between the ages of 50 and 64, health-care costs rise on average $152 annually. Furthermore, for every 10% increase in the number of seniors, there is a 7.9% increase in hospital volume (*Modern Healthcare* 2003). By 2027, seniors are expected to account for 51% of all inpatient admissions, and 59% of beds, up from 40% and 49% respectively in 2002. Hospitals are counting on these statistics to hold true, as they are rapidly expanding to accommodate for the aging baby boomers.

However, many people believe this expansion is unwarranted, and risky. They argue that baby-boomers will not age in the same way as past generations. Medical advancements and increased health-consciousness are lengthening life spans, and reducing the need for health-care services in the 65 and over population. Moreover, outpatient services are a growing trend in health care. Both efficient and convenient, these services are expected to further increase in popularity as the baby boomers age. Both of these trends could lead to lower inpatient volumes for hospitals, despite the increased number of seniors.

Long term health-care services are another area that will likely be impacted by an increased elderly population. As the baby boomers age the demand for long-term health care is expected to increase. Currently, about 6.5 million older Americans need assistance with daily living activities. That number is expected to double by 2020 (My Third Life 2003). Until about 10 years ago, this would mean large growth in the area of nursing homes. However, with rising financial and family resources, falling rates of disability in the elderly, and reductions in Medicare coverage for long-term care, the trend is going away from nursing homes. Utilization rates at these facilities has been falling steadily for the last couple of decades, and are expected to continue to decline. Alternatives such as assisted living and home health care are becoming increasingly popular. These services offer a more specialized type of senior-care facility, and appeal to people who need some day-to-day help, but still want to preserve their independence. Moreover, assisted living can often be more affordable than nursing homes. The average annual cost of long-term individual care in a nursing home is $41,000, compared to $22,000 annually in assisted living facilities (National Governors Association Center for Best Practices 2003).

Another strategy that will be important in reducing costs and meeting baby-boomer demands for health information in the future is medical call centers and nurse staffed telephone triage support centers. These services help the consumer determine whether

their symptoms warrant an ER visit, physician visit or self/home care. They may also provide decision support information about treatment options relative to major medical issues, chronic disease management, or health risks and counseling on life style choices (Focus Group/Survey 2003).

The Internet is also having a major impact on health care in the United States. The availability of health-care information can greatly increase patient education, thereby improving the patient's visit to the doctor and reducing the amount of unnecessary visits. This could potentially help mitigate rising health-care costs. A recent survey published by Accel Healthcare revealed that 60% of MDs believe the patient/doctor encounter has improved since the advent of healthcare information on the web, and 84% of physicians expect improvements in the information available on the web that will allow them to better use it as a patient education tool (Accel Healthcare Communications, Inc. 2003).

While telemedicine is already being used in various ways to deliver medical services, its use is expected to increase in the future. Telemedicine makes specialty care more accessible, especially to rural and underserved urban populations, by eliminating prohibitive travel and associated costs. In addition, it may reduce costs of rural medical care. Current barriers to expanding telemedicine services include lack of appropriate telecommunications technology with adequate bandwidth, reduced federal funding to support infrastructure improvements, and high costs of equipment. As these barriers are resolved, telemedicine could become a major industry in the health-care field (Brown 2002).

One trend in the health-care industry that is stirring up lots of debate is the growth of specialty or "boutique" hospitals. These facilities are generally physician owned, and focus on a narrow set of procedures, such as cardiology, neurology, or orthopedics. According to a report released by the General Accounting Office (GAO) earlier this year, there are currently 92 specialty hospitals open in the United States, with at least 20 more under development. The number of these centers has tripled since the 1990s (Denver Post 2003). "Boutique" hospitals are very appealing to physicians. They offer physicians control over their work. They also offer high profits, since the centers focus mainly on the most lucrative specialties – neurosurgery, cardiology, and orthopedics. Growth in this area has sparked major controversy. Proponents of the facilities argue that they offer a friendlier, healthier, more comfortable environment. They say that boutique hospitals offer improved efficiency, reduced costs, and improved quality of the care they provide. Opponents of specialty hospitals believe that their growth will devastate the health-care industry. Ken Hanover, president and CEO of the Health Alliance of Greater Cincinnati called boutique facilities "the biggest threat to the survival of the community hospital that I have ever seen in my 30 years in health care." (*Cincinnati Post* 2003). Community hospitals are able to offer emergency care and other critical but unprofitable services by subsidizing them with the high profit margins they make in areas such as cardiology, neurosurgery, and orthopedics. With specialty hospitals offering these services at lower costs, community hospitals expect to lose a good portion of the profitable parts of their business. This could force hospitals to increase their fees, putting further strain on the rapidly rising cost of health care. Many people argue that giving physicians a financial

stake in their work is unethical, and leads to unnecessary procedures, and biased referrals. Critics argue that "boutique" hospitals are "cherry-picking" their patients. Physicians with ownership stakes in specialty hospitals have a major incentive to recommend their facilities to the patients which they deem to be the most profitable. GAO reported that patients at specialty hospitals tended to be less sick than patients at general hospitals in the same communities. An estimated 84% of specialty hospitals were treating a less acute mix of patients. This leaves general community hospitals with sicker, higher cost patients, and makes it nearly impossible to compete with specialty hospitals. Numerous states are considering legislation which would limit the growth of specialty hospitals, and level the playing field with community hospitals. While state and federal restrictions could slow growth, most experts still expect specialty hospitals to continue their rapid expansion.

New and reemerging infectious diseases and the threat of bio-terrorism attacks are focusing new public and government concern on the ability of the public health system to deal with an immediate health crisis. These concerns have resulted in increased attention and government funding targeted toward strengthening first responder and basic health-care systems. Unfortunately, in many cases these preparations will require the diversion of resources from other public needs including other health-care needs (Blendon 2003).

Colorado Competitive Position

According to a recent study conducted at the Milken Institute, Colorado is not a major center for health-care services in the United States. Based on employment concentration, Colorado ranked 44th in the United States, with an employment location quotient of 0.83. Pennsylvania, Rhode Island, Massachusetts, and New Jersey were the top four states. However, certain areas within the health-care industry are prevalent in Colorado. The state ranked 9th in both employment concentration and employment growth from 1996-2001 in health-care research and testing services. The state also ranked 9th in medical instruments and supplies employment concentration, and 10th in medical and dental laboratory employment growth, from 1996-2001. Colorado was also ranked 7th in venture capital investment in the biotech industry and 5th in venture capital investment in the medical devices industry.

In addition to ranking the states, the Milken study also looked at the health-care industry in each of the nation's 317 metropolitan areas. Each MSA was evaluated based on industry concentration and share of national health-care employment, the top Metropolitan Area was given a benchmark score of 100, and subsequent rankings were driven off this benchmark. Denver PMSA was ranked 35th with a health pole index of 17.08. Boulder-Longmont PMSA ranked 138th with a score of 3.56, Colorado Springs MSA ranked 198th with a score of 2.03, Pueblo MSA ranked 224th with an index of 1.68, Greeley MSA ranked 259th with a pole index of 1.14, and Grand Junction MSA was 271st with an index of 0.94. Boston, New York, Philadelphia, and Chicago were the top four metropolitan areas in the country. Again, Colorado metropolitan areas were strong in certain sectors of the health-care industry. Boulder-Longmont ranked 17th in the country in the pharmaceutical industry, and 18th in research and testing services. Denver ranked

12th in the country in medical instruments and supplies, 19th in health and allied services, and 22nd in offices and clinics of dentists. Grand Junction ranked 16th in offices of osteopathic physicians.

Employment and Wages

In 2002, there were 184,000 employees in the health-care and services sector of the Colorado economy. Employment in these sectors represented 8.4% of the total state employment; up from 8.1% in 1993. The location quotient suggests that this sector does not have a high concentration in Colorado relative to the United States. The largest subsector in the industry was ambulatory health-care services, followed by hospitals. Social assistance was the smallest subsector.

From 1993 to 2002, the health-care and social services sectors had a CAGR of 3.5%, slightly faster than the state average of 3.0%. The fastest growth has been in the area of hospitals and social assistance.

COLORADO HEALTH CARE AND SOCIAL SERVICES EMPLOYMENT

NAICS	Description	2002 Employment	CAGR vs 1993	% of Total 2002 HC&SS	Location Quotient
622	Hospitals	45.5	4.1%	24.7%	0.6
623	Nursing and Residential Care Facilities	33.9	2.9	18.4	0.7
621	Ambulatory Health Care Services	74.6	3.1	40.5	1.0
624	Social Assistance	30.1	4.0	16.4	0.9
	Total Health Care and Social Assistance	184.0	3.5%	100.0%	0.8

Source: Bureau of Labor Statistics. CES data.

Additional medical personnel are employed in Colorado medical call centers. The state was a leader in this field in the 1990's. Even though call centers have subsequently expanded in areas of the country with lower pay scales, Colorado remains one of the largest medical call centers in the country. Hospitals such as Denver Health Authority, Children's Hospital, Kaiser (St. Joseph's), and Centura Hospital Systems have all established nurse staffed telephone triage or after hours nurse advice lines to reduce unnecessary hospital visits or disease management support programs. National Jewish markets their respiratory disease management telephone programs and lifestyle change (smoking cessation) programs. Not only are these call centers large employers but they do successfully reduce health-care costs by supporting self management and appropriate care demand (Focus Group/Survey 2003).

In addition, Colorado is using distance learning to support continuing education of health-care professionals in rural areas, and pursuing the use of telemedicine to support diagnostic and medical consultations to rural physicians and hospitals. For example, the University of Colorado Health Sciences Center (UCHSC) is linked to provide telemedicine training and consultations to a variety of urban medical facilities as well as to rural communities including Grand Junction, Glenwood Springs, Telluride, Durango, Cortez, Fort Lupton, Trinidad, the Limon Correctional Facility, and the High Plain Rural Health Network. This telemedicine system is pursuing delivery of OB/GYN ultrasound

interpretations, neonatal echocardiogram consultations, bone marrow evaluations and other clinical consultations (UCHSC 2003). The High Plains Rural Health Network is a self-funded network reaching rural hospitals in Northeast Colorado, Western Kansas, Southeast Wyoming and Western Nebraska. It uses two-way interactive video conferencing technology to deliver specialty medical care, medical education, and business services to member hospitals (High Plains 2003).

Barriers to Growth

The health-care services industry in Colorado is currently facing a lot of the same problems that exist nationally. There is a severe nursing shortage in the state, a situation impacting most of the country. An estimated 126,000 nurses are needed to fill the vacancies at U.S. hospitals (American Association of Colleges of Learning 2003). The number of U.S. nursing school graduates who sat for the national licensure examination for registered nurses has decreased 26.9% between 1995 and 2002. This is coming at a time when the demand for nurses is increasing. There are also labor shortages in numerous other health care-related occupations. Physicians, pharmacists, nurse aids, and hospital tech support workers are all in short supply. These contribute to the rapidly rising costs that plague the industry.

While increased demand is anticipated as rural populations grow, these communities may struggle to support the health-care infrastructure to meet these needs. Rural populations include more elderly with a higher incidence of chronic disease; more self-employed and independent farmers who are uninsured or underinsured; and a lower population density that makes it difficult to support specialty services and local hospitals (Ormond 2000).

Colorado's health-care industry is also limited by the state's higher education system. The nation's premier medical schools are located on the coasts. Growth starts at the universities. Top-notch medical schools attract the top faculty, top students, and the R&D funding, and they put out the top doctors and the best research and development. Private companies are also more likely to locate near superior medical schools. Improvement in medical education programs at Colorado universities, such as development of CU's Health Sciences Center, should advance Colorado's standing in the health-care industry.

Growth Opportunities

The University of Colorado Health Sciences Center (UCHSC) is a leading medical research and educational center in the Rocky Mountain region. Located in Denver, the center is working to expand medical knowledge, and improve health care. UCHSC is currently bringing in over $200 million annually in research and training grants and contracts. The center presents a major opportunity to support growth in the health-care industry. The center is in the process of moving to Fitzsimons. This move will allow UCHSC to expand significantly, and will create more funding for the center. With these improved facilities and increased national recognition, UCHSC is expected to attract significant research funding, develop a quality health-care workforce, and offer the

specialized health-care services and new technologies that attract the best physicians and health-care providers.

Colorado's emerging biotech industry should also benefit the health-care services industry. Colorado is already one of the leading states in biotech. As biotechnology becomes integrated into medical treatment, Colorado has the potential to become a leading center for health-care services nationally.

Population can often drive growth in the health-care industry. As people continue to migrate to Colorado, and as the baby-boomers reach the age when their need for health care increases dramatically, the industry could experience significant increase in demand. Some of this increased demand could take place in rural Colorado, where a significant elderly population exists and is expected to grow. The demand for health-care services presents an opportunity for growth to the extent that health-care costs can be managed and supported by private and public pay systems.

Growth of telemedicine and medical call centers will help meet urban and rural health service demand in the future. Existing systems are expected to expand to serve more rural communities as the availability of broadband networks replace more costly and less robust ISDN telecommunication systems. Rural health services could benefit greatly from a renewed state commitment to extension of the Multi-Use network to public sector hospitals and health centers around the state.

With expectations of rising demand in health care, new hospitals are springing up across the metro area. By the end of 2004, metro Denver is expected to have four new hospitals, and 451 more beds. The added capacity should reduce wait times, and possibly lower costs. However, critics of the construction believe that costs may actually rise. The projects are expected to cost a total of $577 million, and the hospitals will have to somehow recoup these expenses. People also say that the problem is not a shortage of beds, but rather a shortage of nurses. If the new hospitals cannot hire new nurses, then the unrecovered capital investment in added capacity will negatively impact the industry.

Another emerging trend in the health-care industry is the idea of consumer-driven health-care plans. As costs are rising, consumers are demanding more flexibility, customization, control, and choices in their health-care plans. Last year, the first consumer-driven health-care plan became available to Colorado residents. The plan allows employees to create their own personal network of doctors and hospitals, and select their co-payment levels. These unique and personalized health-care plans are poised for significant growth. According to a survey conducted in 2001, 70% of employers said they wanted to shift health-care decisions to their employees (PR Web 2003).

Specialty or "boutique" hospitals could also experience growth in Colorado, although some would argue that this is at the expense of community hospitals. Most of the current growth in the specialty hospital area is in states where hospitals do not need to prove that there is a community need in order to build, and in communities with rapid population

growth. Both of these factors make Colorado a potentially high-growth market. The state's first specialty hospital is already planned for Durango.

Call Centers

Call centers are a central part of business today. Ranging in size from half a dozen people to thousands of employees, call centers span across virtually every industry, and perform a variety of different functions, from customer service and technical support, to sales and credit/collections, and beyond. One example that illustrates this point is McDonalds. Franchises in Colorado and Minnesota are beginning to route orders through call centers. Customers at these restaurants call in their orders from telephones sitting at their table, the employees at the call center then relay the order electronically to the appropriate restaurant's kitchen. The orders appear on screen in the kitchen, and identify the table where the order originated. Employees at the restaurant bring the customers their food, and collect the payment. This system lowers costs, increases sales, eliminates waiting in line, and reduces overall customer wait time (Guy 2003). With improvements in telecommunications, and information technologies, call centers are rapidly evolving and expanding, changing the way many companies operate.

According to 2002 Current Employment Statistics from the Bureau of Labor Statistics, there were 373.3 thousand people employed in call centers in the United States. However, other sources estimate that the industry is much larger. One article in *Stores Magazine* estimated that over 7 million people in the United States worked as agents for call centers, and forecasted annual growth of up to 20%. People generally consider these positions to be low skill and low pay; however, as call centers have evolved to take on customer service functions, technical expertise has become more important and the skill level and pay are on the rise.

Call centers often spring up in the nation's rural areas. These locations offer a large pool of relatively cheap labor. Smaller communities are embracing large call centers since they create a large number of jobs, and do not negatively impact the environment. Businesses are also looking at agricultural areas, where the farmers can work at the call center during the winter months, and handle the increase in business that many companies experience during the holiday season. College towns are also becoming popular areas for call centers, providing another good source of inexpensive labor.

Call centers are being negatively impacted by several national trends. Beginning in October of 2003, a federal "Do Not Call List" went into effect, creating a major hurdle for telemarketing firms throughout the nation. Industry leaders are concerned about the negative effects the list may have on employment and revenue, and some analysts are estimating up to 2 million jobs could be lost, as companies plan for a major decline in business (*Sun-Sentinel* 2003). This would be a considerable blow to the industry, which employed 4.1 million people, and generated $274 billion in sales in 2001.

Another trend affecting many major call centers is the move overseas to places like India and South Africa. As of October 2003, roughly 250,000 telemarketing jobs have already

moved overseas (*Baltimore Sun* 2003). The cheaper rent and labor costs found in other countries are attractive to large call centers, and the development of Internet telephony make the international calls no more expensive than domestic calls. As the national no-call list continues to grow, more and more telemarketing companies are expected to move their call center operations overseas to offset the certain decrease in business.

Still, offshoring of call center functions is not as large an issue as it is often made out to be. In fact, less than 5% of call center business is being moved overseas (*Sun-Sentinel* 2003). It takes plenty of money, and patience to develop call centers overseas. Typically, the companies that successfully transfer their call center functions to other countries are major corporations with deep pockets and a preexisting global presence. While offshoring is likely to continue, and even increase, the demand for call centers is growing rapidly enough that the industry is not in jeopardy in the United States.

Colorado telemarketing firms have felt the effects of a state no-call list since May 2001. With over 1 million households on the Colorado list, and over 50 million on the national list, Colorado companies have been forced to find other ways to market their products. Many business owners believe direct mailing and email marketing will help replace cold-calling, but most are still worried about losing business and employees.

It is important to realize that call centers perform a variety of functions beyond telemarketing. While telemarketing call centers may be endangered, call centers in general are growing. This market offers a major opportunity for Colorado; however, numerous barriers could impede growth. Already, many firms have moved their call centers out of the metro area into more affordable locations. In 2002, Merrill Lynch moved its 1,200 employee call center from Douglas County to New Jersey and Florida. On the other hand, call centers are one of the fastest growing industries in the Colorado Springs area. The state's rural areas could be the biggest benefactors of growth in the call-center industry. These areas are very attractive to companies looking to build or relocate their centers. Virtual call centers, where employees work out of their homes, are also becoming a reality. As the State MNT project brings high-speed Internet access into these areas, the growth of rural Colorado as a major call-center hub becomes a real possibility. Areas of the state that can offer lower wages and real estate costs will have the best chance of competing with international and lower cost rural locations elsewhere in the country.

BIBLIOGRAPHY

Accell Healthcare Communications, Inc. (2003). *A Majority of MDs Believe Internet Can Improve Patient Care.* <http://www.primezone.com/pub/headlines.mhtml?d=46870>

American Association of Colleges of Nursing (2003). *Nursing Shortage Fact Sheet.* <http://www.aacn.nche.edu/Media/Backgrounders/shortagefacts.htm>

American Association of Health Plans (2003). *What is Fueling the Increase in Health Care Costs?* <http://www.aahp.org/Content/NavigationMenu/Inside_AAHP/Healthplan_Magazine/What_Is_Fueling_the_Increase_in_Health_Care_Costs_.htm>

American iatrogenic Association (AiA) (2003). Information that Improves Understanding of Medical Error, Philosophy, and Practice. <http://www.iatrogenic.org/library/antibioticlib.html>

Beauprez, Jennifer (2003). "CSU Hopes Lab Leads to Biotech Hub." *Denver Post*, October 22.

Blendon, Robert J., and Catherine Desroches (2003). "Future Health Care Challenges." Issues in Science and Technology online, summer. <http://www.nap.edu/issues/19.4/blendon.html> December 9.

Brown, Nancy (2002). "Telemedicine Coming of Age." Telemedicine Research Center, May 3. <http://trc.telemed.org/telemedicine/primer.asp> December 9, 2003.

Colorado Department of Labor and Employment (2003). ES202 Employment and Wage Data, and Current Employment Statistics. <www.coworkforce.com/lmi>

Eye, Karen and G. Horvath (2002). "Economic Outcomes for Colorado Companies – A Survey of Colorado SBIR Award Winners." May 2002.

FDIC (2003). State profiles, fall 2003. <http://www.fdic.gov/bank/analytical/stateprofile/index.html>

Guy, Sandra (2003). "McD Franchisee in Colo. Routing Orders through Call Center." *Chicago Sun-Times*. October 9.

High Plains (2003). High Plains Rural Health Network. <http://www.hprhn.org/History.htm> December 9.

Hoovers (2003). Health Care Services Overview. <http://premium.hoovers.com/subscribe/ind/overview.xhtml?HICID=1379>

Institute of Medicine (IOM) Roundtable (2000). A New Health System for the 21st Century. < http://www.fsu.edu/~nursing/pdf/IOM-New-HealthCare-System.PDF>

Insurance Information Institute and the Financial Services Roundtable (2003). *The Financial Services Fact Book.*

Modern Healthcare (2003). "Boomer Bust?" July 28.

My Third Life (2003). *Assisted Living.* <http://www.mythirdlife.com/assited_living.htm>

National Governors Association Center for Best Practices (2000). Stateline: Creating Assisted Living Facilities: Expanding Options for Long-Term Care. <http://www.nga.org/center/divisions/1,1188,C_ISSUE_BRIEF^D_676,00.html>

National Restaurant Association (2003). Public Policy Issue Briefs - Why the NRA Supports Medical Malpractice Reform. <http://www.restaurant.org/government/issues/malpractice.cfm>

National Science Foundation (2003). *Industrial Research and Development.* <http://www.nsf.gov/sbe/srs/indus/start.htm>

NRF Enterprises (2001). "Call Center Monitoring Technology Offers Improved Customer Relationship Management. *Stores Magazine*." November.

Ormond, B., S. Wallin, and S. Goldenson (2000). "Supporting the Rural Health Care Safety Net." The Urban Institute, March 2002.

Plunkett Research (2003a). *Plunkett's Engineering and Research Industry Almanac*.

_____ (2003b). *Plunkett's Financial Services Industry Almanac*.

_____ (2003c). *Plunkett's Health Care Services Industry Almanac*.

PR Web (2003). Vivius, MMA to Provide Colorado with First-of-Its-Kind Consumer Driven Health Plan. August 15, 2002. <http://www.prweb.com/releases/2000/8/prweb44351.htm>

Rocky Mountain Insurance Industry Information Association (2003). <http://www.rmiia.org/Insurance_Industry/Insurance_Industry.htm#Colorado>

Securities Industry Association (2003). Key Trends in the Securities Industry. <http://www.sia.com/research/html/key_industry_trends_.html>

Sun-Sentinel (2002). "Hewlett-Packard's Move of Call Center to Overseas Does Not Foretell Trend." August 11.

Svaldi, Aldo (2003a). "Hedgers Drawn to Colo." *Denver Post*, September 21. FINANCE

_____ (2003b). "Denver's Mutual-Fund Glory Days Petering Out." *Denver Post*, October 19.

Thompson Media (2003). "By the Numbers." *Bank Technology News*, June 20.

UCHSC (2003). TeleHealth/TeleEducation Program, University of Colorado Health Sciences Center. <http://www.uchsc.edu/telehealth/bann%20our%20prg.htm> December 9.

SOFTWARE

The software industry may be characterized as a mature market with a small number of large companies, and many small firms. The Colorado Technology Alliance lists 577 major software companies in the state, and the *Denver Business Journal's* Technology Directory of Colorado lists more than 900 companies in the software industry. Yet industry leaders estimate that there are upwards of 3,000 small software companies, consultants or custom developers with between one and 200 employees (Colorado Technology Alliance 2003) (Focus Group/Survey 2003).

While the software market consists of three major segments, software is an enabling technology that has applications in every market in the economy. The three major segments are:

- Software package developers (also called ISV—Independent Software Vendors)
- Software integrators and consultants
- Software custom developers

The market structure of the industry, and software's enabling technology function, are characteristics that are important to an analysis of this sector. Determining growth industries relevant to the state of Colorado's economy requires an analysis of the markets and trends to which this enabling technology is applied.

National and International Industry Trends

Information Technology

Software is included in the broader industry sector of "information technology" which includes products and services that turn data into useful, accessible information. The information technology industry involves the use of computer hardware, software, and services. Telecommunications hardware, software, and services are also included in the definition. This definition, including the Internet, hand held devices, intelligent machines, and other equipment make it difficult to distinguish between "information technology" and "telecommunications."

The United States leads the world in information and communications technology (ICT) products and services, providing almost 35% of global expenditures. U.S. spending on ICT has grown close to 70% since 1992, reaching $813 billion in 2001. A compound annual growth rate of 6.7% from 1993 to 2001 indicates the high rate of growth in the ICT industry. Member nations of the G-8 experienced a growth rate of 6.2% for the same years. The United States is one of the world's largest per capita ICT spending countries with a level of $3,000 per person. In the United States about 10.1 million people receive their income from information technology jobs, with 85% of these employees working for non-IT companies. Almost 19,500 IT companies in the United States employ 50 or more employees each (Information Technology Association of America 2002).

It is projected that the information technology sector worldwide will grow 34% between 2001 and 2006. This growth rate could be closer to 49% if software piracy worldwide were to be reduced by 10%. In the United Kingdom, where software piracy rates are the lowest in Europe (25% in 2001), there has been a very high growth rate in the information technology software industry and services. Almost 200,000 new jobs were added between 1995 and 2001. Spain, with a significant reduction in software piracy since 1996, is projected to see a growth rate in its information technology software industry that is three times faster between 2001 and 2006 than between 1995 and 2001. Since 1996, the sharpest reductions in software piracy have been achieved in Ireland, Norway, and Spain, while in France software piracy increased slightly and remained about the same in Germany (*European Report* 2003).

Software Sector

Within the software market there are many segmented applications. Trends in identity management, electronic design automation, warehouse management systems, GIS (Geographic Information Systems), and wearable computers are discussed below.

A March 2003, Frost & Sullivan survey forecasts significant growth for the European identity management market. The report forecasts that during the period 2002 to 2006, revenues from this market will grow from EUR250.3 million in 2002 to an estimated EUR827.4 million in 2006, a strong compound annual growth rate of 27.01%. The total market revenue includes sales from digital certificates, Web access control solutions, and provisioning management solutions. Security issues are a prime force in driving the European identity management industry (Telecomworldwire 2003).

In earlier years the electronic design automation (EDA) market was the domain for the small entrepreneurial startup. There have been cycles of consolidation over the years, until gradually, a few companies have emerged as the market leaders. Now, over the past two years, the 3 largest companies in the EDA industry—Cadence Design Systems Inc., San Jose, California; Synopsys Inc., Mountain View, California; and Mentor Graphics Corp., Wilsonville, Oregon—have acquired 12 smaller firms. The soft economy, extremely expensive marketing costs, and increased desire by customers for a one-stop EDA shop make it very unlikely that any EDA start-up will ever challenge the major companies. Furthermore, there is an increasing emphasis on integrated solutions, which suggests that new EDA technologies will occur within the larger companies (*Electronic Business* 2003).

The global Warehouse Management System (WMS) industry expanded by close to 5% in 2002, reaching $737 million in total market revenue. There was a 6% decline in 2001. Since the WMS market is a mature market, it is projected that a cumulative average growth rate of 4.5% will prevail for the global WMS market during the next five years (*Chemical Week* 2003).

Global GIS (Geographic Information Systems) software revenue was $1.1 billion in 2001, an increase of 14.3% from 2000. The utilities industry, with 21% of all software revenue, accounts for the biggest share of market revenue, with state and local

governments, the telecommunications industry, and organizations involved in earth resources management also accounting for significant shares. The largest component of the GIS revenues is services, which includes needs analysis, process re-engineering consulting, and IT-related services such as systems integration, implementation, customization, commissioning, and data conversion. The table below provides the share of revenue generated by the largest GIS software companies.

2001 WORLDWIDE GIS REVENUE (Software only)
Total revenue 2001 EST $1,073 million

Company	% of Total Revenue
ESRI	35%
Intergraph	13
GE	7
Autodesk	7
Leica	6
Mapinfo	6
IBM	5
SICAD	5
Logica	3
Other	14

Source: Electric Light & Power 2003

In 2002 an IT Spending and Strategy (ITSS) survey of technology buyers at end-user companies indicates that budgets for e-business projects were falling, customers were keeping their hardware longer, and low ROI projects were being shelved. The survey revealed that e-business projects were expected to account for only 25% of end-user companies' IT budgets. Twenty-eight percent estimated that e-business would account for less than 10% of their 2002 IT budgets, while 12% expected it to account for more than half of their IT budgets. Still, one-third of the corporate managers surveyed expected to spend more on IT in 2002 than in 2001, while 40% expected to spend about the same. A majority of the respondents (56%) predicted that the increased spending would occur in the second half of 2002. Higher spending was predicted for solution providers as a way of reducing costs and risks for customers. For the year 2002, 17% of the managers surveyed expected to spend more of their IT budgets indirectly through resellers, integrators, or consultants than they did in 2001. Services and consulting accounted for the highest 2001 expenditures (30%), according to survey results. Technology end-users realized that the acquisition, integration, implementation, and management of IT infrastructures aren't among their core competencies, and they expected to keep services and consulting for 2002 as the most important technology spending priority for 2002 (29%). Research results indicated that the most important software-technology areas were security (29%), disaster recovery (19%), database management (16%), and CRM (11%) (*VAR Business* 2002).

By 2006, global shipments of wearable computers are expected to jump eightfold to $563 million from the sales level $70 million in 2001, which is a compound annual growth rate of 51%. The two major types of wearable computers are belt and head-worn products equipped with a head-mounted display, headset microphone and tablet display; and wrist or finger-worn devices that have a bar code scanner and a voice or touch screen interface.

They are used primarily in distribution/warehousing, transportation, field service, and the military. This market has a small number of suppliers: Symbol Technologies Inc., Vocollect Inc., Xybernaut Corp., ViA Inc., Psion Teklogix Ltd, Metrologic Instruments Inc., and Voxware Inc. A few larger companies like Hitachi Ltd., Panasonic, and Hewlett-Packard Co. have also entered the market. Metrologic has a wrist scanner and Symbol makes a finger scanner, which are used in retail and warehouses. Vocollect and Voxware provide speech-based units for hands free operations. Xybernaut, makes belt-worn PCs, for the military market (*Frontline Solutions* 2002).

Microsoft will provide software and tech support to 250 digital community centers in rural Mexico, which will help President Vicente Fox achieve his e-Mexico initiative to bring the majority of the country online by 2006. Microsoft will provide the community centers with 2,500 free licenses of its Windows operating system, and train 4,500 tech operators to run them. Later, Mexico will have the option to acquire up to 50,000 more licenses at a 90% discount. Now, just over 4 million Mexicans are online and the number is expected to surge to nearly 14 million users by 2005, according Jupiter Media Metrix. Online spending is expected to rise by 80%, from $75 million to $1.54 billion during the same period (*Business Mexico* 2003).

Growth Opportunities

By far the most important growth sector is homeland security and the impact that anti-terrorism efforts will have on the security and investigations industry. As an enabling technology, the demand for software packages and their installation will surge in the next decade and beyond. The security and investigations industry includes infomatics, corporate investigations, video-surveillance monitoring equipment, biometric identification devices, concertina wire (thick, heavy barbed wire), and security guards. Robert McCrie, professor of security management at John Jay College of Criminal Justice and editor of The Security Letter, forecasts that global revenues for the security and investigations industry will grow to $158 billion by 2004. In 2002, revenues for this industry are estimated to be $100 billion (*Advertising Age* 2002).

Companies that provide security technology and services will see strong demand for improvements in virtual private networks (VPNs), public key infrastructure (PKI), identity-management packages, intrusion-detection systems, encryption tools and firewalls, vulnerability assessments, and surveillance of physical data centers as government agencies and corporate management add protective security layers to their systems. Also, there will be increased efforts to establish and upgrade security management systems that keep track of policies and procedures. Software is an important enabling technology in achieving all these efforts. While the larger contractors that provide security technologies which were employed in the past by corporations and government agencies will receive many of the contracts to upgrade and expand security networks, alliances with smaller providers will be needed to provide custom expertise as needed. Much of the new homeland security dollars are expected to trickle down to state and local governments, since the police, highway patrols, fire departments, and health-

care facilities are the primary groups that will defend against and respond to acts of terrorism.

The security software market is forecasted to grow 18% in 2002, according to a report published by Dataquest, a unit of Gartner Inc. Sales of security software worldwide will reach $4.3 billion in 2002, up from $3.6 billion last year. Companies want better defensive security technologies such as antivirus software, intrusions detection systems, and firewalls (Newsbytes News Network 2002).

While spending for software has slowed in the current slack economy, a market research firm, AMR Research, projects that supply chain software packages (execution and fulfillment applications) will have $6.4 billion in sales this year, with sales growing by 26% annually to $13.6 billion by 2006. End-user companies are changing from planning to execution applications such as warehouse management and transportation management systems. Planning applications, which generally forecast demand, will grow by only 9% annually to 2006 (*Modern Materials Handling* 2002).

In the 1990s, the market for global software and IT service outsourcing was developed by India. Over the last decade, Indian firms have developed and maintained software in offshore factories located in India. Now, offshore software development is a $12 billion a year industry globally, and India controls close to 70% of the market. Companies are increasingly looking for offshore savings, and global demand will grow beyond India's ability to train new programmers. Forrester Research estimates that, by 2005, more than 400,000 new programming jobs will be needed outside of India to satisfy the demand for offshore services (*Business Mexico* 2002).

Russia's offshore programming market is expected to grow at a rate of 50% per year and reach $348 million by 2003, according to Market-Visio/EDC. The demand for outsourcing IT services by corporations from the United States and Western Europe alone is expected to increase by 40%. Offshore outsourcing will soon make up 28% of companies' IT budgets, according to Forrester Research, and the number of offshore IT workers worldwide is expected grow from 360,000 now to more than 1 million in 2005 (*Inzhenernaya Gazeta* 2002).

Colorado Competitive Position

Colorado is ranked fifth in the United States for software services employment, and the Boulder-Longmont “diagonal” has been ranked as the leading area in the country for software employment for the past four years, according to a national trade organization, the Software and Information Industry. In this national ranking, Denver was 13th and Colorado Springs was in 24th place (*Boulder County Business Report* 2003).

Software industry leaders agree that the Colorado industry has many competitive strengths including an educated labor force, access to good universities and colleges, people with innovative ideas, an entrepreneurial culture, lower cost of living and cost of doing business, and many software companies with diverse products and services. In

addition, the industry is supported by the Colorado Software and Internet Association, a nine-year-old trade organization offering public policy, advocacy, programming, affinity, and leadership for software companies (Focus Group/Survey 2003).

The table below lists the number of software companies in each Front Range county based only on primary companies listed by Colorado Technology Alliance:

COLORADO SOFTWARE COMPANIES

County	# of Companies	% of Total
Boulder	107	18.5%
Arapahoe	84	14.6
Denver	69	12.0
Jefferson	57	10.0
Adams	21	3.6
Broomfield	14	2.4
Douglas	11	1.9
Metro Denver Total	**363**	**63.0%**
El Paso	57	10.0
Larimer	39	6.8
Weld	8	1.4
State Total	**577**	**100.0%**

Source: Colorado Technology Alliance (CTA) 2003

Some of the more significant Colorado-based software companies include:

- PeopleSoft (which acquired J. D. Edwards in 2003), located in the Denver Tech Center, is an international software developer. The company produces business-to-business software for electronic commerce.
- QuarkXpress creates software for newspapers, magazines and catalogues, which is used worldwide.
- Freshwater Software, offers products for web-monitoring and related services. Mercury Interactive Corp. purchased the company for $147 million.
- SignalSoft Corp., develops geographically-based software for the wireless industry, which allows wireless providers to determine where cell phone users are located at any given time.
- Optx Corporation provides software for a database of cancer treatment and research that is shared with oncologists globally.

Data storage is an important part of the software and information technology sector, and includes: StorageTek; McData Corp.; Maxtor Corp.; Iomega Corp.; Chaparral; InPhase Technologies; and Benchmark Storage (Colorado Technology Alliance 2003).

In addition, many companies in other technology industries have developed strong software competencies. For example, Sun Microsystems and Hewlett Packard are significant contributors in the area of information technology management software and Colorado's telecommunications industry, developing software or providing more software consulting (Focus Group/Survey 2003).

The $4.3 billion software security market in 2002 is a high growth market with strong demand for improvements in virtual private networks (VPNs), public key infrastructure (PKI), identity-management packages, intrusion-detection systems, encryption tools and firewalls, vulnerability assessments, anti-virus software, and surveillance of physical data centers. Also infomatics, corporate investigations, video-surveillance monitoring equipment, and biometric identification devices are security areas that require software for their implementation. Colorado companies that provide software for these security areas are poised for significant growth and expansion.

In Colorado, 78 software companies are in the security market, including: Adaptec - data protection and storage; Symantec Inc.; Advanced Internet Security Inc.; IT Strategic Solutions; Check Point Software Technologies; E-Fense Inc.; Fuzion Security; Seagate Technology; NuWorld Solutions Inc.; Riskology Inc.; Software Security Solutions; Security Sentinels Inc.; Secure Network Solutions; Vericept Corp; Webroot Software Inc.; Cisco; Northrop Grumman Information Technology; Qwest; Counter Intrusion Inc.; Integrated Database Solutions Inc.; Intrusion.com Inc.; and Colorado Intrusion System Inc. (Hoovers online 2003).

Market analysis for the software sector suggests that potential high-growth segments, in addition to the software security market, include the information and communications technology industry, chain software packages (execution and fulfillment applications), and identity management.

Colorado firms that package software for disaster recovery, database management, CRM, and execution and fulfillment applications should see strong growth opportunities.

A large Colorado company, CIBER, Inc., located in Greenwood Village, Colorado, reported sales of $608.3 million, and employment of 5,400 in 2002. The firm specializes in enterprise application design, network integration, and operational process outsourcing. Other service areas include business intelligence and data mining, Web development and other Internet support, security, and wireless development. Its primary industry classification is computer software and services – information technology consulting, (NAICS Code: 541511) – custom computer programming services; (NAICS Code: 541512) –computer systems design services. Its Enterprise Solutions division offers consulting and support for enterprise software from SAP, PeopleSoft, Oracle, and other companies. Other service areas include business intelligence and data mining, Web development and other Internet support, security, and wireless development. Its DigiTerra unit offers business process software integration, while CIBER Solution Partners specializes in implementing software from SAP. CIBER also owns 80% of security consultant Enspherics (Hoover's Online 2003).

Offshore outsourcing of IT services is projected to grow at a high rate as more firms look to this market as a low-cost source of expansion. The number of offshore IT workers is expected to almost triple from the present to 2005. While this trend results in jobs going outside the state and country, Colorado software industry leaders believe that offshoring is an asset for firms in that it enables them to use highly skilled, yet lower cost,

employees, thus producing lower priced products that are competitive in the global market. At the same time, software business leaders want to hire from the available labor pool in the state as much as possible to retain the educated workforce needed for industry growth. While this dynamic may cause some lower wage software production to leave the state, the demand is growing for highly compensated senior software engineers who can design and integrate software systems. Overall programming employment may decrease, although overall payroll may remain the same or increase (Focus Group/Survey 2003).

The following two tables provide sales data for the largest companies in Denver County, Colorado, that provide computer systems design services and custom computer programming services. These firms should play an instrumental role in the software market growth segments. The top 30 companies in these two market segments had combined sales in 2002 of $806 million and $307 million, respectively.

NAICS CODE 541512 – COMPUTER SYSTEMS DESIGN SERVICES
SALES OF THE LARGEST 30 COMPANIES
446 Companies in Denver County, Colorado

Company	2002 Sales (in dollars)
Immedient Corporation	$56,024,000
Berger It Co	26,300,000
Boldtech Systems, Inc	26,128,638
Ecollege.com, Inc.	23,691,803
Datatrend Information Systems	22,500,000
West Image Projections Inc	19,100,100
I T Berger Co	15,300,000
Global Technology Resources	11,600,000
Excel Professional Services	9,473,476
Keane, Inc	8,300,000
ACS State Healthcare, Llc	8,300,000
Auto-Trol Technology Corporation	7,933,000
Carl Corporation	7,712,715
Enscicon Corp	7,000,000
Ultradata Corporation	6,700,000
Computer Horizons Corp	5,900,000
Cap Gemini America Inc	4,400,000
The Summit Consulting Group Lt	4,000,000
J B Charles, Inc	4,000,000
Sabre Inc	3,800,000
Gavs Information Services Pvt	3,400,000
Mindbank Consulting Group of Denver	3,100,000
Computer Resource Systems Inc	3,000,000
The Parsec Group Inc	2,939,984
Global Business Systems Inc	2,900,000
Integra5 Communications, Inc.	2,900,000
Axis Networks, Inc.	2,733,655
Valtech Technologies Inc	2,600,000
Nortel Networks Inc	2,500,000
Greenbrier & Russel, Inc.	2,400,000

(D & B – Duns Market Identifiers 2003)

NAICS CODE 541511 – CUSTOM COMPUTER PROGRAMMING SERVICES

SALES OF THE 30 LARGEST COMPANIES

310 Companies in Denver County, Colorado

Company	2002 Sales (in dollars)
Encoda Systems, Inc	$128,763,288
Analysts International Corporation	29,300,000
Taliant Software LLP	15,510,527
Infonow Corporation	12,779,000
Frx Software Corporation	12,700,000
Landmark Graphis	11,800,000
Mincom, Inc	11,200,000
Compri Consulting Inc	10,171,307
Harland Delivery Systems	9,600,000
V R G Development Inc	7,600,000
Dillon Companies Inc	6,500,000
Emery Datagraphic Inc	6,100,000
Interdata Inc	5,000,000
Indigio Group Inc	4,897,551
C T S I	4,600,000
Xi Graphics Inc	4,500,000
The Implementation Partners LL	4,200,000
Drake Automation Inc	4,200,000
Cerner Multum Inc	4,000,000
Tobin International Ltd	3,900,000
State Board For Community Colleges	3,900,000
Ferrell Companies Inc	3,800,000
Intellocity USA Inc	3,600,000
Sys.test Labs, LLC	3,231,397
Sapient Corporation	3,200,000
Nexgen Technologies Inc	3,083,151
Ecovate Inc	3,000,000
Petroweb	3,000,000
Proxima Technology, Inc.	2,900,000
Systems West Computer Resource	2,800,000

(D & B – Duns Market Identifiers 2003)

Summary

Software is a significant contributor to the Colorado economy and industry leaders agree that there will be sustained growth in the software industry in coming years. While software firms could locate any place in the state, most are located along the Front Range. Key requirements are talent pool (bachelor's degree with experience), high-speed connectivity, a community of other software companies, and industry support services. Companies want to be able to meet informally, talk to their peers, and learn from each other (Focus Group/Survey 2003).

Software is a problem solver and an enabling technology that makes many other types of products better, more efficient, and higher value. In addition to the homeland security, system security, and data management areas discussed above, growth areas identified for Colorado include web-based solutions for home consumers, scientific software for astronomical and atmospheric applications, defense and aerospace applications, software

for biopharmaceutical and health sector applications, and GPS-based, hand-held, remote-use applications (Focus Group/Survey 2003).

While Colorado has always been able to generate many small firms with unique products, it has not always been able to keep them in the state. Historically small firms relocate elsewhere in order to access needed venture capital, or are bought up by larger firms. Even large, well-established companies may be lost to the state as they seek second and third-round financing, or due to merger and acquisition as the industry continues to consolidate. The limited amount of local venture funds continues to be a handicap for Colorado, especially compared to other high-growth technology areas. In addition, the local cluster lacks real industry support specialists, for example, attorneys with experience in some of the hardcore software patent issues (Focus Group/Survey 2003).

A recent negative trend is that economic hard times in Colorado have resulted in companies downsizing and many skilled workers being unemployed or underemployed. There is a real risk that these workers will leave the state unless we do have one, or more, relocations of larger firms that have the capacity to hire a number of people (Focus Group/Survey 2003).

Any large company relocation to Colorado is seen as positive to the industry as a whole. The negative aspects are that large companies relocating from other areas often offer higher wages forcing existing local firms to compete for the best employees. On the other hand, they bring highly skilled workers with them that add to the talent pool available to other firms. These workers also add to the industry by spinning out their own new companies (Focus Group/Survey 2003).

There needs to be more information collected and made available to in-state firms, as well as to out-of-state and investment interests, about the positive attributes of the software industry in this state, including a profile of the industry, the industry association, strengths of higher education, skilled workforce, cost of doing business, tax structure, etc. The "media infrastructure" in general, needs to be improved to provide more public information about new technology or software products and software companies that would help build customer awareness and demand. It is also suggested that the industry work with the Denver Convention and Visitors Bureau to attract major industry trade shows to Colorado and use those venues to showcase the state as an attractive business location (Focus Group/Survey 2003).

In order for the state to be competitive with other areas, Colorado should identify a variety of solutions to support the software industry and companies in the state. Included should be an R&D tax credit for software similar to that available to biotechnology. Other states offer tax and employee training incentives that are not available to software firms in this state which places Colorado at a competitive disadvantage (Focus Group/Survey 2003).

Another underutilized resource is Colorado's universities. Many software companies do not know how to take advantage of graduate student interns, research capabilities, and

available technology. And, Colorado's universities lack the infrastructure to value and spin-out their software discoveries into commercial ventures (Focus Group/Survey 2003).

In Colorado, state government, universities, companies, and the industry association need to work together and leverage limited resources to support the software industry. This requires commitment to a long-term strategic plan for industry growth, and a proactive promotional campaign targeted to vulnerable geographic areas that focuses on our industry strengths rather than simply the climate and quality of life.

BIBLIOGRAPHY

Advertising Age (2002). "Marketing of Safety Enters Mainstream." Vol. 73, p. 1. Secondary source: DIALOG(R)File 9:Business & Industry(R) (c) 2003.

Boulder County Business Report (2003). "Boulder-Longmont Still Best for Software." September 19-October 2, p. 2-A.

Business Mexico (2003). "Gates' 'Gifts': Is Microsoft's Offer too Good to be True?" Vol. 12, no. 6, p. 57, June. Secondary source: DIALOG(R)File 9:Business & Industry(R).

_____ (2002). "If Only...: Mexico's Software Industry Potential Remains Untapped." Vol. 12, no. 10, p. 57, October. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Chemical Week (2003). "Warehouse IT Market Rebound. (Information Technology). Forecasts for Global Warehouse Management System Market."Vol. 165, no. 15, p. 22, April 23. Secondary source: DIALOG(R)File9:Business & Industry(R).

Colorado Technology Alliance (2003). "Software Industry Overview." <http://www.coloradota.org/companies/industry.asp?bcid=15&BcName=Software> May 15.

D&B (2003). Dun's Market Identifiers DIALOG® File 516.

Electronic Business (2003). "Buying Boom or Selling Surge? EDA Consolidation Represents the End of an Era." Vol. 29, no. 5, p. 31, April 15. Secondary source: DIALOG(R)File9:Business & Industry(R).

Electric Light & Power (2003). "GIS Software Market Sees Dynamic Growth." Vol. 81, no. 2, p. 6, February. Secondary source: DIALOG(R)File9: Business & Industry(R).

European Report (2003). "Information Technology: Reducing Software Piracy Could Bring Major Job and Tax Receipt Benefits." April 9, p. 361 Secondary source: DIALOG(R)File9:Business & Industry(R).

Focus Group/Survey (2003). A software industry focus group and survey conducted in May.

Frontline Solutions (2002). "Wearable Computers: The New Fashion-Ware for the Future." Vol. 3, no. 13, p. 8, December. Secondary source: DIALOG(R)File9:Business & Industry(R).

Hoover's Online (2003). "Ciber, Inc., Company Capsule." <http://www.hoovers.com/co/capsule/4/0,2163,17154,00.html> May 29.

Information Industry Association (2003). <http:// www.siia.net>

Information Technology Association of America (2002). "The U.S. Information Technology Industry: A Brief Overview." <http://www.itaa.org>

_____ (2003). <http://www. itaa.org>

Inzhenernaya Gazeta (2002). "Russia: Russia's Offshore Programming Market is Expected to Grow at a Rate of 50% Per Year." June 25, p. 4. Secondary source: DIALOG(R)File 9:Business & Industry(R).

Modern Materials Handling (2002). "Execution Applications Will Outsell Planning Software." Vol. 57, no. 9, p. 15 (1), August. Secondary source: DIALOG(R)File9:Business & Industry(R).

Newsbytes News Network (2002). "Security Software Market to Grow 18 Percent in '02." *Newsbytes News Network*, p n/a. February 4. Secondary source: DIALOG(R)File9:Business & Industry(R).

Telecomworldwire (2003). "Frost & Sullivan Survey Points to Growth for European Identity Management Market." *Telecomworldwire*, United Kingdom Journal. March 19. Secondary source: DIALOG(R)File9:Business & Industry(R).

VAR Business (2002). "The Customer Speaks: Research Signals Signs of Recovery for IT Spending." April 29, p. 28. Secondary source: DIALOG(R)File 9:Business & Industry(R).

TOURISM AND HOSPITALITY

World Market Size and Expected Growth

In 2003 travel and tourism in the world is expected to generate $4,544.2 billion of economic activity (total demand), growing to $8,939.7 billion by 2013. Travel and tourism employment in 2003 is estimated at 194,562,000 or 7.6% of total employment (1 out of every 13.2 jobs). It is projected that by 2013, this total will increase to 247,205,000 jobs, or 8.4% of total employment (1 in every 11.9 jobs) (World Travel & Tourism Council 2003a).

According to the Office of Travel and Tourism Industries (OTTI), U.S. Department of Commerce, in 2002 the United States saw declines in international arrivals for the second straight year. The decreases were not all equal as numerous states and cities saw declines either greater or lesser than the national average. Denver received 249,000 overseas visitors in 2002, compared to 240,000 in 2001, for a 4.0% gain. The city's market share increased from 1.1% in 2001 to 1.3% in 2002 (OTTI 2003). It is projected that international visitation to the United States will return to pre-September 11, 2001, levels by 2004. A record 60 million international visitors are estimated to come to the United States in 2006, a 32% increase over 2001 (IPK International 2003).

A $50 million appropriation to create an international travel and tourism marketing and promotion campaign was approved in 2003. Canada, Mexico, the United Kingdom, Japan, and Germany are the five countries that efforts will be focused on (U.S. International Trade Administration 2003).

National Market Size and Expected Growth

From 1993 to 2002, total employment in the leisure and hospitality sectors grew at a compound annual growth rate (CAGR) of 2.3%, slightly more than the 1.8% CAGR for total U.S. nonfarm wage and salary employment. Only the accommodations sector grew at a CAGR less than the rate for the total sector. In 2002, total leisure and hospitality employment represented 9.2% of total nonfarm employment, up from 8.8% in 1993.

U.S. LEISURE AND HOSPITALITY SECTOR EMPLOYMENT GROWTH RATE

NAICS	Description	2002 Employment (in thousands)	CAGR vs 1993	% of Total 2002 L&H
71	Arts, Entertainment, and Recreation	1,778.0	3.5%	14.9%
712	Museums, Historical Sites, Zoos, and Parks	112.5	4.1	0.9
713	Amusement, Gambling, and Recreation	1307.6	3.8	10.9
711	Performing Arts and Spectator Sports	357.9	2.5	3.0
72	Accommodations and Food Services	10,191.2	2.1	85.1
722	Food Service and Drinking Places	8,411.7	2.3	70.3
721	Accommodations	1,779.2	1.3	14.9
	Total Leisure and Hospitality	11,969.0	2.3%	100.0%

Source: U.S. Department of Labor.

In 2003 travel and tourism in the United States is projected to generate $1,387.8 billion of economic activity (total demand), increasing to $2,560.4 billion by 2013. Travel and tourism employment is estimated to total 16,347,900 jobs, or 12.0% of total employment (1 in every 8.3 jobs). By 2013, this total is projected to increase to 17,907,000 jobs, or 11.9% of total employment (1 in every 8.4 jobs) (World Travel & Tourism Council 2003b).

In terms of domestic travel, travelers took 1,017.8 million person-trips in 2001, a 2% gain over 2000 despite the September terrorist attacks and economic downturn. The Travel Industry Association of America projects this figure to increase 0.3%, to 1,021.3 million, in 2002 (TIA 2002). Leisure trips account for the majority of all U.S. domestic travel (76%). Business travel totaled 206.5 million person-trips, or 21% of all U.S. domestic travel, in 2001 (TIA 2002, p. 9). Leisure travel is estimated to total 780.5 million person-trips in 2002, up 1.8%, while trips for business are projected to fall 5.5%, to 195.2 million.

Spending by international and domestic travelers generated $98.7 billion in tax revenue for local, state, and federal governments in 2001 (TIA 2002, p. 10). Total projected domestic and international expenditures for 2001 were $537.2 billion, a decline from $570.5 billion in 2000 (TIA 2002, p. 10). It is estimated that this figure will decline further, to $525.1 billion, in 2002 (TIA 2003a).

Industry Segments

The tourism industry can be examined in several ways. This discussion follows the North American Industry Classification System (NAICS), which is used in the analysis of employment trends in other parts of this study.

From 1993 to 2002, there was a CAGR of 2.9% for employment in the NAICS Supersector Leisure and Hospitality. This rate is slightly less than the total state wage and employment CAGR for Colorado, which is 3.0%. Total leisure and hospitality employment was 11.3% of total state employment in 2002 compared to 11.4% in 1993. The overall concentration of leisure and hospitality employees, as noted by the location quotient, is noticeably higher than the United States.

COLORADO LEISURE AND HOSPITALITY SECTOR EMPLOYMENT GROWTH RATE

NAICS	Description	2002 Employment (in thousands)	CAGR vs 1993	% of Total 2002 L&H	Location Quotient
71	Arts, Entertainment, and Recreation	41.8	3.1%	16.9%	1.40
72	Accommodations and Food Services	205.6	2.9	83.1	1.20
722	Food Service and Drinking Places	166.2	3.3	67.2	1.18
721	Accommodations	39.4	1.5	15.9	1.32
	Total Leisure and Hospitality	247.4	2.9%	100.0%	1.23

Source: U.S. Department of Labor.

NAICS Sector 71: Arts, Entertainment, and Recreation

Subsectors 711 and 712: Museums, Historical Sites, Performing Arts, and Spectator Sports

A recent report by Americans for the Arts (2002) gathered evidence that the nonprofit arts are a significant industry in the United States, generating "$134 billion in total economic activity. This spending—$53.2 billion by nonprofit arts organizations and an additional $80.8 billion in event-related spending by their audiences—supports 4.9 million jobs and delivers more than $23 billion in total government revenue."

A 2001 poll conducted by the Travel Industry Association of America (TIA) found that 45% of the U.S. adult population indicated they included at least one cultural, arts, heritage, or historic activity or event while on a trip of 50 miles or more (one way) in the past year. Visiting historic sites was the most popular activity, followed by visiting museums, and attending live theater, heritage/ethnic festivals or concerts and visiting art galleries (TIA 2002, p. 28). Historic and cultural travelers spend an average of $631 per trip compared to $457 for all U.S. travelers (does not include transportation). According to a survey of National Tour Association tour operators in 2002, historical attractions were the best-selling attraction type, followed by museums and cultural/ethnic attractions (National Tour Association 2003).

The American Association of Museums predicts that by 2005 revenues from heritage and cultural tourism are anticipated to reach $200 billion (TIA 2002, p. 28).

In the metro Denver area, cultural organizations generated more than $1 billion in economic impact in 2001, including $648 million in industry spending and $436 million event-related spending by cultural audiences. Cultural organizations employed nearly 7,700 people. Cultural tourism generated $139 million in 2001, and nearly 860,000 cultural visitors were from out of state (CBCA 2002).

Subsector 713: Amusement, Gambling, and Recreation Industries

Amusement. Attendance at the approximately 600 parks and attractions in the United States has increased nearly every year since 1990. Attendance totaled 324 million in 2002, with total revenue at $9.9 billion (International Association of Amusement Parks and Attractions 2003).

Attraction attendance in the metropolitan Denver area was down 2.1% in calendar year 2002 compared to the same period in 2001; however, in fourth quarter 2002 attendance rose slightly, 1.6% (The Adams Group 2002). Statewide attraction attendance fell last summer due the effects of 9/11, the poor economy, and wildfires. Attendance is holding steady during summer 2003 (Focus Group/Survey 2003).

Gambling. In 2001, gross gaming revenue in the United States totaled $25.7 billion, a 5% increase. The workforce numbered more than 364,000 people, earning wages of $11.5

billion (American Gaming Association 2002). Nationwide, casinos attracted 52.3 million people for a total of 303 million visits in 2001.

Although Colorado casinos in Black Hawk, Central City, and Cripple Creek posted their first-ever drop in revenues in fiscal year 2002-03, gaming taxes did not decline. The amount of gaming taxes climbed from $95.7 million in fiscal year 2001-02 to $97.5 million in 2002-03 (Blevins 2003b). The Colorado Division of Gaming projects casinos will pay $101.1 million in gaming tax proceeds in fiscal year 2004. Colorado casinos recorded more than $62.1 million in adjusted gross proceeds in May 2003, a 1.8% increase compared to the same period in 2002 (Colorado Division of Gaming 2003). The Colorado gaming industry employs more than 7,000, with total wages of $194.8 million (American Gaming Association 2002).

In Central City casino revenues continue to fall. The city recorded a $4.7 million decline in 2001-02. A planned new road connecting Central City with Interstate 70 may help generate new business (Blevins 2003b).

Outdoor Recreation. In 2001 the U.S. National Park Service reported 9.8 million overnight visitors. Domestic and international travelers made just over 277 million recreation visits to recreation areas administered by the NPS in 2002 compared to 280 million visits in 2001 (TIA 2002). In 2001, 10% of person-trips by U.S. resident travelers were to national or state parks, and in a TIA Travel Poll, 31% of all U.S. adults reported taking at least one trip of 50 miles or more, one-way, away from home to visit a state or national park and/or forest (TIA 2002).

In areas in Colorado administered by the National Park Service, recreation visits fell 7.9% in 2002 compared to 2001 (National Park Service 2003), most likely due to the wildfires in the state and the economic slowdown.

The results of the "Colorado State Parks' Market Assessment Study," conducted in 2002, reveal that about 43% of Colorado residents older than 18 have visited at least one Colorado state park during the past two years, indicating a "significant opportunity for increased market penetration" (PricewaterhouseCoopers 2002). More than 2.2 million residents over 18 have not visited a Colorado state park in the past two years.

The "Participation – State by State Report," which is published annually by the National Sporting Goods Association, indicates that residents of Colorado are nearly three times as likely to ski as the national average, more than twice as likely to hike and mountain bike, and nearly twice as likely to backpack or camp (National Sporting Goods Association 2002).

Mountain biking, a relatively new form of recreation, is an important part of the Colorado outdoor recreation tourism package. Mountain biking annually brings millions of dollars to ski towns such as Vail and Winter Park (International Mountain Bicycling Association 2002). Trails attract mountain bikers and boost adjacent lodging, food, and retail businesses. Just over 50% of all summer visitors to Colorado resorts in 1999 engaged in

bicycling (Colorado Department of Transportation 1999). While this study has not been updated, the 2002 Longwoods International study conducted for the Colorado Department of Economic Development and International Trade found that 28% of respondents strongly agreed that compared to the U.S. norm Colorado is "great for mountain/off-road bicycling" (Colorado Office of Economic Development and International Trade 2003).

The visitor and image research study conducted by Longwoods International for the 2002 travel year found that Colorado is the 14th most popular state for an outdoors vacation (Colorado Office of Economic Development and International Trade 2003).

Skiing. Preliminary skier visit data indicate the nation's ski areas enjoyed a very strong 2002-03 season, recording 57.6 million visits. This total is 0.5% above the visits recorded in the record 2000-01 season. The Rocky Mountain area, which includes Montana, Idaho, Wyoming, Utah, Colorado, and New Mexico, showed a 3.2% increase in visits over the 2001-02 season (National Ski Areas Association 2003).

Colorado ski resorts posted a 4.29% increase in skier visits during the 2002-03 season (Colorado Ski Country USA 2003). The season's total of 11,605,588 visits was just short of the record visits set in the 1997-98 season. All three resort groupings—destination resorts, Front Range destination resorts, and Front Range resorts—showed an increase in skier visits.

The Longwoods International study found that Colorado maintains a 17% market share of ski trips and is the number one destination for overnight ski vacations (Colorado Office of Economic Development and International Trade 2003).

NAICS Sector 72: Accommodation and Food Services

Accommodation

In 2001, the American Hotel & Lodging Association (AH&LA) reported a 60.3% average occupancy rate and sales of $103.6 billion. Total industry revenue increased from $62.8 billion in 1990 to $108.6 billion in 2000 (TIA 2002, p. 25).

According to PricewaterhouseCoopers, the lodging industry is poised to recover slowly in 2004, barring any further terrorist actions. The firm estimates occupancy will first bottom out to 59.1% by year-end 2003, then increase to 60.1% in 2004 and 61.6% in 2005 (*Meetings and Conventions 2003*). The newly released Runzheimer International Annual Survey and Analysis of Business Travel Policies and Costs forecasts firms will increase their hotel spending 5% in 2004, while corporate travel budgets will increase 6.5% (Runzheimer International 2003).

In April 2003 American Hotel & Lodging Association Governmental Affairs Committee Chairman William H. Edwards, Jr., who is also Area Vice President for Hilton Hotels Corporation and General Manager of Hilton Washington, testified before Congress on the

current state of the lodging industry. In his testimony, he reported the lodging industry has eliminated approximately 130,000 jobs since mid-2001, and has shifted some employees to part-time work until business improves. Domestic business travel is down almost 9% since 2000, and international arrivals have dropped 17%. Lodging property profits declined 9.6% in 2002, on top of the 19.4% drop in 2001 (American Hotel & Lodging Association 2003).

In the Denver metro area, lodging nights in Denver County rose 6.6% and 9.3% in the suburban counties in fourth quarter 2002 compared with fourth quarter 2001. For the year, the vacancy rate increased 0.7 percentage points in Denver County and declined 2.2 percentage points in the metro area. Average room rates fell 1.5% for 2002 in the county of Denver and 2.8% in the metro area (The Adams Group 2002).

Meetings and Conventions and Business Travel. Total spending for the meeting and convention industry in 2001 was $102.3 billion (Meeting Planners International 2003). According to the International Association of Convention and Visitor Bureaus, delegates who attended meetings, conventions or trade shows in 2001 spent an average of $248 per day in the host city (excluding registration fees or transportation to/from the destination). Length of stay was approximately three nights, so the total impact per delegate per event was $748 (TIA 2002, p. 16).

The Business Barometer survey conducted by the International Association of Convention & Visitor Bureaus (IACVB) indicates that sales leads and definite bookings have remained stable or have increased for first quarter 2003 against the same period in 2002 for more than 60% of convention and visitor bureaus.

The Center for Exhibition Industry Research's *Exhibition Industry Census* revealed that Denver ranked 12th in the number of exhibitions hosted by U.S. and Canadian cities in 2000.

According to the Longwoods study conducted for the 2002 travel year, business travel in Colorado is up 8%, to 4.1 million overnight trips, but remains behind the record 4.9 million overnight trips posted in 2000 (Colorado Office of Economic Development and International Trade 2003).

The Colorado Convention Center in Denver will double in size by December 2004. The expansion project, which includes 292,000 square feet of new exhibit space and 35,000 square feet of new meeting space, will make the center the sixth largest convention center west of the Mississippi. Additionally, the City of Denver is financing an 1,100-room convention headquarters hotel on a site adjacent to the existing center. It is projected that the expansion will generate additional spending of $100 million per year in Denver and support 3,800 jobs (Denver Metro Convention and Visitors Bureau 2003).

In November 2002 voters in Vail passed a tax increase to construct a 50,000-square-foot convention facility in west Lionshead (Meetings and Conventions 2002).

Food Services and Drinking Places

Average sales in 2000 were $650,000 at full-service restaurants and $585,000 at limited-service (fast-food) restaurants. Food and drink sales are forecast to total $426.1 billion in 2003. Sales growth in the full-service sector is anticipated to reach $153.2 billion in 2003, a 4.8% increase over 2002 sales. Fast-food sales are projected to increase 4.1%, to $120.9 billion (National Restaurant Association 2003a,c).

Eating and drinking establishments in Colorado totaled 11,184 in 2001, with 167,800 employees. Sales for 2002 are projected at $5.9 billion, with growth from 2001 estimated at 6% (National Restaurant Association 2003b).

In this uncertain economic environment, quick-service operators report recruiting and retaining employees is their top challenge, followed by building and maintaining sales volume. Full-service operators reported the economy is their key challenge (National Restaurant Association 2003c).

Barriers

The Economy

Tourism depends on discretionary income. Performance of the economy affects tourists' behavior. When consumers' perception of the economy is pessimistic, they tend to increase savings, worry about layoffs, and postpone vacations. While some people will continue to travel even when they feel the economy is not performing well, they will take shorter trips closer to home and spend less money (Focus Group/Survey 2003).

Health and Safety Issues

Chronic Wasting Disease

Chronic wasting disease (CWD), an incurable brain disease that is fatal to deer and elk, could jeopardize communities that depend on revenue from hunters. Even if the incidence of CWD is low, the spread of the disease could erode hunter confidence. Hunters pump an estimated $600 million annually into local economies, according to an economic impact model prepared for the Colorado Division of Wildlife (Gerhardt and Hartman 2002).

Foot and Mouth Disease

The foot and mouth epidemic in the United Kingdom in 2001 greatly affected the region's tourism industry. The overall cost of the lack of access to the countryside was about £270 million (approximately $432 million) per week in March 2001 (Diamond 2001). If this disease was ever found in Colorado, the state's tourism industry could suffer similar consequences.

HIV/AIDS

Although a review of the literature reveals little definitive evidence of the relationship between tourism and HIV/AIDS, it is conceivable that given the nature of the industry, tourism is "likely to be significantly affected" by the epidemic (Forsythe n.d.). Fear of AIDS among tourists could discourage them from visiting certain countries; however, the United States is not usually placed in this category.

Severe Acute Respiratory Syndrome

The Severe Acute Respiratory Syndrome (SARS) epidemic, combined with other factors, heavily affected the tourism industry and particularly those destinations that registered the highest numbers of victims. China alone may lose 1.8 million jobs in the tourism sector (Staff 2003). The threat of SARS affected hotels, airlines, and tourist destinations as travelers stay away from high-risk areas around the world. As a precautionary measure, the World Health Organization urged travelers to avoid trips to highly affected areas, such as Beijing, Hong Kong, and Toronto (DeMarco 2003). Airlines have been hit harder than they were by the war in Iraq, according to World Tourism Organization (WTO) Secretary-General Francesco Frangialli. While SARS is the latest disease to impact tourism, other diseases like AIDS are still deterrents to travel in some areas of the world.

Terrorism

Terrorist acts have a devastating effect on the world economy and the tourism industry worldwide. The airline industry lost nearly $8 billion in the months following the attacks on September 11, 2001. Many large airports experienced double-digit decreases in demand, and the impact on small and medium airports was even more significant (U.S. Conference of Mayors 2002). Denver International Airport realized a decline of approximately 7% in the number of enplaned passengers in 2001. The Colorado Springs airport recorded a nearly 35% drop in enplaned passengers from September 2000 to the same period in 2001.

From October 2000 to October 2001, airports in Colorado's small communities, including Aspen, Eagle, Durango, Gunnison, Hayden, and Montrose, experienced reductions in daily turbo prop and daily jet departures. These declines may be turning around in selected areas. Aspen saw increased capacity in the winter 2002-03 season (Urquhart 2002).

Accessibility issues to the United States stemming from the 9/11 terrorist attacks are presenting challenges (Focus Group/Survey 2003). Beginning October 26, 2004, each visa waiver program traveler must present a machine-readable passport at a U.S. port of entry to be admitted to the United States without a visa. Those travelers without machine-readable passports must obtain a nonimmigrant visa (U.S. Department of State 2003). As of 2001, the United States issued 10 million visas per year. By the end of 2002 that

number had fallen to 6 million, with a more significant drop anticipated in the future (Focus Group/Survey 2003).

West Nile Virus

Federal health officials announced in October 2003 that Colorado leads the nation in the number of reported cases of West Nile virus. More than 2,171 human cases and 43 deaths have been confirmed by the Centers for Disease Control (*Rocky Mountain News* 2003). Since the onset of West Nile in the United States, some nations have issued travel warnings to their citizens traveling to the United States. Currently, the United Kingdom has issued a health advisory to their citizens traveling to the United States urging them to take protective measures against this disease (Staff 2003).

Growth Opportunities

The Travel Industry Association of America suggests that the following recent travel trends will likely continue:

- The preference for domestic travel rather than international travel will likely intensify due to anti-Americanism concerns and international conflicts.
- Fear of flying is increasing the popularity of closer to home destinations, which could benefit locations near major population centers.
- With the resolution of the war, oil prices are expected to decline, lower gas prices will continue to change travelers' preferences, and auto vacation travel is expected to do well (TIA 2003b).

<u>e-Tourism</u>

The importance of new information and communication technologies for the tourism industry has grown tremendously in the past few years. According to a study carried out by Yesawich, Pepperdine & Brown/Yankelovich Partners in 2002, 32% of American leisure travelers made a reservation on the Internet in the past 12 months. This figure was 33% for business travelers. Last year the figure for business travelers was 25% (Carton 2002). When the question is broadened to include those who use the Internet to search for information and prices, the figures are 53% of leisure travelers and 55% of business travelers. Clearly, the Internet has become a major tool in travel planning, and presents challenges and opportunities for tourism businesses. However, the lack of technology can sometimes hurt small businesses that lack the resources to develop and maintain a web site (Focus Group/Survey 2003).

Another challenge presented by technology is how to control pricing on the Internet and how to better use the Internet to maximize revenues. Direct hotel bookings by conference attendees significantly affect room blocks held by the conference organizer. The meeting/convention industry must learn to deal with this issue (Focus Group/Survey 2003).

Ecotourism

Ecotourism is defined by the International Ecotourism Society as "responsible travel to natural areas which conserves the environment and sustains the well-being of local people." It is concerned with preserving a destination's total geographic character, including the natural and human attributes that make the area unique. According to a recent study entitled *Geotourism Study: Phase I Executive Summary* conducted by the Travel Industry Association of America and *National Geographic Traveler*, 55 million Americans are now classified as sustainable or "geotourists" (TIA 2002, p. 15). The study found that travelers in the top three segments (from a total of eight segments) represented more than one-third of the total traveler market, or approximately 55.1 million travelers (TIA 2002, p. 15).

Based on a nationwide study of nature-based vacations, visiting parks, hiking, exploring a preserved area, wildlife viewing, and nature trails in ecosystems were the top five nature-based activities (Visit Florida Research Office 1999). All of these activities may be found in Colorado.

With an increased focus on active vacations and holidays spent with family on outdoor activities, this market represents a growth opportunity in Colorado (Focus Group/Survey 2003).

Adventure Tourism

The adventure travel segment comprises both hard and soft adventure activities, including hiking, biking, viewing wildlife, scuba diving, sailing, mountain climbing, and learning about other communities around the world. The Adventure Travel Society (ATS) and the Adventure Travel Trade Association (ATTA) report that adventure travel has grown 7 to 8% since 1987. According to ATTA, more than $115 billion is spent on adventure travel annually in the United States, while an additional $125 billion is spent on outdoor recreational equipment (TIA 2002, p. 33). About two-thirds of Americans participate in outdoor recreation each year. Women, families, and mature travelers make up the majority of adventure travelers. The ATS estimates that adventure travel in the United States will remain at $245 billion for 2002 and grow 3% in 2003 (Adventure Travel Society 2002).

River Rafting

More people go whitewater rafting in Colorado than in any other state (Colorado River Outfitters Association 2003). Colorado river-rafting outfitting is a $122 million per year industry in the state (TIA 2002, p. 33). Colorado has 13 world-class river systems serviced by more than 40 licensed outfitters. The river-rafting industry in Colorado experienced a serious drop in use in 2002—39%—due to the sluggish economy, drought conditions, and wildfires in the state (Colorado River Outfitters Association 2003). The number of river rafters rose in 2003, but did not climb as high as anticipated due to a sluggish economy. Preliminary figures indicate that rafting companies experienced a

good rebound in 2003, although business did not reach 2000 or 2001 levels (Blevins 2003c).

Agritourism

Colorado tourism professionals consider agritourism, which refers to the act of visiting a working farm or any agricultural, horticultural, or agribusiness operation for the purpose of enjoyment, education, or active involvement in the activities of the farm or operation (Lobo 2003), a potential growth area for rural communities. Agritourism is an alternative for improving the incomes and potential viability of small farms and rural areas that does not require massive infrastructure. It could help keep ranches and farms complete, rather than selling off the property to developers. There may be opportunities to enhance visitor experience and highlight local products by organizing and promoting some "rural tours" that include stops at stores with "Made in Colorado" products and restaurants that feature menu items with Colorado-grown meat and produce. Other entrepreneurial ideas include weddings in nontraditional settings, bed-and-breakfast stays on farms, and wind farm tours (Focus Group/Survey 2003).

Dude Ranches

Dude ranches, which number around 40 in Colorado, are a unique way to experience the "Old West." After 9/11 more travelers are choosing secluded vacation sites, and family-oriented holidays. The Dude Ranchers' Association reports an 81% surge in visitors to their member ranches, from 39,120 guests in 1995 to 70,650 in 2000 (Relly n.d.).

Golf

Currently, there are more than 26.7 million golfers age 12 and older. About 6.3 million of these play 25 or more rounds of golf annually (TIA 2002, p. 36). Golf vacations continue to be popular. The number of golf facilities in Colorado grew 62% from 1989 to 2002. The state has more than 250 golf courses throughout the state that contribute $700 to $800 million in retail sales annually. This industry employs more than 18,000 people. In addition, The International, a Professional Golf Association tournament first held in 1986, brings top golfers to the state. Hosted by Castle Pines Golf Course in Castle Rock, the tournament was first held in 1986.

Culture

Cultural activities and events, such as theater productions, concerts, dance performances, and festivals, are an important element of a community's quality of life and a total tourism package. Colorado has a vibrant arts/culture community, with offerings as varied as opera productions presented at the historic opera house in Central City, the Telluride Film Festival, performances by Colorado Ballet, the Creede Repertory Theatre, and the performances by world-renown artists at the Aspen Music Festival. Moreover, the expansion of the Denver Art Museum, which is scheduled to be completed in 2006, will be a landmark for Denver and the surrounding area. Distinguished architect Daniel

Libeskind designed the new addition, which will nearly double the size of the facility. In 2003 the New York Philharmonic begins a three-year commitment at the Bravo! Vail Valley Music Festival. Ticket sales have increased 30% from last year (Shulgold 2003).

Heritage Tourism

Colorado is rich in historical sites, but visitors are often not aware of them. Offerings are as varied as Bent's Old Fort, the remains from the ancient Anasazi culture at Mesa Verde, and the fossil quarries and museums on the Dinosaur Diamond Scenic and Historic Byway. This market represents great growth potential that the industry can build on (Focus Group/Survey 2003). Visiting historical places is one of the top 10 leisure/recreation activities participated in by overseas travelers in 2000, and nearly all (89%) of historic/cultural person-trips involve an overnight stay (TIA 2002, p. 28).

Colorado Tourism Industry Strengths

The Colorado Tourism Office contracted with Longwoods International to conduct a visitors study in 2002 that included visitor research, image research, and advertising accountability/return on investment research (Colorado Office of Economic Development and International Trade 2003). The findings include the following:

- Colorado has "virtually no image weaknesses." Colorado surpasses the competition with its image for family-orientation; great scenery; outdoor recreation, including skiing and camping; being safe and friendly, with a relaxed atmosphere; affordable accommodations and dining; and interesting small towns.
- Colorado is one of the top states that American vacationers dream about visiting.
- Colorado appears to surpass recent visitors' expectations in the key area of variety, including lots to see and do generally, interesting towns and historical sites, a great place for sightseeing on foot, and exciting casinos.

Colorado is marketable as a year-round destination (Focus Group/Survey 2003). The state is unique in that it offers a variety of activities on any given day depending on the altitude. On a warm, early spring day, for example, a tourist may ski, hike, or bicycle. The tourism industry needs to more effectively communicate what the state has to offer.

Colorado Tourism Industry Weaknesses

State Tourism Budget

The loss of state funding for tourism advertising occurred in a vote taken in November 1993. Colorado rapidly lost market share in the tourism industry. The state reinstated funding for a state-sponsored advertising campaign in 1997 and began rebuilding its market share. In 2000, the Colorado Tourism Office replaced the Colorado Tourism Board and the Colorado Travel and Tourism Authority. That same year the state spent $2.24 million on advertising and media. In 2001, $3.24 million was spent, and $2.99 million was spent in 2002. The Longwoods study showed that every dollar invested in

Colorado tourism promotion makes $12.74 in state and local taxes. Tourism received a one-time boost of $9 million in fiscal year 2003-04; however, a permanent funding source for the Colorado Tourism Office was not established. Base funding for the office was cut from $5.7 million to approximately $2.8 million for fiscal year 2003-04 (Dalgar 2003).

State tourism professionals emphasize the importance of a consistent level of funding that will pull together the industry (Focus Group/Survey 2003). Continuity is critical for promotion and development purposes. Inadequate marketing at the state level is a primary competitive weakness that puts Colorado at a disadvantage compared with other states (Focus Group/Survey 2003).

State funding for research, product development, technical assistance, and education is also needed to support this industry (Focus Group/Survey 2003). A lack of strong academic programs to prepare future professionals is a weakness that could prevent tourism from growing in the state (Focus Group/Survey 2003).

Wildfires and Drought

Colorado received a federal disaster declaration June 19, 2002, because of wildfires burning throughout the state. The initial declaration covered 56 counties and 2 Indian reservations. The wildfires during the summer of 2002 greatly affected tourism businesses. The Longwoods study reports that nearly all of the gains in leisure visitor numbers occurred in the first half of the year. Severe drops occurred in the July to October period compared to 2001 levels. "The fires and attendant publicity clearly had a major negative impact on Colorado tourism," according to the Longwoods report. Even with the snowpack at 94% of average statewide as of April 1, 2003, compared with 52% of average on the same date in 2002, Colorado remains in a drought. This situation may affect the tourism sector through a decline in recreational activities, including skiing, hunting, fishing, camping, and park visits (Colorado Office of State Planning and Budgeting 2002).

Distance from Major Markets and State Population

The results of the Longwoods study indicate that 61% of all overnight leisure trips to Colorado come from the following census regions: Mountain (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Wyoming), West North Central (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota), and West South Central (Arkansas, Louisiana, Oklahoma, and Texas). California was also a major contributor. The average trip length in Colorado in 2002 was nearly two days longer than the national norm, which is consistent with the state's distance to major markets and its attractions. Colorado does not have the population to draw from for in-state tourism such as New York or California, and is relatively removed from significant population centers (Focus Group/Survey 2003).

Shorter Vacations

As the average trip duration for leisure travelers decreases, direct air service will become increasingly critical for the long-term success of tourism in rural parts of the state (Focus Group/Survey 2003). A challenge for the state's tourism industry is how to take advantage of travelers' time limitations.

Airline Market Share

United Airlines is the largest carrier at DIA, with 52.5% of flights. Frontier Airlines occupies the second place position, with nearly 12.0 % (Denver International Airport 2003). The dependence on United at DIA could be viewed as both positive and negative. United's financial problems have negatively impacted the industry. At the same time, these difficulties have created opportunities for other carriers (Focus Group/Survey 2003).

Summary

The Colorado tourism industry is an important part of the state's economy as results of the Longwoods study indicate. The dollars spent on advertising generated an incremental 1.86 million visitors, who spent an additional $522 million in Colorado, resulting in a $32.4 million boost in taxes taken in by state and local treasuries (Colorado Office of Economic Development and International Trade 2003). These results demonstrate clearly that dollars spent on tourism promotion provide a significant return on investment to the state, and that promotion is essential for Colorado to realize the growth opportunities of this industry. Many of the growth segments outlined in this report are available in rural parts of the state, where it is critical to take advantage of economic development opportunities. Targeted promotion can highlight Colorado's market strengths to the appropriate audiences in adjacent states, and include messages that address concerns such as safety and costs, and market trends like shorter vacations.

BIBLIOGRAPHY

The Adams Group, Inc. (2002). "Metropolitan Denver Tourism Indicators, Fourth Quarter 2002." <http://www.coloradoeconomy.com/tourism.html>. June 17, 2003.

Adventure Travel Society (2002). "U.S. Adventure Travel Strong for 2002." <http://media.adventuretravelbusiness.com/index.php/press_releases?item_id=5.>

Americans for the Arts (2002). *Arts & Economic Prosperity: The Economic Impact of Nonprofit Arts Organizations and Their Audiences.* <http://www.manyonline.org/MANY-Article01.htm>.

American Gaming Association (2002). *State of the States: The AGA Survey of Casino Entertainment 2002.* <http://www.americangaming.org/survey2002/economic_impact.html>. June 26.

American Hotel & Lodging Association (2003). "AH&LA Testifies Before Congress on the State of the Lodging Industry." <http://www.ahma.com/news_view_release.asp?mstr=345>. June 17.

Blevins, Jason (2003a). "Tourism Budget Escapes the Knife." *The Denver Post*, May 7, Sec. C, p. 1.

_____ (2003b). "State Casinos See First-Ever Revenue Drop." *The Denver Post*, July 17, Sec. C, pp. 1, 3.

_____ (2003c). "Rising Rivers Lift Rafting Business." *The Denver Post*, August 14, Sec. C, pp. 1, 3.

_____ (2003). "Tourism Ads Aim to Brand Colorado." <http://www.denverpost.com/Stories/0,1413,36%257E33%257E1589604,00.html ?search=filter>. August 26.

Carton, Luc (2002). "66% of American Users Believe that eTourism Web Sites Provide Better Services than Travel Agents!" <http://www.etourismnewsletter.com/ecommerce.htm#behaviour>. July 22, 2003.

Center for Exhibition Industry Research (CEIR) (2002). *Sixteen North American Cities Play Host to Nearly Half of All Exhibitions.* <http://www.ceir.org/Display_sub.cfm?K_DC_Id=17>.

Colorado Business Committee for the Arts (CBCA) (2002). *The Economic and Social Impact of Metro Denver Culture 2001*. <http://www.cbca.org/econBiannual.asp>.

Colorado Department of Transportation (1999). *The Economic Impact of Bicycling in Colorado*. <http://www.dot.state.co.us/BikePed/Study/ExecSum2.pdf>.

Colorado Division of Gaming (2003). *Gaming Update*, vol. 12, no. 7, July 2003.

Colorado Office of Economic Development and International Trade (2003). *Colorado Visitors Study 2002*. <http://www.state.co.us/oed/visitorstudy/LongwdIndex.htm>.

Colorado Office of State Planning and Budgeting (2002). "Economic Impact Task Force Report on the Impact of the Drought Memorandum." April. <http://cwcb.state.co.owc/Drought_Planning/Economy_IFT_report.pdf>. July 2003.

Colorado River Outfitters Association (2003). *Executive Summary Commercial River Use in Colorado 2002*. <www.croa.org>. June 18.

Colorado Ski Country USA (2003). "Colorado Reports 11.6 Million Skier Visits for 2002-2003." <http://www.media-coloradoski.com/pressroom/pressreleases_detail.cfm?ID=107>. June 26.

Cornelius, Coleman (2003). "5 More Cases of West Nile." <http://www.denverpost.com/Stories/0,1413,36~24167~1551966,00.html>.

Dalgar, Stefani (2003). E-mail correspondence. August 5.

DeMarco, Donna (2003). "SARS Takes Toll on Hotels." The Washington Times, May 2. <http://dynamic.washtimes.com/twt-print.cfm?ArticleID=20030502-92373020>.

Denver International Airport (2003). "Denver International Airport Passenger Traffic Continues To Surpass 2002 Numbers." May 30. <http://www.flydenver.com/pr/DIAPR_030530.pdf> (August 7, 2003).

Denver Metro Chamber of Commerce (2003). <http://www.denverchamber.org/chamber/pdf/WaterPaper.pdf>.

Denver Metro Convention and Visitors Bureau (2003). "Colorado Convention Center Expansion and New Convention Center Hotel." <http://www.denver.org/planners/cce.asp>. October 6.

Diamond, Emily (2001). "Briefing – Friends of the Earth Foot and Mouth Disease." <http://www.foe.co.uk/pubsinfo/briefings/pdf/20010419120526.pdf>. July 29.

Focus Group/Survey (2003). Tourism/film focus group and survey conducted in August.

Forsythe, Steven (n.d.). "AIDS Brief for Sectoral Planners and Managers: Tourism Sector." <http://www.und.ac.za/und/heard/AidsBriefs/sec/Tourism.pdf>. July 30, 2003.

Gerhardt, Gary, and Todd Hartman (2002). "Killer in the Herds." *Rocky Mountain News*, June 1. <http://cfapp.rockymountainnews.com/cwd/killer/1.cfm>.

International Association of Convention and Visitor Bureaus (IACVB) (2003). "IACVB Sees Brighter Horizon Ahead for CVBs with Business Barometer Survey for 1Q2003." <http://www.iacvb.org/iacvb/media_center/pr_view.asp?maction=VIEW&mcode=56>. May 27.

International Association of Amusement Parks and Attractions (2003). <http://www.iaapa.org/modules/MediaNews/index.cfm?fuseaction=Details&mtid=3&iid=1051>. June 26.

International Mountain Bicycling Association (2002). "Strength of Numbers." *IMBA Trail News*, Vol. 15, No. 3. <http://www.imba.com/news/trail_news/15_3/itn_15_3_opinion.html>.

IPK International (2003). *The Latest Global Travel Trends 2002-2003*. World Travel Market Forum, November 2002. Malta: IPK International. <http://www.mpiweb.org/media/home/factsheet.asp>.

KCNC-TV (2003). "Colorado West Nile Cases Now at 31." <http://news4colorado.com/localnews/local_story_213142739.html> August 4.

Lobo, Ramiro (2003) "Helpful Agricultural Tourism (Agri-tourism) Definitions." <http://www.sfc.ucdavis.edu/agritourism/definition.html>. August 12.

Meeting Professionals International (2003). "The Economic Impact of the Meeting and Convention Industry in the U.S." <http://www.mpiweb.org/media/home/factsheet.asp>.

Meetings and Conventions (2003). PricewaterhouseCoopers June 2003 Forecast Alert. <http://www.meetings-conventions.com/>. June 23.

_____ (2002). Breaking News. <http://www.meetings-conventions.com/newsline/newsbreak/1106break.html>. October 10, 2003.

National Park Service (2003). *National Park Service Statistical Abstract 2002.* Denver: National Park Service, Public Use Statistics Office.

National Restaurant Association (2003a). "Industry at a Glance." <http://www.restaurant.org/research/ind_glance.cfm>. June 26.

_____ (2003b). "State Statistics." <http://www.restaurant.org/research/ind_glance.cfm>. June 26.

_____ (2003c). " 2003 Restaurant Industry Forecast: Executive Summary." <http://www.restaurant.org/research/ind_glance.cfm>. June 26.

National Ski Areas Association (2003). *Kottke National End of Season Survey 2002/03: Preliminary Report.* <http://www.nsaa.org/nsaa2002/media_room/national_convention_releases/2003/kottke_preliminary_rpt_0203.pdf>. July 9.

National Sporting Goods Association (2002). "NSGA Looks at What Sports Are Most Popular State-by-State." <http://www.nsga.org/public/pages/index.cfm?pageid=593>. June 26.

National Tour Association (2003). *Courier*, June 2003, pp. 22-23.

Office of Travel and Tourism Industries (OTTI) (2003). Overseas Visitors to Select U.S. Cities/Hawaiian Islands 2002-2001. <http://tinet.ita.doc.gov/view/f-2002-45-561/index.html?ti_cart_cookie=20030621.125625.24791>. June 21.

Praco (2003). Case Studies. <http://www.praco.com/work_casestudies.html>. May 27.

PricewaterhouseCoopers (2002). *2002 Colorado State Parks' Market Assessment Study*. Boston: PricewaterhouseCoopers.

Relly, Jeannine (n.d.). "End of an Era: Tucson's Dude Ranches Disappearing." *Arizona Daily Star*. <http://www.azstarnet.com/destinations/profiles/tucson/azduderanches.html>.

Runzheimer International (2002). <http://www.runzheimer.com/tmc/scripts/satravel.asp>. June 23.

Shulgold, Marc (2003). "How Vail Fest Orchestrated the Big Deal." *Rocky Mountain News*. <http://www.rockymountainnews.com/drmn/music/article/0,1299,DRMN_54_2102008,00.html>. August 14.

Staff, Rusty (2003). "Truth about Reporting of SARS." <http://www.sarstruth.org/_wsn/page5.html>.

Travel Industry Association of America (TIA) (2002). *Tourism Works for America, 11th Ed.* Washington, DC: TIA.

_____ (2003a). TIA's Travel Forecast. <http://www.tia.org/MembersOnly/nov12forecasts.asp>. June 10.

_____ (2003b) "TIA Domestic Leisure Travel Outlook." *Travel and Tourism Research Association Newsletter*, Spring 2003, p. 3.

Urquhart, Janet (2002). "United Ups Winter Service into Aspen." *The Aspen Times*. <http://aspenalive.com/apps/pbcs.dll/artikkel?SearchID=73138538442265&Avis=AA&Dato=20021015&Kategori=TRANSPORT&Lopenr=210150001&Ref=A> June 6.

U.S. Conference of Mayors (2002). "New Report Documents Decline in Air Service Since 9/11. Travelers Face Reduced Schedules, Less Direct Flights. U.S. Urgently Needs More Transportation Options." <http://www.usmayors.org/uscm/news/press_releases/documents/airservice_121802.pdf>.

U.S. Department of Labor (2003). Bureau of Labor Statistics <http://data.bls.gov/labjava/outside.jsp?survey=ce>. September 1.

U.S. Department of State (2003). "Visa Waiver Travel Requires Machine-Readable Passport." <http://travel.state.gov/vwp.html>. August 7.

U.S. International Trade Administration (2003). "Secretary Evans Announces Markets for Promotional Tourism Efforts." <http://www.commerce.gov/opa/press/2003_Releases/Sept/08_tourism.htm>.

Visit Florida (1999). *Nature-Based Activities and the Florida Tourist.* Tallahassee: Visit Florida Research Office. <http://www.ecotourism.org/textfiles/usfactsheet.txt>.

World Tourism Organization (2003). "WTO Warns against Overreaction to SARS, Calls for Objectiveness and Cooperation." <http://www.world-tourism.org/newsroom/Releases/2003/May/sars.htm>. June 26.

World Travel & Tourism Council (2003a). *Travel & Tourism – A World of Opportunity.* World report. London: World Travel & Tourism Council.

_____ (2003b). *Travel & Tourism – A World of Opportunity.* U.S. report. London: World Travel & Tourism Council.

FILM

National Market Size and Expected Growth

During the annual state-of-the-industry speech at ShoWest 2003, Motion Picture Association of America (MPAA) president and CEO Jack Valenti announced record high revenues in the film industry. The theatrical film box office in the United States soared to $9.52 billion in 2002, continuing an 11-year streak of expansion. Admissions also rose in 2002 by 10%, to 1.64 billion, the highest level since 1957. The bad news is that many film commissions are suffering from the economic downturn and that the cost of making and marketing a movie for a MPAA member company increased nearly 14% in 2002, to $89.4 million, the largest percentage increase since 1997.

The copyright industries (movies, TV programs, home videos, books, music, computer games and software) were responsible in 2001 for approximately 5% of the gross domestic product (GDP) of the nation. Over the past quarter century, these industries' share of GDP grew more than twice as fast as the remainder of the economy. They earn more international revenues than automobiles and auto parts, more than aircraft, and more than agriculture (International Intellectual Property Alliance 2003). A recent five-year outlook at the global media and entertainment industries by PricewaterhouseCoopers revealed a very strong forecast for the 2003-07 period (Focus Group/Survey 2003).

Film commissions can be found on nearly every continent. They currently number approximately 175 in the United States and over 300 internationally, according to the Association of Film Commissioners International (2003).

Colorado Market Size and Expected Growth

In a recent study of the Colorado film industry conducted for the Governor's Office of Economic Development and International Trade (OED&IT) (2003), the industry was defined as companies in Standard Industrial Classification Codes 7812 (motion picture and videotape production and allied services, including teleproduction and postproduction services) and 7819 (motion picture and videotape distribution and allied services), and sole proprietors with an emphasis in production. Employees in these three groups totaled 1,992.

From 1992 to 2001 the Colorado film industry (SIC Codes 7812 and 7819) experienced more rapid growth than the state as a whole. Companies in the film industry showed an 8.1% compound annual growth rate (CAGR) for employment, 13.0% for wages, and 4.5% for average wage per employee. For the state, growth rates were 3.8%, 8.7%, and 4.7%, respectively.

Occupational Projections for Colorado

As a service to the public, the Colorado Department of Labor and Employment provides occupation projections. It was estimated the demand for film editors will increase at a

rate of 8.1% from 1998 to 2008, from 181 to 326 editors. It was also forecasted that the demand for actors, directors, and producers will grow from 1,614 jobs to 2,701 jobs during that same period, an increase of 6.7%.

State of the Industry

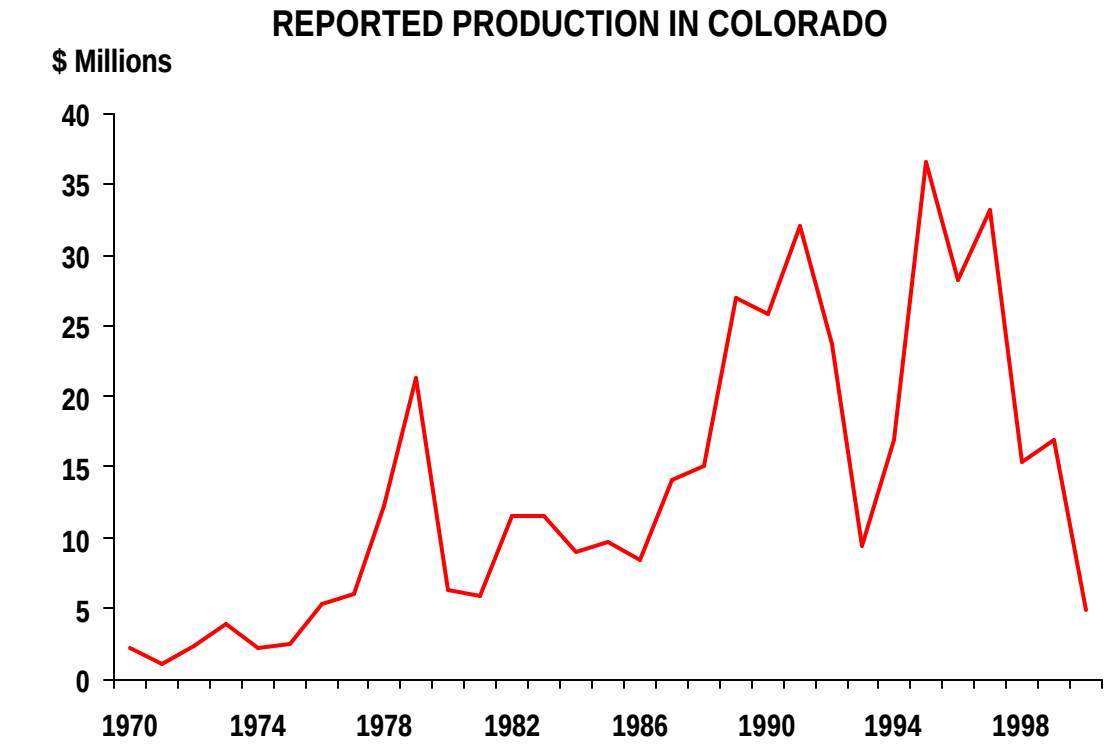
Productions

From 1970 to 2000, the Colorado Film Commission tracked revenue generated from new film and video projects that it and other local film commissions brought to Colorado from other states and countries. Typically, these projects were feature movies, commercials, still shoots, or television shows and did not represent all production that took place within the state.

Until recently, it was easy to make the distinction between in-state and out-of-state companies and projects. In the late 1990s the structure of the industry changed to the point where it was no longer possible to classify companies using this criterion. Subsequently, the criteria for tracking revenue changed, resulting in a break in the data starting in 2001. The data set for 2001 and 2002, which was recorded on a calendar year basis, includes the dollars spent in Colorado on out-of-state projects, along with some in-state production revenue. In calendar year 2001 production totaled $31.1 million, and declined to $30.4 million the following year. Since the data for the period 1970 to 2000 are not comparable to the production figures for 2001 and 2002, revenue for the last two years is not shown in the following chart.

The figures represent production reported only by firms that worked with the Colorado Film Commission; the Denver Mayor's Office of Art, Culture and Film; the Colorado Springs Film Commission; and other Colorado communities in calendar year 2002. The chart shows the volatility of the industry. The chart also indicates the growth of the film industry from 1985 to 1990 occurred at a time when the state economy was either declining or stagnant.

It should also be noted that despite a decline in production in the state at the end of the 1990s, wage growth was possible. Production going out of state is unlikely to be tracked by the Colorado Film Commission and would therefore not appear in the chart on the next page. It may also be the case that firms worked on less lucrative projects during that period.



Source: Colorado Film Commission.
Note: Figures are for fiscal year.

During 2002, the Colorado Film Commission tracked production projects in at least 40 of the state's 64 counties. It seems logical to think that projects filmed in rural counties are particularly valuable, even if those projects are of short duration. Such projects do not require an increase in infrastructure and bring in outside dollars to the local economy.

Employment and Wages – Direct and Indirect

The study prepared for the OED&IT included the following employment and wage findings:

SIC 7812 (Producers)

- 1,311 employees in 2001
- 272 firms with employees in 2001
- Average firm size: 4.7 employees
- 5.3% compound annual growth rate for employment 1992-2001
- $66.3 million in wages in 2001
- $221.6 million in receipts in 2001, 75% from out of state
- Economic impact: 3,933 total direct and indirect jobs and $205.5 million total direct and indirect wages

SIC 7819 (Suppliers)

- 681 employees in 2001
- 75 firms with employees in 2001
- Average firm size: 8.9 employees
- 17.3% compound annual growth rate for employment 1992-2001
- $21 million in wages in 2001
- $83.4 million in receipts in 2001

Sole Proprietors

- 675 estimated establishments in 2001
- $24 million estimated receipts in 2001

If the film industry were more broadly defined to include equipment and manufacturers, television stations, cable companies, distribution firms, video rental stores, and theaters, 24,559 employees and $1.4 billion in wages would be added to the Colorado film industry in 2001. Of 10 potential sectors, those most likely to have strong ties to the film industry are SIC Code 4833 (television stations), SIC Code 4841 (cable companies), SIC Code 7822 (motion picture distribution), and SIC Code 7829 (distribution services). A compelling case can be made that a majority of the employees working at motion picture distribution and distribution-related companies have significant connections to the film industry. In 2001 there were 72 employees in these categories with combined wages of $3.4 million. While companies in SIC Codes 4833 and 4841 have important ties to the industry, it is felt that only a portion of their combined 15,622 employees and $1.2 billion in wages can be included in the Colorado film industry.

Leading Industry Segments

A series of surveys were conducted as part of the OED&IT film study to gather information about the industry. A summary of the results appears in the table below.

SURVEY RESULTS

Production Companies	In-House Production Companies	Industry Supply, Equipment and Service Providers	Film Commissions	Film Festivals	School Districts	Universities and Colleges
? Median number of employees per company: 1 ? Median gross revenue per company: $194,500 ? 76.7% of total revenue was derived from out-of-state sources. ? 69.8% of total expenses was spent in Colorado.	? Total of 350 employees ? Median annual in-house production costs: $82,000 ? Median annual outsource costs: $124,000	? Almost 87% of companies have fewer than five employees. ? Median gross revenue per company: $77,000 ? Approx. 64% of total estimated receipts from out-of-state sources	? 100+ local film contacts. ? Estimated total of 15 FTE workers	? Total of 60 FTE employees and 1,800 volunteers. ? Total gross revenue: $4.3 mil ? Total expenses: $4.0 mil, of which $3.0 mil was spent in Colorado ? 87,000 total festival attendees ? Total film festival spending in Colorado: $12.6 mil. Of this, about $9.6 mil spent by visitors and $3.0 mil spent by organizers.	? Primarily located in high schools in both rural and metro areas	? Average film program enrollment: 267 ? Total enrollment: More than 2,000 students ? Number of faculty teaching classes: About 80

Note: All data for 2001 unless otherwise indicated.
All figures based on survey respondents.

Technology

Technological Developments

The film industry is in a period of tremendous change, largely due to new technological advances that are breaking down filmmaking barriers and allowing more diversification (Focus Group/Survey 2003). The transition from film to tape alone is having major repercussions, including a negative impact on employment and budgets and an increase in margins. High-powered computers, high-density digital storage, and specialized software are becoming the new postproduction facilities (Wright 2001). New production markets can now build a technical infrastructure without relying solely on local sources. As Colorado has one of the highest concentrations of computer, communications, and technology companies in the country, it is positioned to jump on the digital bandwagon and climb to the top of the film industry. With technology allowing easier filming and production in one place, local and independent filming is set to emerge. This type of filmmaking and producing creates jobs and money for the Colorado economy. It should be noted, however, that the postproduction/visual effects industry is currently in a state of flux due to high labor costs, low profit margins, and a soft economy. Four established computer graphics firms—Disney's Secret Lab, London's Mill Films, Centropolis in Culver City, and Kodak's visual effects firm Cinesite—have closed or are scheduled to close (Crabtree 2003).

Entertainment on Internet High-Speed Connections

Video entertainment over the Internet is likely to become very popular, especially as more people acquire faster Internet connections. The AOL and Time Warner merger in January 2001 created cable access for both TV and the Internet (broadband) (Jones 2001). Rapid technological advances allow consumers to easily access new entertainment choices, including online movies. The joint Internet venture, MovieLink, is making changes that will make renting and downloading movies easier and faster (*Washington Post* 2003). The inaugural Ten Second Films Competition (www.tensecondfilms.com) attracted more than 1,000 digital video entries (Emling 2003). Denver-based "City's Edge" is a novel soap opera that is only broadcast on the Web (Ostrow 2002). All scenes are shot in Denver, all production takes place in Denver, and the crew is Denver based. In the future, a possible negative effect of new technology is that software and hardware advances may make it easier for filmmakers to mimic locations on sound stages (Wright 2001). This means that fewer production companies would actually have to film in Colorado since the state's main selling point has been location. However, these advances could have a positive effect on the digital segment of the industry in the state.

Growth Opportunities

Independent Films

Changing demographics and a more diverse population are creating a market for independent and art films, and evidence suggests they are rising in popularity in the state and in the nation. Indeed, the number of screens in the Denver metro area devoted to art films (which are often independent films) grew from 9 to 26 from 2002 to 2003 (Denerstein 2003). This growth increases the variety of film offerings and creates opportunities for special programming, including sessions with directors and screenings of documentaries, followed by discussions. Working against these films, however, is the "open big policy," whereby films must open in theaters nationwide and perform very strong the first weekend or else die. Many quality movies are not shown in theaters long enough to develop positive word of mouth.

Creative Class

Based on the 2000 Census, nuclear families represent less than one-quarter of the population, and the number of singles and never-been-marrieds is rapidly growing. Many of these young workers are part of what researcher Richard Florida calls the creative class, a fast-growing, highly educated, well-paid segment of the workforce that includes artists, entertainers, actors, and designers (Florida 2002). The distinguishing characteristic of this group is that "its members engage in work whose function is to create meaningful new forms" (Florida 2002). The creative class enjoys a mix of influences and activities; they want to hear different music and different opinions, and see different films. They are a new force in the economy because these individuals are attracted to communities that strive to break down barriers and cultivate diversity.

These changes in our culture and the growing importance of creativity and individuality place greater emphasis on film. As creativity becomes more valued, independent films, film festivals, and film as a form of communication will become more vital to our communities. An artistic environment, along with economic incentives, also makes an area more welcoming for filmmakers (Focus Group/Survey 2003).

Connection with Tourism Industry

A symbiotic relationship exists between the tourism industry and the television and film industries (Focus Group/Survey 2003). The Virginia Tourism Corporation contends that film projects act like "super-tourists" when they film on location. Those involved in projects stay in hotels, eat in restaurants, shop at local stores, and visit area attractions (Virginia Tourism Corporation 2002). A secondary benefit is that film and television shows can stimulate tourism (Virginia Tourism Corporation 2002). Visits to Civil War battlefields and historic sites jumped "dramatically" after Ken Burns's Civil War series was broadcast (Zwick 1999). Moreover, "visitation at Lewis and Clark sites in North Dakota, Oregon, Iowa, and many other places witnessed an increase . . . after the broadcast" of the Lewis and Clark program (Zwick 1999). Anecdotal evidence suggests that projects filmed in Colorado benefit the state's tourism industry in a similar way. State tourism offices are joining corporations and foundations as underwriters for public television series. Virginia's tourism office was an underwriter of Ken Burns's *Thomas Jefferson* series, Montana underwrote part of the *Lewis & Clark* film, Illinois contributed to *Frank Lloyd Wright*, and New York assisted with the series on Elizabeth Cady Stanton and Susan B. Anthony (Zwick 1999). There is even a web site (www.movie-locations.com) that is the "worldwide guide to movie locations." Its marketing slogan: "You've seen the film, now do the holiday."

Barriers

Movie Pirating

The downloading of movies could have a major effect on the film industry. Presently, it takes hours to download a movie using the fastest connections. However, with increases in Internet speeds taking place daily, movie pirating could become a more serious problem. According to a June 2003 report by Deloitte & Touche, the global film industry is currently losing $3 billion to $3.5 billion per year to illegal piracy operations (Frater 2003b). On the other hand, filmmakers could distribute their films using the same means, thereby completely bypassing distributors and retail chains. In fact, some studios are already taking a proactive role by creating their own subscriber on-line content services (Bellini 2001).

Runaway Productions

A current problem in the film industry nationwide is the flight of productions to Canada and other countries. U.S. production companies that choose to film in Canada and other countries are dubbed "runaway productions." The estimated loss to the U.S. economy

since the Canadian rebates is $4.1 billion, or about 25,000 jobs, a year (Katz 2001). However, another economic impact study of runaway productions estimates the loss to Hollywood alone at $10 billion annually (McNary 2003). Runaway films to British Columbia alone created $2.82 billion in revenues for fiscal year 2001 (British Columbia 2001). Production companies are drawn by lower costs, better tax incentives, and attractive exchange rates (Wright 2001), which "save anywhere from 40 to 50%" in production costs (Focus Group/Survey 2003). The ease of transmitting data over long distances and in short periods, combined with a technical infrastructure and a skilled labor force, has enabled filmmakers to take advantage of lower labor and production costs in other countries.

The significance of this problem is underscored by the pledge by show business executives and union leaders to form industry-union task forces to address runaway production issues (McNary 2003). Furthermore, the nonprofit Creative Coalition created the New York Runaway Production Task Force, which will focus on "combating the negative economic impact that runaway film and television production has on New York" (Mohr 2003).

Tax Incentives

Legislation

Congressmen Dreier and Berman introduced the United States Independent Film and Television Production Incentive Act of 2003 to Congress in February, which would provide tax credits to anyone producing a movie within the United States. The bill, which is identical to legislation introduced last Congress, is targeted at small independent film and television productions. It provides a wage-based tax credit for television and film projects produced in the United States (United States House of Representatives 2003).

Colorado Competitive Position

Economic Impact

Using an employment multiplier of 3.0, the economic impact of film production, which strictly includes companies in SIC Code 7812 (producers), is 3,933 jobs, according to the study conducted for the Office of Economic Development and International Trade (2003). Of this total, 1,311 are direct jobs in SIC Code 7812 and 2,622 are indirect jobs that include sole proprietors, employees in SIC Code 7819 (suppliers), and workers directly benefiting from the presence of the film industry. Similarly, using a wage multiplier of 3.1, there are $205.5 million in direct and indirect wages for the industry, $66.3 million of which is attributable to companies in SIC Code 7812 and $139.2 million in indirect wages.

In 2001 there were 272 companies in SIC Code 7812 with total estimated receipts of $221.6 million. The number of firms in SIC Code 7819 totaled 75, with 681 employees, wages of $21.1 million, and estimated receipts of $83.4 million. There were 675 sole

proprietorships with total estimated receipts of $24 million. These receipts cannot be totaled; doing so would overstate sales for the industry within the state. The impact of the receipts is not mutually exclusive; therefore, any summation results in double counting.

Weaknesses

Loss of Film Commission Funding

The Colorado Film Commission lost its funding in the spring of 2003 and was moved under the auspices of the Colorado Tourism Office. Currently, a group of industry and economic development professionals are working with Colorado Film Commission staff to transform the commission to a self-sufficient enterprise. In its new form the commission may be a public-private entity (Focus Group/Survey 2003). The commission, along with its network of more than 100 local film contacts, is the common element between the various segments of the film industry, and as such, has the potential to create synergy between these groups.

Incentives

States and countries have used various forms of incentives as tools for attracting and retaining filmmakers. In fact, more than 35 states offer some form of incentive, primarily room tax rebates, to producers (May 2003). Many of these incentive programs focus on tax incentives, but there are other options. Examples of some of the more creative tax incentive programs include:

- The New Mexico legislature passed five bills in the 2003 legislative session in support of the film industry, which were awaiting the signature of the governor at the time this report was written. The New Mexico Film Office also has a film investment program and offers fee-free locations (New Mexico Film Office 2003).
- In May 2003 Belgium announced a new tax-based film finance scheme that will permit reductions in corporate tax bills in return for guarantees on production spending in the country (Frater 2003a).
- A state law passed in Louisiana in 2002 allows the state film commission "to provide a payroll tax credit of as much as 20 percent, depending on how many Louisiana residents are employed. The law also created an investor credit program, where investors can pay producers between 10 percent and 15 percent of the costs of their production and buy tax credits from the state" (May 2003).
- Florida offers sales and use tax exemptions on motion picture and television production equipment and real property. Florida also offers tax credits of up to $2,000 per employee for companies that create new jobs within 30 designated urban and rural areas (Governor's Office of Film and Entertainment 2003).
- Oklahoma's "Compete with Canada Film Act" was enacted July 1, 2001, and offers a rebate in the amount of 15% of documented expenditures made in the state directly attributable to the production of a long-form narrative film or

television production. The rebate is paid to the production company responsible for the production (Oklahoma State Senate 2001).
- Discussions with industry experts reveal that Illinois is formulating a new incentive plan (Focus Group/Survey 2003).

In addition, many states, including Colorado, offer a transient room tax rebate, as well as free filming on state property. But this isn't enough of an incentive. Comments made in the open-ended comment section of the OED&IT study reveal that those who work in the Colorado film industry find it difficult to attract "out of state [production] because other states have better tax incentives" (Governor's Office of Economic Development and International Trade 2003).

Marketing

More promotion and marketing of the Colorado film industry both out of state and within the state to other industries is crucial (Focus Group/Survey 2003). Integrating the film industry with other businesses will help create greater understanding and develop an indigenous industry.

Summary

In the past, the film industry was comprised of companies in SIC Codes 7812 and 7819, or basically film producers and their suppliers. Continually changing global social and economic conditions, and advances in technology have redefined the structure of the industry. Production in Colorado can be strengthened by considering the following:

- Establish a new private-public film commission;
- Create awareness of the unique economic benefits of production in the state (for example, more than three-fourths of revenue is generated from out of state and much of that money is invested in the local economy; rural and metro areas benefit from film and video projects; production revenue is not necessarily tied to normal economic patterns);
- Encourage Colorado filmmakers and companies to include shots of Colorado locations in their film projects and national television and print ads to increase awareness of the state;
- Build on plans by the Regal Entertainment Group (which has headquarters in Arapahoe County and Nashville and is owned in part by Denver billionaire Philip Anschutz) to change the movie-going experience;
- Capitalize on the recent filming of *Silver City* in Denver and Leadville by independent filmmaker John Sayles;
- Provide incentives to attract more projects to Colorado; and
- Educate financial institutions and other businesses about the distinguishing factors of the industry.

BIBLIOGRAPHY

Association of Film Commissioners International (2003). <www.afci.org>. March 31.

Bellini, Jason (2001). "Studios Hope to Prevent a Movie 'Napster' from Taking Hold." *CNN.com*. <www.cnn.com/2001/fyi/news/02/20/video.sharing>. February 20, 2003.

British Columbia Film Commission (2001). <http://www.bcfilmcommission.com/industry_profile/>. April 1, 2003.

Crabtree, Sheigh (2003). "Digital Pandemonium." *The Hollywood Reporter*, April 17. <www.hollywoodreporter.com>.

Denerstein, Robert (2003). "Reeling in Art: Can City's Influx of Specialized Movie Houses Keep Drawing Audiences?" *Rocky Mountain News*, May 10, pp. 1D, 4D.

Emling, Shelley (2003). "Technology Advances Allow Consumers Easy Access." *Dayton Daily News.* <http://www.emailthis.clickability.com/et/emailThis?clickMap=viewThis&etMailToID=980701158&pt=Y>.

Florida, Richard (2002). "The Rise of the Creative Class: Why Cities without Gays and Rock Bands Are Losing the Economic Development Race." *The Washington Monthly Online*. <www.washingtonmonthly.com/features/2001/0205.florida.html>

Focus Group/Survey (2003). Tourism/film focus group and survey conducted in August.

Frater, Patrick (2003a). "Brussels Flexes Tax Muscles." *Screen Daily*. <http://www.screendaily.com/story.asp?storyid=12517&st=michael+cowan&s>. June 6.

_____ (2003b). "Global Film Industry Losing up to $3.5bn from Piracy." *Screen Daily.* <http://www.screendaily.com/story.asp?storyid=12781>. July 24.

Governor's Office of Economic Development and International Trade (2003). *The Impact of the Film Industry on Colorado*. Denver: Colorado Film Commission.

Governor's Office of Film and Entertainment (2003). Florida Entertainment Industry Exemption. <http://www.filminflorida.com/incentives/index.htm>.

Hudson, Kris (2003). "Moving Pictures." *The Denver Post*. <http://www.denverpost.com/Stories/0,1413,36~33~1812944,00.html>. December 7.

International Intellectual Property Alliance (2003). <http://www.iipa.com/pressreleases/2002_Apr22_SIWEK.pdf>. June 2.

Jones, Jennifer (2001). "Cable Industry Slices into Broadband Market." *CNN.com*. <www.cnn.com/2001/TECH/computing/01/31/cable.broadband.market.idg/index.html>.

Katz, Stephen (2001). "The Migration of Feature Film Production from the U.S. to Canada: Year 2001 Production Report." Center for Entertainment Industry Data and Research (CEIDR) <www.ceidr.org>.

May, Lucy (2003). "Film Commission Steps Up Efforts to Draw Filmmakers, and Their Economic Impact, to the Tri-State." *Bizjournals.com*. <http://www.bizjournals.com/industries/economic_view/economic_snapshot/2003/09/15/cincinnati_story3.html>. September 16.

McNary, Dave (2003). "Pols Discuss Production Relief; Hollywood Studios to Form Industry-Union Task Forces." *Variety*, April 24. <www.variety.com>.

Mohr, Ian (2003). "Creative Coalition Tackles Runaway Production." *The Hollywood Reporter*, April 24. <www.hollywoodreporter.com>

New Mexico Film Office (2003). Incentives and Resources. Economic Development Department. <http://www.edd.state.nm.us/FILM/RESOURCES/resource.html>.

Oklahoma State Senate (2001). "Compete with Canada Film Act." <http://www2.lsb.state.ok.us/2001%2D02bills/sb/sb674%5Fsflr.rtf.>. June 2, 2003

Ostrow, Joanne (2002). "Denver Stars in Cybersoap Opera: 'City's Edge' Internet Drama on a Computer Screen near You!" *The Denver Post*, July 11.

Pate, Kelly (2003). "State Film Panel Envisions Private Funding Lured by Economic Gains." *The Denver Post*, July 20, Sec. K, p. 5.

_____ (2003). "Ready for 'Action!'" *The Denver Post*, July 20, Sec. K, pp. 1, 5.

Robinson, Claude (2003). "Connecting the Dots between Media, Entertainment and Tourism." *The Jamaican Observer*, September 14.

United States House of Representatives (2003). "Dreier, Berman Reintroduce Runaway Production Legislation." <http://www.house.gov/berman/pr021203.htm>. February 12, 2003.

Virginia Tourism Corporation (2002). "Vision Plan for Virginia's Tourism Industry." <http://www.vatc.org/administration/VisionPlan/VisionPlan.pdf>. August 27, 2003.

Washington Post (2003). "Hollywood Upgrades Its Movie Downloads." September 12.

Wright, Kevin (2001). "The New Film and Video Industry: Getting Our Share." *Advertising & Marketing Review*, September. <www.ad-mkt-review.com/public_html/docs/fs030.html>. August 1, 2003.

Zwick, Jim (1999). "The Ken Burns Documentary on Mark Twain: An Interview with Coproducer Dayton Duncan." <http://www.boondocksnet.com/twainwww/essays/ken_burns_twain9901.html>. August 27, 2003.

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