

Advanced Technology in Colorado – Then and Now

In 1991, Nancy J. McCallin, then Chief Economist at the Colorado Legislative Council, reported on the role of advanced technology in the Colorado economy. This study presents an update on the role that Colorado's advanced technology industries play in the state's economy today.

Summary

- In 1998, advanced technology jobs comprised 6.1 percent of all nonfarm employment, a total of 125,000 out of 2,051,000 workers in Colorado.
- Wages in the advanced technology sector were 46 percent higher than the average Colorado nonfarm wage in 1998, \$47,000 compared with \$32,192.
- The largest share of the advanced technology work force — an 18.9 percent share — in Colorado is located in Boulder County.

What is Advanced Technology?

Quantifying the advanced technology sectors was difficult in 1991 and remains difficult in 1998. There is still neither an accepted definition as to what constitutes advanced technology, nor official government data for advanced technology industries. Advanced technology encompasses a range of businesses. These include the electronics, biomedical, research and development, computer, space, and communications industries. In addition, advanced technology industries include firms that provide traditional products or services produced by cutting-edge methods and firms that provide cutting-edge products produced by traditional methods.

For purposes of continuity, we define advanced technology here using the same definition that was employed by McCallin in 1991. These industries, listed in the table at the end of this section, were selected after considering three factors: the technical sophistication of workers and production processes, research and development (R&D) expenditures, and the product itself. The 1991 study quantified the presence of advanced technology in Colorado using a variant of the Bureau of Labor Statistics (BLS) definition reported in “High Technology Today and Tomorrow: A Small Slice of the Employment Pie” (*Monthly Labor Review*, November 1983). An industry is included if the ratio of technology-oriented workers — defined as engineers, life and physical scientists, mathematicians, engineering and science technicians, and computer specialists — to total employment is higher than the ratio for all manufacturing, and R&D expenditures relative to sales are greater than or equal to the average for all industries. We exclude from the original BLS list petroleum refining and part of the chemical industry.

Advanced technology encompasses a range of businesses — electronics, biomedical, research and development, computer, space, and communications industries.

Advanced technology is concentrated primarily in manufacturing, but includes a small part of the service industry.

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As defined here, advanced technology is concentrated primarily in manufacturing, but includes a small part of the service industry (software and research laboratories). The available historical data are aggregated in ways that makes it hard to exclude portions of the identified industries that are not specifically engaged in advanced technology. Furthermore, changes to the industry classifications over the past two decades hamper comparison of employment in the advanced technology sector at a greater level of detail. Despite these difficulties, there is little doubt that advanced technology has had — and continues to have — a significant impact on Colorado’s economy.

Advanced Technology Employment

In 1972, employment in advanced technology industries made up 4.8 percent of total employment in the state. In 1998, advanced technology jobs comprised 6.1 percent of the work force. In 1972, advanced technology industries employed 39,000 workers in Colorado. By 1989, the number of jobs had grown to 102,000 workers. Today, more than 125,000 employees in Colorado work in advanced technology industries.

At the end of the 1990s, advanced technology-related employment in the U.S. is dominated by the computer and data processing services industries of the “information technology” sector, which provides the infrastructure and knowledge necessary to make information rapidly available. Information technologies include software producers and consultants who can increase the productivity of current operations, and can help create new products, services and capabilities for firms. The U.S. defense and aerospace industries, once an important contributor to advanced technology jobs, are being downsized and experiencing slow or no growth, while U.S. computer hardware manufacturers have been moved “off shore.”

As is true for the nation, Colorado’s employment in the advanced technology sectors has grown significantly over the past quarter century. It increased by a remarkable 221 percent from 1972 to 1998, compared with 136 percent for total state nonfarm employment for the same period. Furthermore, in Colorado advanced technology employment growth is also now dominated by increases in the computer-related services sector. **Figure 12** and **Figure 13** show how Colorado’s advanced technology employment has changed over the past 27 years.

The pie charts in **Figure 12** and **Figure 13** display the shares held by each component of the advanced technology sector in 1972 and 1998, respectively. The most significant difference is that employment in Software & Computer Services grew from 3.2 percent of advanced technology employment in 1972 to 37.4 percent of advanced technology employment in 1998. Meanwhile, both Instruments and Chemicals experienced a decrease in share of total advanced technology employment from 1972 to 1998.

Figure 12
Advanced Technology Employment by Sector – 1972

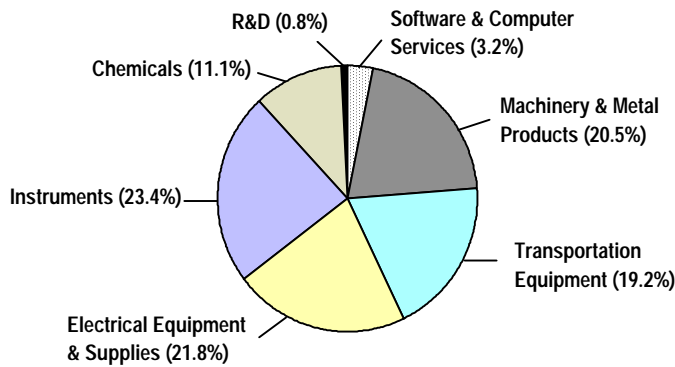


Figure 13
Advanced Technology Employment by Sector – 1998

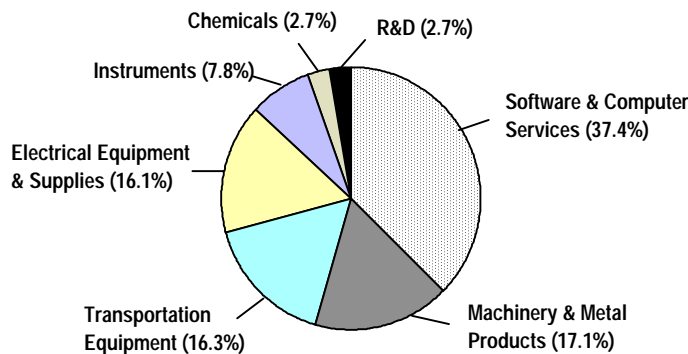


Table 13 shows the compound annual growth rates of Colorado’s advanced technology sectors from 1972 to 1998, along with three ten-year subperiods from this same time span. As **Table 13** shows, overall growth in the advanced technology industry has slowed throughout the time period examined. After increasing at a pace stronger than average job growth from 1972 to 1988, advanced technology job growth lagged overall job gains from 1988 to 1998. This was primarily because of the downsizing at Rocky Flats and because of reductions in Machinery & Metal Products.

As is true for the national economy, Colorado’s advanced technology growth has not been consistently strong throughout the seven industry classifications that comprise the advanced technology sector. Throughout the 26-year time period examined, software and computer services displayed the most consistent strength, increasing at a compound annual average growth rate of 14.4 percent per year. In

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1972, none of Colorado's seven advanced technology sectors was significantly larger than the others. By 1998, this was no longer the case. Although all seven of the advanced technology categories showed employment growth between 1972 and 1988, only Software & Computer Services showed substantial growth between 1988 and 1998.

Table 13
Compound Annual Advanced Technology
Employment Growth Rates

Standard Industrial Classification	(SIC Code)	1972-98	1972-82	1978-88	1988-98
Software & Computer Services	(737)	14.4%	17.8%	15.6%	12.5%
Machinery & Metal Products	(34-35)	3.7%	8.0%	7.4%	-0.6%
Transportation Equipment	(38)	3.8%	12.4%	-1.0%	2.1%
Electrical Equipment & Supplies	(36)	3.2%	7.5%	6.7%	0.2%
Instruments	(37)	0.2%	3.2%	7.5%	-4.5%
Chemicals	(28)	-0.9%	2.9%	4.5%	-6.4%
R&D	(8731)	9.2%	18.8%	15.4%	1.8%
Total Advanced Technology		4.4%	8.1%	5.9%	2.4%
Total Nonagricultural Employment		3.2%	4.1%	2.1%	3.8%

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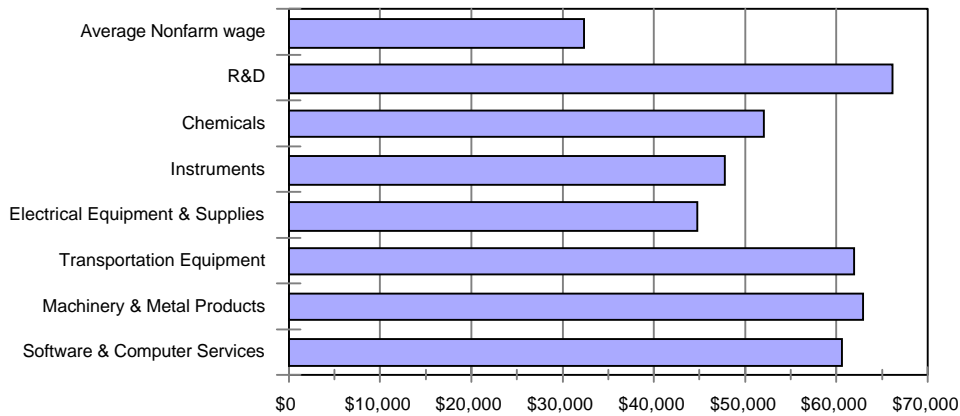
In the fourth quarter of 1998, a total of 4,858 firms were engaged in advanced technology in Colorado, up 239 percent from 1989. Of these, 95.5 percent had fewer than 100 employees, 3.6 percent had between 100 and 499 employees, and 0.9 percent had more than 500 employees. Although the state's advanced technology industry is overwhelmingly comprised of small businesses, it is less so than the state as a whole — 97.5 percent of the firms in all sectors have fewer than 100 employees, 2.2 percent have between 100 and 499 employees and 0.3 percent have more than 500 employees.

Advanced Technology Wages

In 1998, wages in the seven advanced technology sectors averaged more than \$47,000, an amount 46.0 percent higher than the average Colorado nonfarm wage.

In 1989, wages in the advanced technology sector were 44.8 percent above the average wage for nonfarm employment in Colorado and 7.8 percent above those for manufacturing industries. In 1998, wages in the seven advanced technology sectors averaged more than \$47,000, an amount 46.0 percent higher than the average Colorado nonfarm wage, and the average advanced technology worker earned 14.5 percent more than the average manufacturing worker in the state. **Figure 14** shows that average annual salaries were highest within the R&D and Machinery and Metal Products sectors, followed by Transportation Equipment, Software & Computer Services, Chemicals, Instruments, and Electrical Equipment & Supplies.

Figure 14
Average Advanced Technology Wage and Salary – 1998



Geographic Locations of Advanced Technology Industries within Colorado

Although traditional “cost-of-doing-business measures” — tax rates or incentives, costs of compensation, land and office space, energy, and capital, and the firm’s perception of the general business climate — are important to advanced technology industries, “other factors appear to contribute the most to high-tech firms’ location decisions. These other factors include: access to a trained/educated work force, close proximity to excellent educational facilities and research institutions, an existing network of suppliers, availability of venture capital, climate As we enter the age of human capital where firms merely lease knowledge assets, firms’ location decisions will be increasingly based upon quality-of-life factors that are important to attracting and retaining this most vital economic asset. In high-tech services, strict business-cost measures will be less important to growing and sustaining technology clusters in metro economies. Locations that are attractive to knowledge assets will play a vital role in regional economic success.” (America’s High-Tech Economy. Milken Institute, July 1999.)

As is true for the nation as a whole, Colorado’s advanced technology enterprises are concentrated in only a few of the state’s counties. **Table 14** shows Colorado’s top-ten counties for advanced technology employment in 1989, and how they fared in 1998. There has been some leveling of the distribution of advanced technology employment within these counties over the past decade, although little change in the corresponding rankings.

- In 1989, Jefferson County held the greatest share of advanced technology workers, 23.6 percent. Jefferson County’s rank dropped to third by 1998 and accounted for only 11.3 percent of the advanced technology workers. The share of advanced technology workers decreased in Jefferson County because of the closing of Rocky Flats.

Firms' location decisions will be increasingly based upon quality-of-life factors.

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**Table 14
Top Ten Counties for Colorado Advanced Technology Employment – 1989 and 1998**

	Employment				Firms			
	1989 Percent	Rank	1998 Percent	Rank	1989 Percent	Rank	1998 Percent	Rank
Adams	5.4%	7	5.1%	7	4.3%	8	3.5%	8
Arapahoe	10.7%	4	11.6%	4	17.2%	3	16.2%	2
Boulder	23.2%	2	25.8%	1	19.3%	1	18.9%	1
Denver	5.7%	6	9.6%	6	18.0%	2	14.5%	4
El Paso	14.8%	3	18.0%	2	11.3%	5	12.7%	5
Jefferson	23.6%	1	13.3%	3	13.3%	4	14.5%	3
Larimer	8.9%	5	10.7%	5	5.2%	7	5.9%	7
Mesa	1.5%	9	1.0%	9	1.1%	9	0.8%	10
Pueblo	0.9%	11	0.8%	10	0.9%	11	0.6%	11
Weld	3.9%	8	3.8%	8	1.0%	10	1.1%	9
All Others	1.4%	10	0.3%	11	8.4%	6	11.2%	6
Total	100.0%		100.0%		100.0%		100.0%	

Colorado’s Advanced Technology Rankings within the Nation

Colorado’s concentrations of advanced technology employment — especially those in the Boulder-Longmont, Colorado Springs, Denver, Fort Collins-Loveland, and Greeley metropolitan statistical areas (MSA) — are noteworthy at the national level.

- As measured by advanced technology real output growth rates between 1990 and 1998, Colorado Springs ranked 28th, Denver ranked 38th, Greeley ranked 42nd, and Boulder-Longmont ranked 47th out of the top 50 metropolitan statistical areas nationally.
- Denver ranks 20th nationally in terms of share national advanced technology real output in 1998.
- Denver was second only to the Seattle-Bellevue-Everett MSA when measured based on changes between 1978 and 1998 in advanced technology services output as a proportion of national advanced technology services output, while Colorado Springs ranked 16th when measured based on the analogous measure for advanced technology manufacturing output.

Colorado as a whole also ranks high with regards to advanced technology employment and output, according to results reported by the American Electronics Association in 1999.

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- Colorado is 4th in the nation in the number of advanced technology jobs added between 1990 and 1997: Colorado added 40,000 advanced technology jobs during this period, topped only by Texas, California and Georgia which added 102,000, 66,000, and 46,000 jobs, respectively.
- Colorado is 2nd only to New Hampshire when ranked by advanced technology workers per 1,000 private workers in the state.
- Colorado ranks 10th among the 50 states when measured by average advanced technology wages in 1997, 12th when measured by number of advanced technology jobs, and 13th when measured by growth in advanced-technology employment.

Performance and Risks

In McCallin's discussion of advanced technology in Colorado, she noted that advanced technology employment for defense activities — more than half of Colorado's advanced technology employment in 1989 — was sensitive to changes in fiscal policy at the national level. She also noted that advanced technology production facilities have the potential to be moved offshore where labor costs are lower. The state's experience in the mid-1980s also showed that advanced technology industries were not immune to business cycle fluctuations and are sensitive to international competition. These risks and experiences held true throughout the early 1990s.

By 1998, Colorado's advanced technology sector had lost a significant portion of the employment involved with defense activities and manufacturing. These losses, however, were more than compensated by increases in Software & Computer Services employment, which grew at a stellar average compound annual rate of 14.4 percent from 1972 to 1998.

Overall, the strong advanced technology sector will continue to post strong growth in Colorado, but not without risks. Advanced technology industries can be volatile as is any manufacturing industry. This was most obvious in the mid-1980s when the industry had a significant contraction. In addition, because advanced technology exports comprise a large share of Colorado's international trade — 71 percent in 1998 — the state is becoming more closely tied to national and international developments. Furthermore, the advanced technology sector can cause widening income disparity between technology "haves" and "have nots." The pace of change in this sector may reduce job security and job tenure while "technical obsolescence" may increase the risk of unemployment among formerly high-paid workers. Offsetting this concern is the fact that advanced technology products hold the key to coping with present and upcoming labor shortages by enhancing work force productivity.

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Skilled labor is critical to the expansion and reinforcement of Colorado's advanced technology industries.

Conclusion

Advanced technology establishments continue to be pursued as high growth, high paying businesses that provide Colorado with a competitive advantage. In 1998, Colorado's advanced technology employment was 6.1 percent of total nonfarm employment. More than one-third of these jobs are in the Software & Computer Services category of the advanced technology sector.

Colorado's advanced technology jobs are primarily located in the greater Denver metropolitan area. The highest numbers are in Boulder, Arapahoe and Denver counties, in that order. Advanced technology firms are still most likely to be small, employing fewer than 100 employees. Wages in these firms average 46 percent more than other state wages.

Skilled labor is critical to the expansion and reinforcement of Colorado's advanced technology industries. Low cost and other traditional business measures are less important to advanced technology firms than having a readily available pool of highly-qualified labor, and providing the quality-of-life resources that this class of labor demands.

**Table 15
Advanced Technology Sectors**

Major Group	Industries	SIC
Chemicals	Industrial Inorganic Chemicals	281
	Drugs	283
Metal Products & Machinery	Ordnance and Accessories	348
	Engines and Turbines	351
	Special Industry Machinery	355
	Computer and Office Equipment	357
Electrical Equipment & Supplies	Electric Transmission and Distribution Equipment	361
	Electrical Industrial Apparatus	362
	Household Audio and Video Equipment and Audio Recordings	365
	Communications Equipment	366
	Electronic Components and Accessories	367
	Miscellaneous Electrical Machinery, Equipment, and Supplies	369
Transportation Equipment	Aircraft and Parts	372
	Guided Missiles and Space Vehicles	376
Instruments	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical Systems, Instruments and Equipment	381
	Laboratory Apparatus and Analytical, Optical, Measuring and Controlling Instruments	382
	Surgical, Medical and Dental Instruments	384
	Photographic Equipment and Supplies	386
	Computer Programming, Data Processing, and Other Computer Related Services	737
Research Labs	Commercial Physical Research	8731

