Report to the Colorado General Assembly:

RECOMMENDATIONS FOR 1983
COMMITTEE ON:

ELECTRONICS INSTITUTE

COLORADO LEGISLATIVE COUNCIL

RESEARCH PUBLICATION NO. 274
December, 1982

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COLORADO GENERAL ASSEMBLY

LEGISLATIVE COUNCIL

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To Members of the Fifty-Fourth General Assembly:

Pursuant to Senate Joint Resolution No. 19, 1982 regular session, the Legislative Council appointed a Committee on the Electronics Institute to conduct a study of the advisability of creating a Colorado Electronics Institute for the purpose of coordinating and promoting the development of research and teaching in electronics at state universities and colleges.

Submitted herewith is the report of the Committee on the Electronics Institute, reviewed and approved by the Legislative Council for transmittal to the Fifty-fourth General Assembly.

Respectfully submitted,

/s/ Representative John G. Hamlin
Chairman
Colorado Legislative Council

LEGISLATIVE COUNCIL

COMMITTEE ON THE ELECTRONICS INSTITUTE

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Sen. Al Meiklejohn*
Sen. Harvey Phelps
Sen. Ron Stewart

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* Senator Anderson resigned from the committee on September 27 and was replaced by Senator Meiklejohn.

TABLE OF CONTENTS

COMMITTEE ON THE ELECTRONICS INSTITUTE

Senate Joint Resolution No. 19, 1982 session, directed that the Legislative Council appoint a committee for the purpose of conducting a study of:

> The advisability of creating a Colorado Electronics Institute for the purpose of coordinating and promoting the development of research and teaching in electronics at state universities and colleges.

The committee has conducted such a study and submits the following recommendations:

-- That the General Assembly establish, by statute, a Colorado Advanced Technology Institute (CATI) to promote, develop, and coordinate education and research programs in all fields of high technology.

-- Electronics is to be the initial priority of the institute, but programs in other fields of advanced technology are to be developed as soon as feasible.

These recommendations, therefore, would provide for the encouragement of technologies more broadly based than only in the area of electronics. Examples of other areas of high technology include biomedical and biotechnical sciences, mining and materials technologies, aeronautics, and aerospace engineering. Other disciplines now exist or are emerging which are also considered "high tech" fields of study -- robotics, optics, bio-engineering for plants and animals, and manufacturing technology to name a few such areas.

Further, it is difficult to place in exact categories many of the areas of advanced technology because of overlapping disciplines. As one example, the study of trace elements may have application to the technologies of microelectronics, bio-medical sciences, and materials science.

Definition of Advanced Technology

For purposes of this report, "high" or "advanced" technology are used interchangeably as synonyms. These words are commonly used to describe research, education, or industries which have several common characteristics. One description of these characteristics as found in high tech industries is provided in a staff study for the Joint Economic Committee of the U.S. Congress:

> High technology industries consist of heterogeneous collections of firms that share several attributes. First, the firms are labor-intensive rather than capital-intensive in their production processes, employing a higher percentage

of technicians, engineers and scientists than other manufacturing companies. Second, the industries are science-based in that they thrive on the application of advances in science to the marketplace in the form of new products and production methods. Third, research and design inputs are much more important to the continued successful operation of high technology firms than is the case for other manufacturing industries.

The report continued by listing the following types of industries involved in high technology:

> Although analysts have reached no general agreement on a definition of a high technology industry, there is a general agreement that the following Standard Industrial Classification (SIC) industries qualify: chemicals and allied products (SIC 28); machinery, except electrical (SIC 35); electrical and electronic machinery, equipment and supplies (SIC 36); transportation equipment (SIC 37); and measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and clocks (SIC 38). Employment in these industries is used in this section to measure the importance of the high technology industries to job development in the national economy.

Technological Industries in Colorado

Manufacturing employment in Colorado has been increasing at a significantly higher rate than the whole of the United States has experienced. In the eleven years ending 1981, a recent report of IntraWest Financial Corporation 1/ said that Colorado's employment in manufacturing increased by fifty-seven percent, compared with five percent for the nation. Most notable in Colorado has been the growth in production of electronics, computers, telecommunication, instrumentation, and other high tech items. These industries in Colorado account for two out of five of the state's manufacturing workers.

Most of the high technology industries in Colorado are concentrated in the front range counties. The IntraWest report contained the following information on the numbers of manufacturing establishments and high tech manufacturers in the following counties:

1/ References to this report and the others mentioned herein are contained on page 45, "selected references".

County	Total Manufacturers	Total High Tech Manufacturers	% High Tech
Denver	1170	330	35.5%
Boulder	393	175	22.5%
Arapahoe	355	135	26.3%
Jefferson	323	116	27.8%
Adams	309	106	29.2%
El Paso	291	89	32.7%
Larimer	232	72	32.2%
Weld	124	36	34.4%

(Source: University of Colorado Business Research Division, Directory of Colorado Manufacturers, 1982.)

There are reasons for the concentration of these industries in certain areas. The IntraWest report stated that high tech firms, in particular, benefit from a clustering of firms in a geographic area. Large numbers of similar firms increase the availability of skilled labor and other specialized resources. There are, of course, many other reasons for manufacturers to locate in Colorado, including climate, lifestyle, and support services. However, technology and highly skilled labor are more important considerations for high tech plant location than traditional considerations such as transportation and communication costs.

The clustering of these industries in several communities along the front range places special responsibilities on the research universities, colleges, and technical training institutions located in the same area. One reason industry has located in areas near these institutions is to be able to draw on their strengths. There also develops a relationship under which industries are vitally concerned with the further development of the institutions and are willing to commit resources for this purpose.

A survey conducted by University of Colorado Business Research Division, Graduate School of Business Administration, for the United Banks of Colorado, used the Standard Industrial Classification groups listed above as criteria for determining the list of companies involved in high technology goods and services in Colorado. This definition of high technology industries included manufacturing, communication services, and distribution facilities devoted to the following:

- Electronic components and accessories.
- Computers and peripheral equipment.
- Engineering, laboratory, scientific instruments and equipment.
- Measuring and controlling instruments.
- Optical instruments.
- Surgical and medical instruments and apparatus.
- Photographic equipment and supplies.

- Cablevision service.
- Telecommunications.
- Wholesale Trade.
  - Electronic parts and equipment.
  - Commercial machines and equipment.

The list of Colorado firms identified as engaged in one or more of these activities totaled 722, ranging from very small to very large in size. In fact, of the 357 companies (of 722) responding, over 46 percent employed ten or fewer employees and another 40.3 percent employed between ten and 99 persons. The twelve largest plants each employed between 1,000 and 7,000 persons with a total of over 34,000 employees. 2/

The same survey identified the following types and total number of firms of each type:

Type	Total Number Firms
Office and Computing Machines	22
Electric and Electronic Equipment	110
Instruments and Related Products	126
Miscellaneous Manufacturing Industries	1
Communication	49
Wholesale Trade -- Durable Goods	414
Total	722

Since electronics is specified as the initial priority on which the Colorado Advanced Technology Institute is to focus, some facts concerning the development of this part of the high tech industries are important. The rapid growth of this industry in Colorado in five year intervals from 1970 to 1980 is shown below by the following three indicators: 3/

2/ The twelve largest firms reported are: Ampex Corporation, Ball Aerospace Systems Division, Cobe Laboratories, Inc., Digital Equipment, Eastman Kodak Company, Hewlett-Packard Company (3 plants), IBM, Storage Technology Corporation, TRW Colorado Electronics, Inc., Western Electric.

3/ Data for 1970 are partially estimated.

Electronics Industry	Year	Total
Total Employees	1970	5,121
	1975	13,560
	1980	29,320
Wages and Benefits Paid	1970	$ 57 M
	1975	238 M
	1980	663 M
State and Local Taxes Paid	1970	$1.5 M
	1975	5.1 M
	1980	18.7 M

Another characteristic of electronic firms is the rapid development of new companies entering the competitive market. Of the twenty-seven companies included in a 1980 survey 4/, twelve were established since 1975. Further, the survey reported that fourteen of the twenty-seven companies planned definite expansion in Colorado by 1985.

Educational Needs of High Tech Industries

The greatest needs of high tech industries in Colorado appear to be for professional and technical training at all levels. The priorities of the companies differed, but responses from high tech industries to questions concerning their further growth and development centered on educational concerns. One example of a company's priority needs in educational programs is quoted below:

> (a) Continuing education for degreed employees in state-of-the-art technology of electronics, computers, management and related fields.
>
> (b) Graduate level programs leading to the Masters and Ph.D. degrees of bachelor degreed employees who desire to advance.
>
> (c) Bachelor level programs for employees who want to earn their first degree.
>
> Enhancement to improve competence is needed at all levels for two-year technician training through Ph.D. degrees in electronic engineering and computer science ... (our) position is that the major emphasis should be placed on upgrading undergraduate and graduate educational opportunities ... Research is important, especially to attract top faculty, but should be secondary to the primary course work.

4/ Survey by the Colorado Council of the American Electronics Association.

Another newer firm said:

> (Our company) ... needs highly skilled scientists and technicians in the fields of biochemistry, molecular biology, and genetic and biochemical engineering. We are finding more qualified, better trained people out of state, and of course, for economic reasons, would prefer to hire in-state people.

A third company reported:

> ...(W)e recommend that the design automation part of your curricula be placed high on the priority list. Secondly, we find a considerable shortage of semiconductor technicians which hinders growth in the industry. Thirdly, we have to note that the reliability of the manufacturing equipment leaves a lot to be desired. Therefore, we feel a high emphasis should be given to educate technicians in the maintenance of manufacturing equipment. Also ... the graduate program you are proposing will assure the local industry to have the highest education available for its leaders.

It is difficult to generalize in regard to the variety of needs for professional and technical personnel as reported. However, some consensus may be seen as to the first need for strengthening graduate and continuing education programs and the baccalaureate level instruction, with lesser emphasis necessary at this time on programs at the two-year and technician level training.

Taking into consideration the needs and future development of high tech industries in Colorado, and the educational resources available to support these industries, the committee submits Bill 1 to create the Colorado Advanced Technology Institute.

Committee Recommendations

It is recommended that the state establish the Colorado Advanced Technology Institute (CATI) for the purpose of promoting education and research in high technology fields.

There are several reasons as to why the recommendation is made to have the institute involved in activities in high tech areas in addition to electronics. First, there are numerous firms, large and small, located in Colorado engaged in high technologies other than electronics. Electronics may be one part or an important tool for these companies, but the emphasis of these companies may need to be placed on research in areas other than electronics.

High technology companies in Colorado are engaged in diversity of manufacturing related to aeronautics and aerospace, bio-medical

instruments, applications of genetics research, along with other areas. The state has an interest in these activities as well as activities related to electronics. Our future economy is being developed in many fields and we will be fortunate to have industrial strength in several areas rather than having to rely on the changing fortunes of a single industry.

Another reason for recommending inclusion of several advanced technologies in CATI is that our higher education system is already active in research projects in bio-medical, aeronautics and aerospace, mining and material technology, electronics, and in other areas. Some of the research may involve a combination of two or three disciplines such as electronic instrumentation for bio-medical science or technologies. The research capabilities and interests in Colorado higher education range across all fields of high technology and we should take advantage of our strengths in all of those fields. (Appendix A shows the responses received to a survey of the major research activities being conducted in high technology areas at Colorado institutions of higher education).

Title. The term "advanced technology" is used to indicate that the scope of activities of the institute is to encompass more than electronics or any other single field of high technology. Electronics is to have the initial priority, but other advanced technologies are to be developed as soon as feasible.

Legislative intent. The purpose of the legislation is to "promote, develop, and coordinate education and research programs in fields of advanced technology." Specifically, the institute is to seek to improve the quality and the quantity of college and university graduates in fields of advanced technology, to further the research capabilities of higher education, to provide incentives to attract and retain superior faculty members, and to enhance the economic health of the state by encouraging investment, governmental and private, in educational programs which promote advanced technology education and research and development.

Governance. The Board of Directors of CATI will be a combination of representatives of higher education and advanced tech industries and associated businesses. The governing boards of state institutions having colleges of engineering -- the Regents of the University of Colorado, the State Board of Agriculture, and the Trustees of the Colorado School of Mines -- each will appoint one member who shall serve at the pleasure of their board. The executive director of the Department of Higher Education would appoint one member who would act as secretary of the CATI board, to assure coordination with the broader planning functions of the department.

Five members would be appointed by the Governor from the private sector businesses and high technology industries. Names of knowledgeable persons would be submitted to the Governor by groups representative of advanced technology fields. These appointees would be subject to confirmation by the Senate.

Duties of CATI. Bill 1 sets forth the following duties for the commission:

- Assessment of the goals and capabilities of higher education in education and research.

- Analysis of the impact of the institute on the Colorado economy and how to best nurture the economic advancement of high technology in Colorado.

- Establish priorities for the distribution of equipment and moneys available in accordance with the assessment made as to the capabilities of institutions and the economic impact as described in the preceding paragraphs.

- Establish a system to determine needs of high tech industries.

- Establish a peer review process among institutions of higher education for the purpose of obtaining the best current judgements from practicing researchers about projects under consideration by the commission.

- Distribute equipment and moneys among institutions based on the priorities established.

Criteria for development. Bill 1 directs that the CATI board of directors is to develop a plan of action based on the following criteria.

(a) The avoidance of unnecessary duplication of programs, particularly graduate level instruction;

(b) The establishment of centers of excellence for specialties at various campuses of the institutions;

(c) The consideration of industry needs for various educational (technical training, associate degree, baccalaureate level, and graduate) and for in-service education;

(d) The determination of equipment needed for the electronics engineering phase of the institute, where such equipment should be located, and whether it will need to be purchased by the state or whether industry will be willing to provide it.

Funding. Bill 1 contains provision for significant state funding of the institute. Although not binding on future legislatures, a statement of intent is included that the institute will achieve its purposes "...only with a continuing commitment by the state to fund the institute and to match, on an equal basis, contributions from private sources in order to assure the state-of-the-art level of

programs and equipment...." No specific appropriation is included in the bill since estimated figures were not available at the time of completion of the committee's work.

The amount and value of gifts of equipment, consultation, and other contributions to institutions will be difficult to predict. Substantial donations have already been received throughout the entire system, especially by the institutions along the front range. Indications have been given that industry is interested in assisting Colorado institutions in further updating of the state's educational capabilities in high technology areas.

Another important provision of the bill is that appropriations for CATI would be in addition to, and separate from, the state treasury for instructional programs at participating institutions. This language is included to help assure that the appropriations for other segments of higher education would not be diminished because of appropriations to CATI.

Other provisions. A few of the other provisions of the bill are noted below.

- The institute would be a Type I transfer to the Department of Higher Education. This placement would be given maximum autonomy to the institute in its operation, and would fulfill the constitutional requirement that every executive agency be located within one of the twenty principal departments of the executive branch. Another executive department or one of the institutions could be selected for placement of CATI, but the most logical placement would seem to be in the Department of Higher Education, given its existing statutory responsibilities.

- As proposals emerge from CATI, any new programs would be required to be coordinated with the program approval process of the Colorado Commission on Higher Education.

- The institute board would select its own officers and may appoint advisory committees or individuals to advise and assist the commission.

Committee Activities -- Results of Survey

Extensive hearings were held with more than 35 representatives of the two groups primarily concerned with this topic -- high technology industry representatives and representatives of all sectors of higher education. A compilation of the recommendations received is attached as Appendix A. It is important to note from this compilation that different segments of industry and higher education had differing perspectives as to the purposes or emphasis of an advanced technology institute. The committee believes, however, that the emphasis of the draft bill, with its governing board structure, will assure that the priorities of graduate and continuing education, research, and

baccalaureate education will be met.

A major activity undertaken was a survey of the relationship between higher education and high technology industries in Colorado. Purposes of the survey were to obtain institutional views on the following:

-- The areas of cooperation between high-tech industries and higher education through professional cooperation, training of personnel, equipment grants or sharing of equipment and other support, and curriculum development.

-- Major areas of higher education research in high technology fields and the adequacy of present research resources. Estimated costs for meeting the needs in the area of research were requested.

-- Institutional priorities for research and education in the areas of electronics, bio-medical industries, aeronautics and aerospace, mining and materials technology, and other high tech fields.

-- The importance of a special institute in high technology to foster cooperative programs for education, research, and training and the areas in which such an institute should be engaged.

-- The emerging areas of specialization in high technology in which the institutions would want to be involved in the future.

A summary of the results of the survey is Appendix A beginning on page 19, so only a few brief comments will be noted at this point. Some of the conclusions are:

-- There is a substantial amount of research underway in the research university sector of Colorado higher education in all of the high tech areas. The greatest interest, however, appears to be in electronics, followed by bio-medical and mining and materials technology, and then by aerospace and aeronautics.

-- Industry contributions have been significant, with numerous contributions in equipment, collaboration, funds, and personnel.

-- Resources presently available for research may be described as "uneven." Many institutions (or departments) reported as having as their greatest strengths their faculty and the availability of specific types of equipment, laboratories, and physical facilities. However, when asked about the resources not adequate to meet present research needs in areas of high technology, the dollar total of the "greatest" needs was over $45,000,000. Several conclusions may be drawn from this information, but one is that there is a need for a thorough analysis of the most immediate needs and to plan for the careful allocation of the resources that are available.

BILL 1

A BILL FOR AN ACT

CONCERNING THE ESTABLISHMENT OF THE COLORADO ADVANCED TECHNOLOGY INSTITUTE, AND RELATING TO THE DUTIES AND FINANCING THEREOF AND MAKING AN APPROPRIATION THEREFOR.

Bill Summary

(Note: This summary applies to this bill as introduced and does not necessarily reflect any amendments which may be subsequently adopted.)

Creates the Colorado advanced technology institute as a type 1 transfer within the department of higher education. Creates the Colorado advanced technology institute commission to administer the institute. Sets forth the duties of the commission and a list of objectives the commission shall take into account when establishing priorities. Establishes a funding mechanism for the institute and makes an appropriation for the purposes of establishing, administering, and providing for the operational aspects of the institute.

Be it enacted by the General Assembly of the State of Colorado:

SECTION 1. Title 23, Colorado Revised Statutes 1973, as amended, is amended BY THE ADDITION OF A NEW ARTICLE to read:

ARTICLE 11

Colorado Advanced Technology Institute

23-11-101. Colorado advanced technology institute -

creation - legislative declaration. (1) There is hereby created the Colorado advanced technology institute, referred to in this article as the "institute". The institute shall promote, develop, and coordinate education and research programs in fields of advanced technology.

(2) The institute shall seek to improve the quality and the quantity of graduates from Colorado institutions of higher education in fields of advanced technology, to further the research capabilities of Colorado institutions of higher education, to provide incentives to attract and retain superior faculty members at such institutions, and to enhance the economic health of the state of Colorado through encouraging investment by both governmental and private sources in educational programs which promote advanced technology education and research and development.

(3) The institute shall place its initial priority in the area of electronics and related programs. Programs in other fields of advanced technology shall be developed as soon as feasible.

(4) The institute shall exercise its powers and perform its duties and functions specified in this article under the department of higher education and the executive director of the Colorado commission on higher education as if the same were transferred to the department by a type 1 transfer as such transfer is defined in the "Administrative Organization Act of 1968", article 1 of title 24, C.R.S. 1973.

23-11-102. Colorado advanced technology institute commission. (1) The institute shall be administered by the Colorado advanced technology institute commission, referred to in this article as the "commission", which shall consist of nine commissioners. The regents of the university of Colorado, the state board of agriculture, the board of trustees of the Colorado school of mines, and the executive director of the Colorado commission on higher education shall each appoint one commissioner, who shall serve at the discretion of the appointing authority. Five commissioners shall be appointed by the governor and confirmed by the senate, based upon a list of persons knowledgeable in advanced technology fields submitted to the governor by groups which represent advanced technology businesses. These five commissioners shall represent advanced technology industries and associated businesses, and at least one of the five commissioners shall be a representative of a small business enterprise.

(2) The term of each commissioner appointed by the governor shall be four years; except that, of such commissioners first appointed, two commissioners shall be appointed for terms of two years, and three commissioners shall be appointed for terms of four years. A member appointed or designated to fill a vacancy arising other than by expiration of his term shall be appointed for the unexpired term of the commissioner whom he is to succeed. A

commissioner shall be eligible for reappointment for one four-year term.

(3) Commissioners shall serve without compensation but shall be entitled to reimbursement for actual and necessary expenses incurred in the performance of their duties.

(4) The commission shall elect a chairman from its members, the member appointed by the executive director of the Colorado commission on higher education shall serve as secretary of the commission, and the commission may create and fill such other offices as it may determine. The commission shall adopt such rules and regulations governing its procedure as it may consider necessary or advisable and shall keep a record of its proceedings, which record shall be open to inspection by the public at all reasonable times.

23-11-103. Duties of the commission. (1) The commission shall:

(a) Assess the long-range goals and capabilities of Colorado institutions of higher education concerning education and research in fields of advanced technology;

(b) Analyze the impact the institute will have on the economy of Colorado and how the institute can best nurture the economic advancement of advanced technology industries in Colorado;

(c) Establish priorities for the distribution of equipment and moneys available to the institute according to its assessment of the long-range goals and capabilities of

institutions of higher education as determined pursuant to paragraph (a) of this subsection (1) and according to its analysis of economic impact as determined pursuant to paragraph (b) of this subsection (1);

(d) Establish a system to determine the needs of advanced technology industries and a peer review process among institutions of higher education;

(e) Make distribution of equipment and moneys among such institutions based upon its established priorities.

(2) Additionally, the commission shall:

(a) Administer the flow of equipment and money available to the institute by the use of individual institutional accounting structures;

(b) Receive annual reports from the various institutions on the use of allocated funds and equipment and consolidate such reports into an annual report to be presented to the general assembly.

(3) (a) The commission is specifically empowered to receive and expend all grants, gifts, and bequests, specifically including state and federal funds and other funds available for the purposes for which the institute exists, and to contract with the state of Colorado, the United States, and all other legal entities with respect thereto. The commission may accept or provide, within the limitations of its budget, matching funds wherever grants, gifts, bequests, and contractual assistance are available on such basis.

(b) Contributions of advanced technology equipment, grants, gifts, or bequests from an advanced technology company to the institute may be designated to or accepted for use by a specific institution of higher education or may be nondesignated.

(c) Any nondesignated equipment, grants, gifts, or bequests received by the institute shall be utilized for advanced technology industry-generated research to be conducted in equipped laboratories at institutions of higher education and for maintaining state-of-the-art laboratory equipment at such institutions.

(4) The priorities established pursuant to paragraph (c) of subsection (1) of this section shall take into account the following objectives:

(a) The avoidance of unnecessary duplication of programs, particularly at the graduate level of instruction;

(b) The establishment of centers of excellence for specialties at various campuses of the institutions;

(c) The consideration of industry needs for technical training, associate degree, baccalaureate level, and graduate level training and for in-service and continuing education provided by postsecondary education;

(d) The determination of the types of equipment needed for developing the electronics engineering phase of the institute, where various types of equipment should be located, and whether the equipment will need to be purchased by the

state or whether industry will be willing to provide such equipment;

(e) The coordination of proposals emerging from the plan with the program approval process of the Colorado commission on higher education.

(5) The commission may appoint advisory committees or individuals to advise and assist the commission and suggest solutions for the problems and needs of advanced technology industries and institutions of higher education.

23-11-104. Institute funding. (1) The accomplishment of the purposes of the institute will be achieved only with a continuing commitment by the state to fund the institute and to match, on an equal basis, the contributions of equipment and money made by private industry and other private sources to the institute in order to assure the state-of-the-art level of programs and equipment previously attained through such private contributions.

(2) The appropriations from the state treasury for the institute shall be in addition to and separate from the appropriations from the state treasury for the instructional programs of the participating institutions.

SECTION 2. 24-1-114, Colorado Revised Statutes 1973, 1982 Repl. Vol., is amended BY THE ADDITION OF A NEW SUBSECTION to read:

24-1-114. Department of higher education - creation. (2.5) The Colorado advanced technology institute, created by

article 11 of title 23, C.R.S. 1973, shall exercise its powers and perform its duties and functions under the department of higher education as if the same were transferred by a type 1 transfer.

SECTION 3. Appropriation. In addition to any other appropriation, there is hereby appropriated, out of any moneys in the state treasury not otherwise appropriated, to the Colorado advanced technology institute, for the fiscal year commencing July 1, 1983, the sum of _____ dollars ($), or so much thereof as may be necessary, for the purpose of establishing and administering the institute and the sum of _____ dollars ($), or so much thereof as may be necessary, for the purpose of funding the operational aspects of the institute.

SECTION 4. Safety clause. The general assembly hereby finds, determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.

APPENDIX A

EXCERPTS FROM SURVEY OF RELATIONSHIPS BETWEEN HIGHER EDUCATION AND HIGH TECHNOLOGY INDUSTRIES IN COLORADO

This appendix presents a summary of results and a compilation of certain of the responses received to the survey of higher education institutions regarding their relationship with high technology industries in Colorado. Below are some of the results that were compiled from a review of the survey.

Cooperation of Higher Education and High Tech Industries (Question 1)

A tabulation of the extent of cooperation between Colorado colleges and universities with four general areas of industry is shown in the answer to question 1 on page 23. All areas of industry -- electronics, bio-medical, aeronautics, and mining/materials -- are well represented. Most of the research universities and baccalaureate technical institutions indicated participation with technologically related industries. The community college and area vocational school contracts were principally with the electronics industry.

Question 1 (b) related to the additional areas in which institutions would want to provide greater assistance in future years. The responses are varied but show a major emphasis in the electronics and computer science areas. Among other areas mentioned frequently were manufacturing and robotics, geo-physical sciences, and management of high tech industries.

Industry Contributions (Question 2)

The survey asked for a listing of the high tech industries which have assisted the institutions during the last four years through professional cooperation, training of personnel, equipment donations, or curriculum development. Responses are shown beginning on page 26.

Present Research (Question 3)

Activities in research now being conducted were reported under question 3, beginning on page 35. The lists are lengthy under each of the major headings, with electronics, bio-medical, mining/materials technology and "other," each showing 16 research areas. The area with the fewest number of projects is aeronautics/aerospace, with six entries.

Institutions and departments were asked which existing research resources (e.g., equipment, graduate assistants) are most adequate to meet the needs for their present level of research. The results are

quite diverse, with faculty mentioned in some disciplines, computer equipment and laboratory equipment at certain others, and space considered the "only adequate" resource for the University of Colorado-Boulder College of Engineering and Applied Science. One possible conclusion to be drawn is that the present research capabilities, as indicated by the strengths of institutions and departments, are not even, and these differences would reflect on the capabilities of institutions to conduct research in a number of high tech areas.

Question 3 (c) concerned the additional resources needed to meet present research needs in high technology. The grand total of the "greatest" (100%) needs for all institutions would total over $45,000,000, with electronics area being over $36,000,000 and bio-medical and mining/materials technology each around $4.5 million. As reported in the previous question, the needs reported varied throughout between faculty, computer and other equipment items, graduate assistants, and building space.

Priority Needs for Education and Research (Question 4)

Question 4 asked for the opinion of the respondent as to the priority needs if the state were to increase its efforts in research and education for any of the high tech industrial areas -- electronics, bio-medical, aeronautics/aerospace, mining and material technology. The results, not tabulated for each institution, are summarized below by sector of higher education.

Research universities. Institutions responding: University of Colorado (Engineering and the Boulder, Denver, Colorado Springs, and Health Sciences Center); Colorado State University (Chemistry, Natural Sciences, Veterinary Medicine and Biomedical Sciences, Engineering, Computer Science, Agricultural Sciences, Physics); and the Colorado School of Mines. The several responses from CU and CSU are reported each as a composite response, insofar as possible.

The greatest number of responses for the top priorities were in the bio-medical and electronics areas, with mining and material technology third in rank, followed by the aeronautics and aerospace industries. The activities which these universities tended to rank as the highest priorities were in response to (b) "research for faculty and graduate education," (a) "graduate education," and (h) "contracts for specific joint research projects (higher education and industry)." Education at the baccalaureate level was ranked below the graduate and research levels in priority needs, but above the technician training questions in importance.

There were few instances in which an institution indicated that it was the only one interested in a particular aspect of the activity as described. In other words, if one of the research universities responded that an activity should have a high priority, most of the other responses also gave a high priority for the same activities.

Baccalaureate level colleges and non-technical university. Institutions responding: Ft. Lewis College, University of Southern Colorado, Metropolitan State College, and the University of Northern Colorado.

The order of areas of interest for this group of institutions, with the number of highest priority votes shown, was as follows:

Electronics	-- 17
Bio-Medical	-- 10
Aeronautics and Aerospace	-- 8
Mining and Material Technology	-- 6

Other industrial areas mentioned as being of highest interest were applied optics (Ft. Lewis), manufacturing processes (USC), micro-electronics applications (USC), and use of computers in educational programs (UNC).

The activities of greatest interest were in baccalaureate education in electronics and bio-medical areas. Research for faculty and graduate education in electronics, but not for other areas, was also of interest.

Community colleges. As with the research and baccalaureate institutions, the industrial area of greatest interest with the community colleges was in electronics, but with mining and material technology having a higher priority than the bio-medical industries.

The emphasis of this sector of institutions is on training of technicians, especially in electronics at the two year level and on continuing education and inservice training for technicians, either one or two year levels. This pattern also held for the mining and material technology. Other high tech areas mentioned by one or two institutions as having a priority for two year training of technical persons were in bio-medical, aeronautics, robotics, and engineering technologies.

Vocational-technical schools. The area vocational schools responding to the survey rated activities in the electronics industry much higher than the activities in any of the other areas. Training at both the one and two year levels and continuing inservice education for technicians in electronics were their highest priorities for additional emphasis.

Importance of a Special Institute (Question 5)

The question was asked as to the importance of creating a special institute for research and training in high tech industries. The most frequent response "of critical importance" was that an institute be established for electronics, followed evenly by bio-medical and mining/material technology. Aeronautics/aerospace was considered of lesser importance for a special institute.

The research universities placed critical importance on creating an institute more frequently than did the other colleges and universities. Also, the community colleges and area vocational schools generally ranked bio-medical, aeronautics, and mining/materials as of "some" or "not very" important. Electronics was of greater interest but this area received comments of "not very important" at 6 institutions and of "critical" importance at 4 institutions.

Emerging Areas of Specialization (Question 6)

Institutional responses to the question of what emerging areas of specialization they would like to see realized at their institution by 1990 contained the same diversity as demonstrated in other parts of the survey. Research university responses indicated greatest interest in computer areas, materials, and bio-technical areas. Baccalaureate institutions, both technical and non-technical, emphasized electronics, but optics, robotics, and energy systems were mentioned. Most of the community college and area vocational school responses centered on electronics and computers, but other areas (robotics, laser technology, for example) were mentioned. The results of this part of the survey are shown beginning on page 40.

Additional Comments Relative to the Survey

1. Many disciplines in high technology areas are directly related to each other and placement in categories in this memorandum may not be totally appropriate, depending on the special emphasis of research or teaching activity. The purpose of the listing, however, is to show the extent of activity more than to describe the activities.

2. Colleges and universities may be described or classified in many different ways. The classification used herein was devised on the basis of the functions of the institution affected by high technology. As one example, while Metropolitan State College may be described as primarily a liberal arts institution, this survey has concentrated on its technological training function and classifies it with the University of Southern Colorado as a baccalaureate institution having technical programs.

   The tabulations have not included general responses received by letter from some institutions explaining that their level of involvement in high technology was not sufficient to warrant detailed response.

3. The primary area of interest was with state university and college system but, because of the extensive work with industry conducted by the University of Denver through the Denver Research Institute, we asked for and received their participation in the

survey. A response was received from the Colorado Technical College and that response has been tabulated also.

Responses to selected topics have been included in this section of the report. 1/

Topic 1 -- Cooperation of Higher Education and High Tech Industries

Topic 2 -- Industry Contributions

Topic 3 -- Present Research:
Major areas of research activity

Topic 4 -- Emerging Areas of Specialization

This material was selected for inclusion, in part, because of the difficulty in providing an accurate summary of the listing of contributions, research activities, and areas of interest to the institutions. In addition, the array of present research is impressive both in the number and variety of specializations represented and is best indicated by listings of research activities.

TOPIC 1: Cooperation of Higher Education and High Tech Industries

Question 1(a). Briefly indicate the most significant areas in which your college or institution directly assists or cooperates with any of the high technology industries listed below.

The cooperative work at the research university level in the four areas specifically mentioned is indicated in the following table. Activities mentioned in answer to this question included research, training of undergraduates, special continuing education, management training seminars, and consultation with industry.

1/ The complete tabulation of institutional responses is available from the Legislative Council Office.

Research Universities (State)

Electronics	Bio-Medical	Aeronautics/ Aerospace	Mining/Materials Technology	Other
UC-Eng	UC-Eng	UC-Eng	UC-Eng	UC-Eng
UCD	UCD	UCD	UCD	
UCCS	UCCS	UCCS	UCCS	
	UCHSC	UCHSC		
CSM		CSM	CSM	
	CSU-Biochem	CSU-Biochem		
CSU-Eng		CSU-Eng	CSU-Eng	
CSU-NatSci	CSU-NatSci		CSU-NatSci	
	CSU-Ag		CSU-Ag	
CSU-Physics		CSU-Physics		
CSU-Chem	CSU-Chem	CSU-Chem	CSU-Chem	
CSU-VetMed	CSU-VetMed	CSU-VetMed	CSU-VetMed	
CSU-CompSci				

Baccalaureate Institutions with Technical Programs

USC	USC	USC	USC	
Metro		Metro		

Community Colleges and AVS

CCD-North	CCD-North	CCD-North	CCD-North	
Pueblo Voc CC				Arapahoe CC
Pikes Peak CC		Pikes Peak		Morgan CC
Aurora Voc Tech				
Larimer Co				
San Luis Valley				
San Juan	San Juan			

Question 1(b). In which additional areas would you want to provide greater assistance in future years?

Research Universities

CU-Engineering. Manufacturing: design automation for VLSI circuits, CAD/CAM robotics. Office Automation: software tools.

UCD. Advanced computer architecture, computer-aided static and dynamic analysis and design, advanced signal processing, solar and alternative energy resources, robotics, industrial engineering and operations research, bio-mechanics, geo-technical instrumentation, computer graphics, math modeling, trace element analysis, management information systems, graduate and undergraduate education, studies and analyses.

UCCS. Training of administrators and staff analysts, particularly in the area of public/private cooperation. 1) Satisfy

demand for M.S. in information science (Business); 2) Ph.D. in computer information science (Business & Engineering). 3) Ph.D. in high technology management (Business & Engineering). Development of doctoral level program in electrical engineering with research emphasis in design and fabrication of integrated circuits, and development of design methodologies. Solid state chemistry; instrumentation; consulting; work with civil engineering firms to mitigate engineering geology problems; and develop ground water investigation techniques.

CSM. Mining, materials, geology, geophysics, geochemistry, economics, petroleum refining, solid state physics, nuclear physics.

CSU-Biochem. Training technicians, in certain biomedical research methods via short courses.

CSU-Engin. Manufacturing engineering.

CSU-Computer Science. Collaborative research in fault tolerance.

CSU-Physics. Electronics.

Baccalaureate Institutions

Metro. 1. Mechanical engineering technology. With additional support our graduates could be trained in micro-electronics manufacturing techniques. 2. The training of instructors for all phases of hi-tech.

USC. Increase research in micro-electronic process control instrumentation, computer-aided design and manufacturing, artificial intelligence. In-service training, counseling programs in the sciences. M.S. in management of technologies in conjunction with our School of Applied Science and Engineering Technology.

Fort Lewis. 1. Applied optics; 2. Energy systems.

Mesa. 1. Electronic Instrumentation Technology (mining and petroleum). 2. Industrial Electronics (high and low voltage, magnetic and solid state). 3. Baccalaureate Degree in Electronics Technology.

Community Colleges and AVS

CMC. Electronics, robotics, computer technology, machinists.

Colorado NWCC. Computer science.

CCD Auraria. Computer electronic technology.

CCD North. All areas of electronics, particularly in the area of computers.

Arapahoe CC. Research and curriculum development. Industry involvement.

Pikes Peak CC. All areas mentioned in answer to question 1(a), plus computer maintenance and computer application to many of the above fields.

Pueblo Voc CC. Bio-medical; robotics.

Aurora Vo Tech. 1. Short term skill upgrading and retraining for hi-tech industries. 2. Research to identify industry training needs.

Larimer County. Bio-medical instrumentation/avionics/micro-wave communications/integrated circuit technology/instrumentation and control systems (electro-mechanical).

San Juan. Two-year A.S. degree program in the electronic technology program.

Independent Institutions

University of Denver (DRI). Contract research is a maturing industry and there are increasing market pressures to increase interactions between industry and research laboratories, to bring the best skills to bear on major high technology issues. DRI is committed to increasing its partnership relations with an ever-expanding sector of this industry.

Colorado Technical College. More co-op positions with industry on a continuing basis.

TOPIC 2: Industry Contributions

Question 2. Please indicate any of the high technology industries which have assisted your department or institution through professional cooperation, training of personnel, donation of equipment, or curriculum development. (Use the time frame of the last four years.)

I. Research Universities (State)

CU - Engineering (three campuses)

Electronics & Computers

Company	Equipment	Collaboration	Funds	Personnel
Auto-trol	X	X		
Ball Aerospace	X	X	X	
Bell Labs	X	X	X	X

Bureau of Standards	X	X		X
Bureau of Reclamation		X		X
Denelcor		X		
Gates		X	X	
General Electric	X	X	X	
Hewlett-Packard	X	X	X	X
Hughes				X
IBM	X	X	X	X
Martin-Marietta	X			X
Mostek	X			
NBI		X		
NCR			X	
Public Service		X		
Rockwell		X		
STC	X	X	X	
Tektronix				X
United Technologies	X			
Western Electric			X	X

Bio-Medical

Beckman Instruments		X		
Cobe Laboratory		X		
Unirad		X		
Valley Lab		X		

Aerospace

Ball Aerospace	X	X		
Beech				X
Hughes				X
Martin-Marietta		X		X
Stanley			X	

Mining and Materials

Auto-trol	X	X		X
Bromwell Engineering			X	
Bureau of Reclamation		X		
Chevron		X	X	X
Dowell (Dow Corp.)		X	X	X
Gates		X	X	
IBM	X	X	X	
Marathon		X		X
Martin-Marietta		X		
Midwest Steel	X			
Minnesota Mining & Mfg.		X	X	
Mobile Oil			X	
Monsanto			X	
Stefen Robertson & Kirsten			X	
STC	X	X	X	
Union Carbide	X	X	X	

UCD

Electronics. 1. Hewlett-Packard, Denelcor, IBM, Auto-trol -- donation of equipment. 2. Western Electric, Honeywell, Hughes Aircraft, Martin-Marietta, Denver Research Institute, Bell Labs, Hewlett-Packard, U.S. Bureau of Standards, Denelcor, U.S. Bureau of Reclamation, Tektronix, PUC, Technicare, Mountain Bell -- part-time teaching and advice on curriculum.

Bio-Medical. EPA -- part-time teaching and advice on curriculum.

Aeronautic/Aerospace Technology. 1. Martin-Marietta -- donation of equipment. 2. Martin-Marietta, Hughes Aircraft, and FAA -- part-time teaching and advice on curriculum.

Mining/Material Technology. 1. Union Carbide, Midwest Steel, Western Geophysical Co., and Petroleum Information Corp. -- donation of equipment. 2. Inter-North Foundation, Hamilton Brothers Oil Co., Daniel Geophysical, Inc., R.I. Reynolds Industries, Inc., Amoco Foundation -- donation of cash. 3. Martin-Marietta, Rockwell International Corp., U.S. Bureau of Reclamation, U.S. Geological Survey, Chevron -- part-time teaching and advice on curriculum.

Other High-Tech. Environmental Inventory and Analysis -- U.S. Geological Survey -- donation of equipment.

UCCS -- Graduate School of Public Affairs

Electronics. Training -- have used as classroom resource people. Also, curriculum development and finally, cash contribution.

UCCS -- Business and Administration

Electronics. Some have served as honorarium instructors; some gifts to college development fund; gift of HP 9896 minicomputer; membership in our Business Advisory Council (BAC)

UCCS -- Engineering

Electronics. NCR Microelectronics: clean room equipment replacement cost, $1,000,000; electronic components, $800; Hewlett-Packard: new electronic lab instruments, $143,000; faculty development grant, $25,000; grant for graduate students, $15,000; Digital Equipment Corp.: computer disc storage units, $75,000; minicomputer graphics system, $58,800; faculty research grant, $10,000; VAX digital computer $150,000 (matching grant pledge); United Technologies/MOSTEK: computer memory, $102,000; development grant, $20,000 (pledged 1/82); electronic components, $5,000; miscellaneous, $5,000.

UCCS -- Chemistry

Electronics. Digital Equipment Corp: donation of PE 403 Atomic Absorption Spectrometer and Lamps (in working condition); Hewlett-Packard: seminars for science club, participation of adjunct faculty member, faculty search committee help; NCR: faculty search committee, cooperative education.

UCCS -- Communications

Electronics. Hewlett-Packard and Digital personnel have served on advisory committees for program development.

UCCS -- Business and Administration

Bio-Medical. Membership on our Business Advisory Council (BAC).

UCCS -- Chemistry

Bio-Medical. St. Francis Hospital.

UCCS -- Business and Administration

Aeronautics and Aerospace. Membership on our Business Advisory Council (BAC); some gifts to our College development fund; some have served as honorarium instructors.

UCCS --Geology and Applied Earth Science

Aeronautics and Aerospace. U.S. Air Force $5,000/year, one year; NASA $5,000/year, two years.

UCCS -- Business and Administration

Mining and Material Technology. Member on our Business Advisory Council.

UCCS -- Chemistry

Mining and Material Technology. Kaman Sciences -- Coatings project involving students.

UCCS -- Business and Administration

Other High-Tech Industries. Software firms: members on our BAC.

CU - Health Sciences Center

Bio-Medical. Syngene, Proctor and Gamble, various pharmaceutical companies, Penwalt Corporation.

Colorado State University (CSU) -- Biochemistry

Bio-Medical. Beckman Instruments, donation of liquid scintillation counter.

CSU -- Engineering

Electronics. Hewlett-Packard -- over $500,000 in new equipment. Hewlett-Packard, IBM, and Martin-Marietta -- $404,443. NCR -- $12,500 for the new integrated circuits lab. IBM -- $7,500 per year for graduate fellowships. Rockwell -- $6,500 per year for graduate fellowships. Evans & Sutherland -- $120,000 for graphics equipment. Eastman Kodak -- $90,000 for the Computer Assisted Engineering (CAE) lab.

Aeronautics/Aerospace Technology. Martin-Marietta and Rockwell International $500,000 for the Center for Computer Assisted Engineering.

Mining/material Technology. Halliburton -- facility development, $15,000.

Other High-Tech. Computer assisted engineering.

CSU -- Natural Sciences

Electronics. Hewlett-Packard, IBM, General Electric, NCR, Kodak, Rockwell, Martin-Marietta, SERI -- equipment, research contracts.

Bio-Medical. Los Alamos Scientific Laboratory, SERI -- equipment, research contracts.

Mining/Material Technology. IBM, Scandia laboratories, NBS, Naval Research Labs, Los Alamos Scientific Lab, Celanese, Monsanto, DuPont, Dow Chemical Pharmaceutical firms, SERI -- equipment, research contracts.

CSU -- Agricultural Sciences

Bio-Medical. Rolm and Haas, Pfizer.

CSU -- Physics

Electronics. Hewlett-Packard, IBM -- primarily equipment around 10K/year.

CSU -- Chemistry

Electronics. Donation of equipment and services valued at around 100K. Provision of fellowship support around 30K.

Bio-Medical. Advice on curriculum development.

Aeronautics/Aerospace Technology. Donation of equipment around 100K.

Mining/Material Technology. Assistance in developing research proposals.

Other High-Tech. Oil and chemistry industry -- receive around 40K/year in fellowship support. Pharmaceutical -- receive around 15K/year in fellowship support.

CSU -- Computer Science

Electronics. Hewlett-Packard -- $200,000 equipment; NCR -- $2,000 cash; Digital Equipment Corporation -- $75,000 equipment.

Colorado School of Mines

Electronics. Hewlett-Packard, IBM, Vavian Assoc., Tektronix, Bell Labs, Texas Instruments.

Aerospace/Aeronautics Technology. Martin-Marietta -- donation of equipment. Rockwell -- donation of equipment.

Mining/material Technology. Various mining companies -- donation of euipment; U.S. Steel, CF&I, Conoco, ARCO -- support of particulate science lab.

II. Baccalaureate Colleges with Technical Programs

Metropolitan State College

Electronics. Hewlett-Packard -- equipment; IBM -- equipment; Mountain Bell -- equipment; Intel -- components; Martin-Marietta -- cash. MDSI -- computer terminals.

Aeronautics/Aerospace Technology. Beach Aircraft Corp., Gates-Lear, Gates-Combs, Tiger Air, McDonnell Douglas Aircraft, Stapleton Airport Operations -- training for MSL students; Frusca International Simulators, United Airlines -- simulation and procedure training; Analog Training Computers, Inc. -- flight simulators, avionics, instructor training, guest lecturers, field trips, flight engineer material.

University of Southern Colorado

Electronics. Computer equipment, electronic equipment and some medical-related equipment. Hewlett-Packard -- $20,000 donation of test equipment.

Bio-Medical. Parkview Hospital -- donation of $20,000 micro-computer. St. Mary Corwin & Parkview have contributed money to support staffing.

Aeronautics/Aerospace Technology. NASA research program: equipment loans, curriculum development. Sundstrand Corp: donations of supplies.

Mining/Material Technology. CF&I scholarship support, curriculum development, equipment donations. Marathon Oil Co., donation of optical metallurgy microscope and x-ray spectrometer.

Primarily Non-Technical Baccalaurate College

Fort Lewis College

Electronics. O.E.C. -- donation of microprocessors and computer graphics equipment and software.

Bio-Medical. Equipment donations.

Aeronautics/Aerospace Technology. Johnson Space Center (1979) -- faculty fellowship in aerospace training (Prof. of Physics).

Mining/Materials Technology. Funds from Atlantic-Richfield to aid in the instruction of minority students (Dean of Arts and Sciences).

IV. Community Colleges and Area Vocational Schools

Pikes Peak Community College

Electronics. Advisory committees, equipment, specialized lectures, specialized instruction media, summer training for instructors, student placement.

Other High-Tech. Integrated circuit fabrication technology; industrial optics technology; machining technology; mechanical design technology; data processing.*

CCD -- Auraria

Electronics. Western Electric -- curriculum; Storage Technology --curriculum; Hathaway Industries -- curriculum.

Bio-Medical. Area Hospitals -- Cooperative training, curriculum, equipment.

Mining/material Technology. Sterns Rogers -- equipment, curriculum.

Pueblo Community College

Electronics. Assistance from Hewlett-Packard in equipment and curriculum development. Developing contacts with other groups including Honeywell, Tandy Corp., State Electronics Advisory Committee.

Arapahoe Community College

Electronics. Technicare, Auto-trol, Hathaway Instruments, Honeywell, Martin-Marietta, Vari-L, Denelcor.

Colorado Mountain College

Mining/Material Technology. Curriculum development, equipment loans and $1,074 per trainee cash provided by a local coal mine. Equipment loaned: longwell mining control boxes, control boxes for other equipment, one mine donated a continuous miner.

Colorado Northwestern Community College

Electronics. JBC Instruments-Denver -- equipment, personnel; James E. Rowky & Co.-Denver -- equipment, personnel.

Aeronautics/Aerospace Technology. Chevron-Jet engine donation.

Larimer County Voc-Tech Center

Electronics. Hewlett-Packard -- equipment; Woodward Governor -- cash; Kodak, NCR, Storage Tech. Corp. -- all have heavily impacted development of the technology program in curriculum, professional assistance through advisory committee input, and through internships for faculty.

Aurora Voc Tech

Able T.V., Air Incorporated, Audiovox, Cessna Aircraft, Data General, Fistell's Electronics, Frontier Airlines, GTE Lenkurt Division, Heath Kit, Intermountain Telephone, Jet Electronics, Martin-Marietta, Mountain Bell, NCR, Quasar Corporation, R & R Instruments; RCA Corporation, Radio Contract Corporation, Radio Shack, Respiratory Marketing, Incorporated, Rockwell, Sencore, Sorbus, Incorporated, Technicare, Tektronix, United States Air Force, Vari L. Corporation, Zenith Radio Corporation -- equipment, in-service activities, instructional supplies/materials, and cash for Vocational Clubs of America.

V. Research University (Independent)

University of Denver (DRI)

Electronics. Contract research sponsorship amounting to approximately $2,465,327. DRI Advisory Panel-Honeywell, IBM, Bendix.

Bio-Medical. Contract research sponsorship amounting to approximately $975,563.

Aeronautics/Aerospace Technology. Contract research sponsorship amounting to approximately $2,813,997. DRI Advisory Panel -- Martin-Marietta, Ball Brothers, Sundstrand/Denver.

Mining and Material Technology. Contract research sponsorship amounting to approximately $1,676,704. DRI Advisory Panel -- Rockwell International/Rocky Flats, Tosco, Stearns-Roger, Chevron, Climax Molybdenum, Gulf Minerals, Potash Company of America, Shell Oil, Texaco, Vickers Petroleum, Rocky Mountain Energy Co., Johns-Manville.

Other High-Tech Industries. Miscellaneous Projects, $2,340,145. Synthetic fuels research - $3,855,307 (Sponsored research volume). Instructional learning systems - $5,369,064 (Sponsored research volume). Environmental Technology Research - $6,870,097 (Sponsored research volume).

VI. Technical College (Independent)

Colorado Technical College

Electronics. PET & EET advisory boards; PET 22 work co-op with four industries.

Bio-Medical. BMET advisory board; MET 42 with local hospitals.

* (It was also noted in the Pikes Peak Community College response that in all instructional areas noted industry has provided Advisory Committees to provide expert knowledge of curriculum, facilities and equipment, instructor qualifications, and student placement. Industry has provided equipment, specialized lecturers and technical instruction media, student placement, and instructor training and summer work for instructors in applications of state-of-the-art technology. Assistance from industry in similar activities is probably taking place in other institutions of the system.)

TOPIC 3: Present Research

Question 3 (a). If your department or institution is engaged in research relating to high technology industries, please note the major areas of research activity.

Below are listed the responses received to the question of research being conducted in high technology areas. Some of these activities could easily be placed under more than one heading, e.g. thin film technology under "materials technology" rather than "electronics." While the placement in categories may be arbitrary, the point of the listing is to show the extent and variety of research interest in high tech areas in Colorado universities and college.

Not included on these lists were behavioral science and policy research questions noted as being conducted by some institutions. Studies at UCCS, for example, included stress and motivation of personnel in high tech firms, organizational communication, and policy issues relating to urban growth and environmental quality. While these topics are important for the institution and for industry, only the areas of research directly impacting the technological innovations of the industries are reported below.

Electronics	Bio-Medical	Aeronautics/ Aerospace	Mining/Materials Technology	Other
Computer architecture, design and organization (UCD)	Reproductive physiology (CSU - Vet Med)	Digital flight control and guidance (USC)	Visco-elastic properties of oil shale (UCD)	Passive solar applications (UCD)

Electronics	Bio-Medical	Aeronautics/ Aerospace	Mining/Materials Technology	Other
Modeling very small devices - interaction between density packed devices (CSU-Eng)				
Computer Engineering (CU-Eng)	Molecular biology (CSU-Vet Med)		Geotechnical engineering (UCD, UCCS)	Applied optics (Ft. Lewis)
Signal processing (CU-Eng, UCD)	Toxicology/ pathology (CSU-Biochem & Vet Med)	Use of micro-processors and micro-computers in auto flight control (avionics systems) (USC)		Plasma discharges (Ft. Lewis) Wind loading of structures (CSU-Eng) Trace elements (UCD)
High frequency measurements (UCD)	Environmental Health (CSU-Vet Med)		Mining engineering (CSM)	Atmospheric diffusion (CSU-Eng)
Computer-aided design (UCD, UCCS)				Management information systems (UCD)
	Radiation biology and oncology (CSU-Vet Med)	Aerodynamics (CU-Eng)	Petroleum engineering (CSM)	Data base management (CU-Eng)
Math modeling (UCD)			Petroleum refining (CSM) Synthetic fuels projects (DRI)	Turbulence effects on flow separation (CSU-Eng)

Electronics	Bio-Medical	Aeronautics/ Aerospace	Mining/Materials Technology	Other
Semi-conductor electronics (CSU-Eng and NatSci)	Pharma-ceuticals (CSU-Chem)	Combustion (CU-Eng)	Synfuels development (CSM)	Geotechnics (CU-Eng)
Bioelec-tronics (CU-Eng)	Anti-cancer agency development (CSU-Chem)	Fluid mechanics (CU-Eng)	Materials science (CU-Eng, CSU-NatSci)	Robotics (CU-Eng)
			Materials development (CSM)	
	Tissue culture (CSU-Ag)	Numerous selected projects listed by DRI totaling $2.8M	Solid state physics (CSM)	Chemical instrumentation (Ft. Lewis)
Solid state materials (CU-Eng & CSU-Physics)	Antibiotics for animal health (CSU-Ag)		Solid mechanics (CU-Eng)	Programming languages (CU-Eng)
VLSI design and fabrication of integrated circuits (CU-Eng, UCCS, CSU-Eng)	Recombinant DNA technology (UCHSC, CSU-Biochem)		Solid state devices (CSU-Chem)	Nuclear energy (Ft. Lewis)
Device processing - silicon (UCS)			Geochemistry (CSM)	Vector processing (CSU)
			Minerals process development (CSM)	
Software engineering (CSU-CompSci)	Biomaterials (CU-Eng)		Welding (CSM)	

Electronics	Bio-Medical	Aeronautics/ Aerospace	Mining/Materials Technology	Other
Computer-assisted engineering (CSU-Eng)	Bio-electronics (CU-Eng)		Particulate science (CSM, UCCS)	Instructional learning systems; and Environmental technology research -- all listed with selected projects by DRI totaling $2.3M
Computer science (CSU-Nat Sci)	Orthopedics (CU-Eng)		Polymers (CSU-Chem)	
Mathematical and statistical modeling (CSU-NatSci)	Microwave tomography (CU-Eng and UCD)		Magnetic resonance techniques (CSU-NatSci)	
Thin-film technology (CSU-Physics and Eng)	Testing of clinical medical and dental materials (UCHSC)		Safe deposition of uranium mill tailings (CSU-Eng)	
Materials and device studies for new semi-conductor materials (CSU-Eng)				
Use of polysilicon for integrated circuit (CSU-Eng)				

Electronics	Bio-Medical	Aeronautics/ Aerospace	Mining/Materials Technology	Other
Laser annealing (CSU-Eng)				
Numerous selected projects listed by DRI totaling $2.5M	Taste function (UCHSC)		Potential liquification and subsequent structure failure (CSU-Eng)	
	Protein structure (UCHSC)		Biomaterials (CU-Eng)	
	Application of micro-computers to biomedical research (CSU-Biochem)		Catalysis (CU-Eng)	
	Bio-medical applications (USC)		Combustion (CU-Eng)	
	Numerous selected projects listed by DRI totaling $1M		Energy conversion (CU-Eng)	
			Surface physics (CU-Eng)	
			Metals and ceramics coatings (UCCS)	
			Numerous selected projects listed by DRI totaling $1.7M	

TOPIC 4: Emerging Areas of Specialization

Question 6. What emerging areas of specialization in high technology would you like to see (at your institution) realized by 1990?

I. Research Universities (State)

Electronics

Semiconductor electronics (CSU - Natural Science)
Microelectronics and computer engineering (CSU - Eng. -- First Priority)
Advanced computer architecture (and applications to engineering problems) (UCD, UC - Eng.)
Signal processing for medical applications (UCD)
VLSI design and fabrication (UC - Eng.)
CAD/CAM software engineering (UC - Eng.)
Design, fabrication and processing of silicon integrated circuits (UCCS - Eng.)
Knowledge based systems (CSU - Eng.)
Softwater engineering (UC - Eng.)

Materials

Materials science (CSU - Nat. Sci.)
Advanced trace element analysis and math modeling (UCD)
Surface science (CSU - Nat. Sci.)
Polymer science and engineering (CSU - Nat. Sci.)
Solid state physics and materials science (CSM, UCCS, UC - Eng.)
Catalysis and surface physics (UC - Eng.)
Materials shortages and substitute materials (CSM)
Chemistry - some emphasis on materials, solid state and surfaces (UCCS)

Biomedical

Agriculture biotechnology (CSU - Vet Med.)
Medical biotechnology (CSU - Vet Med.)
Veterinary medicine biotechnology (CSU - Vet Med.)
Bio-electronics and bio-materials (UC - Eng.)

Genetics

Molecular genetics and genetic engineering (CSU - Nat. Sci.)
Bio-engineering for plants and animals (CSU - Ag.)

Energy

Coal gasification (UC - Eng.)
Synfuels (continued development) (CSM)

Aerospace

Satellite meteorology (CSU)

Optics

Optical technology (CSU - Nat. Sci.)

Robotics

Robotics/manufacturing (CSU - Eng., UC - Eng.)

Other

Public policy awareness (UCCS - Pub. Aff.)
Public/private sector cooperation (UCCS - Pub. Aff.)
Information science (UCCS - Bus. Ad.)
Computer information science (UCCS - Bus. Ad. and Eng.)
High tech management, Ph.D. (UCCS - Bus. Ad. and Eng.)
Wind engineering (CSU - Eng.)

II. Baccalaureate Colleges with Technical Programs

Robotics - manufacturing - production (USC)
Microcomputers (USC)
Management of technology (USC)

III. Primarily Non-Technical Baccalaureate Colleges and University

Resource center for training industry's teachers through computer assisted and computer managed instruction (UNC)
Energy systems (Ft. Lewis)
Engineering measurements (Ft. Lewis)
Applied optics (Ft. Lewis)
Electronics technicians (Mesa - baccalaureate program)

IV. Community Colleges

Electronics

Computer maintenance (Pikes Peak CC, Arapahoe CC)
Automation technicians training
Computer assisted design, drafting analysis (Aims CC)
Microprocessor control technicians (Morgan CC, Northeastern CC)
Computer technology -- application (CMC, CNWCC, CCD - Auraria)
Computer manufacture
Computer maintenance (Arapahoe CC, CMC)
Electronics (CMC, Morgan CC, CCD-Auraria)
Laser technology (Pikes Peak CC)

Robotics

Robotics (Pikes Peak CC, CMC, Pueblo VCC, Arapahoe CC, Northeastern CC, Aims CC)

Biomedical

Bio-medical technicians (Pikes Peak CC, Pueblo VCC)

Other

Communications technology (Pikes Peak CC)
Machine tool maintenance and repair (Pikes Peak CC, CMC)
Mid-management training for high technology (Pikes Peak CC)
Other emerging technologies (Space Operations Center) (Pikes Peak CC)
Numerical control technologies (Pikes Peak CC)

V. AVS

Robotics

Robotics (Aurora Voc-Tech, San Juan AVS)

Electronics

Computer technology (Aurora Voc-Tech)
Instrumentation technology (Electro Mechanical) (Larimer Co. Voc-Tech)
Integrated circuit technology (Larimer Co. Voc-Tech)
Electronics technology (San Juan AVS)

Computer repair (Warren Center)
Electrical technical program (San Juan AVS)
Electronics instrumentation (Mesa, 2-year program)
Industrial electronics technology (Mesa, 2-year program)

Other

Mining and related technologies (Mesa, 2-year program)

VI Technical College (Independent)

Computer science (Colorado Technical College)

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Gerald L. Allen and C. Kenneth Jones, University of Colorado, Business Research Division, Graduate School of Business Administration. "An Analysis of the High Technology Industry in Colorado: Present and Future Trends". (Report prepared for the Economic Development Department, United Banks of Colorado, Inc., and the High Technology Banking Group, United Bank of Denver, October, 1981). The summary report is entitled "Rocky Mountain High Technology: The Colorado Connection", also published by United Banks of Colorado and the United Bank of Denver.

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Allen A. Boraiko, "THE CHIP -- Electronic Mini-Marvel That Is Changing Your Life". National Geographic, Vol. 162, No. 4, October, 1982.

Moira Johnston, "High Tech, High Risk, and High Life in Silicon Valley". National Geographic, Vol. 162, No. 4, October, 1982.

James Botkin, et al., Global States, Ballinger (Cambridge, 1983).