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# PARTICIPATION IN DETERMINING SCIENCE AND RESEARCH PRIORITIES IN ALBERTA

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## Background Paper

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### **Research application areas are not economic sectors.**

As the name implies, they are areas in which research can be applied (thus generating socio-economic benefits) and therefore are underpinned by basic social and physical science research.

Agriculture and Agricultural Products, Energy Production and Energy Products, Forestry and Forest Products, and Mineral Production and Products, reflect our natural resource strengths and have received varying degrees of research support.

Biotechnology, Environment, Health and Medical, Information and Communications, Manufacturing and Tourism are existing or future growth areas with new opportunities for research.

Education deals with the key resource need to be successful in all of the above.

Arts and Culture , Community Services, Construction, Environment, Health and Medical, and Transportation deal with our quality of life and our ability to keep and attract creative people and have long term impact.

But, of course, there is much overlap in all these areas. Some think the areas are too broad and some think they are too narrow. There is also overlap in the social and physical sciences in each research application area, but not as much as there could be. This is one of the research themes that should be promoted when discussing research priorities.

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# 1. Agriculture and Agricultural Products

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## Description of the Area and Key Supporting Disciplines



The development of new crop varieties, testing crop diversification options, and the improvement of crop yield, quality, economic return or sustainability is important to the continued development of a competitive feed grain and forage industry and market garden and horticulture industry. Studies of animal nutrition, animal health and productivity, animal breeding and management, and work relating to the diversification of the livestock industry help to increase output per animal, improve product safety and quality, reduce production costs and improve economic returns.

New food and non-food products, new food packaging techniques, and assessment of new technologies for shelf life extension, quality control and food safety improvement assure the growth of a competitive processing industry. All manner of farm equipment including tractors, combines, cultivators, chisel plows, seeders, swathers and sprayers and specialized equipment related to livestock, irrigation, dairy, equine, bee keeping, and equipment for lawn and garden applications are included in this application area. Environmental stewardship is critical to this research application area since a growing and globally competitive agrifood industry needs to sustain the natural resources it depends on. Accordingly the area includes the management of soils, water and agricultural wastes, and the effects of fertilizers, herbicides and pesticides, and of climate change and environmental stress. A number of disciplines related to plant and animal sciences are key to the support of this area.

## Current Alberta Infrastructure and Funding

The Department of Agriculture, Food and Rural Development has played a major part in the growth of the agriculture and food industry. The Irrigation and Resource Management Division, the Animal Industry and the Plant Industry Divisions, and Engineering and Processing Services have active programs. The Alberta Agriculture Research Institute coordinates, promotes and supports research for the benefit of the agriculture and food industries. The Leduc Food Processing Centre, the Food Quality Laboratory of Alberta Agriculture, Food and Rural Development, the Alberta Research Council, the Universities of Alberta and Calgary, the Lacombe and Lethbridge Research Centre of Agriculture and Agri-Food Canada and many private sector companies have capabilities for conducting value added processing research.

The Alberta Farm Machinery Research Centre in Lethbridge tests and evaluates farm machinery. Livestock research in Alberta is conducted by feed lot operators, producers, packing plants, universities, Agriculture and Agri-food Canada's Research Centres, Agriculture, Food and Rural Development and the Alberta Environmental Centre.

Collaboration with organizations in other provinces such as the Veterinary Infectious Disease Organization, the Western College of Veterinary Medicine, the Western Grains Research Foundation augment Alberta's infrastructure. Over 350 food and beverage processing companies are located in the province.

## **Current Alberta Research Activities**

The Department of Agriculture, Food and Rural Development has budgeted over \$24 million for research and related scientific activities for 1996/7. The Alberta Agriculture Research Institute funds projects either directly or through matching grants. The On-Farm Demonstration Program provides financial assistance for projects that demonstrate the application of new technology in the field. Examples of research projects include new methods of detecting and correcting copper deficiency in problem soils, development of regionally adapted varieties of canola, improvements in alfalfa seed quality and yield, the development of new high-value materials from meat packing plant by-products and new techniques to increase the shelf life of chilled pork. The Institute continues to emphasize projects funded through matching grants. Matching contributions from outside sources were \$3.3 million in 1995/6. Participants provide land, labor, machinery or cash contributions. Agriculture Canada's research programs are well integrated with those of Agriculture, Food and Rural Development. The Canada-Alberta Environmentally Sustainable Agriculture Agreement provides support for a variety of soil and water research projects and the Alberta-Canada Barley Development Project is aimed at developing improved crop varieties and management methods.

## **National and International Scope and Context**

Global population is once again catching up to the world's food supply. The United States represents Canada's and Alberta's largest export market. Alberta's agri-food exports to the United States were \$1.46 billion in 1993. The positive effect of the Free Trade Agreement on export expansion is attributable to reduced tariffs and an improved trade environment. Markets have increased for beef, pork, processed meats and food products and regional markets exist for beef and pork breeding stock, canola, potatoes and wheat. The United States processed and semi-processed food market is highly competitive, nevertheless there are opportunities for specialty and gourmet food items and products aimed at the ethnic, natural, nutritious and fresh food markets. Growth in the food service industry in the United States is expected to increase demand for agricultural products.

Japan is Alberta's second largest export market with exports of \$504 million in 1993. Bulk commodities such as canola seed, wheat and barley predominate but processed pork and beef exports are increasing. Alberta's agricultural exports to China, primarily wheat, barley, malting barley and cattle hides, were over \$113 million in 1993.

Trade between Mexico and Alberta is complementary in nature with imports from Mexico being fruits and vegetables not produced in Alberta, and off-season vegetables. Exports from Alberta to Mexico are wheat, barley, canola, special crops, pork and dairy products. Alberta exported \$42 million worth of agri-food products to Taiwan in 1993. There is potential for trade with Latin American countries, Ukraine, Australia and the Middle East.

## **Current Socio-Economic Impact**

Alberta accounts for 23.8% of the value of Canada's agricultural production. The agri-food industry accounted for 4.2% of the GDP in 1993 employing close to 105,600 people. The annual value of economic activity generated by primary agricultural production and value added processing exceeds \$10 billion. Farm cash receipts for crops in 1994 were estimated at \$2.15 billion. An economic assessment of a crop research project showed a return of \$38 to the economy for every dollar invested in the project. Alberta's market receipts from livestock sales amounted to approximately \$2.4 billion in 1994, mainly from cattle. The food and beverage processing industry is the largest manufacturing industry in Alberta employing over 16,000 people. In 1994 this industry accounted for \$5.6 billion in shipments. Alberta's agricultural equipment industry employs about 2,000 people in 230 companies.

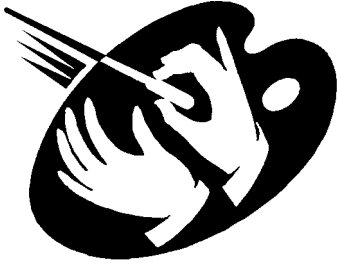
## **Attractiveness**

Research in agricultural production, processing and marketing will ensure agriculture continues to contribute to Alberta's prosperity through increased value added food products and low cost, high quality primary agricultural products. Strong research networks, alliances, collaborations and partnerships with industry already exist to evaluate and adapt agricultural research results and technology from around the world to Alberta conditions while maximizing production. The result of environmental stewardship research creates opportunities for preserving the resource base. The results of crop and livestock development research make important contributions to providing high quality, safe and nutritious food supplies. Industry and government have developed a shared vision of Alberta's agriculture and food industry as one which will be profitable, globally competitive, environmentally sustainable and value its people. There is adequate public and private sector infrastructure capability to implement research findings and capture the benefits that will result from exports. As demand for food production worldwide continues to increase, Alberta has the potential to meet not only local and Canadian needs but to export larger quantities of processed and manufactured agricultural and food products. Medicinal plants, industrial products from plants, and plant nutraceuticals are potential growth areas as is aquaculture.

## **Feasibility**

Considerable potential exists for major improvements in food production and processing because of advances in the application of biotechnology, freeze drying methods, pest management, and robotics and computer technology. Similar potential for improvements in the livestock area is possible through the application of improved management practices, advances in veterinary medicine and in the application of biotechnology to production. Crop research has the potential for reducing production costs, improving feed grains and diversifying the crop base through the application of innovative technologies. Alberta enjoys a marketing advantage because its products are seen as coming from a clean environment. The high quality and ample supply of raw materials Alberta produces, the basic free enterprise economic policy of the government, the regulatory framework and the industry structure are conducive to capitalizing on R&D results. Loss of biodiversity and desertification as a consequence of climate change and soil salinization could become problems.

### Description of the Area and Key Supporting Disciplines



Visual, performing and literary arts are commonly known as the fine arts. Arts history and cultural studies such as musicology and ethno-musicology are academic areas of study. The products created by the fine arts and cultural industries such as paintings and sculptures, music, plays, operas, films, videos, tapes, television programs, sound recordings, books, magazines, compact discs and CD-ROMs, are the most influential forms of cultural expression, entertainment and communication in the world today. New products for the 'information highway' are appearing at an increasing rate. This research application area is supported by the advances in visual arts, music, theater, opera, and performance art. As well, new approaches to play writing, poetry, fiction and non-fiction writing, writing for youth, and scripts for radio, television and film serve the area. Writers also provide support for corporate communications by producing annual reports, brochures, and advertising material. Industrial design and commercial art have links to several other research application areas. Other forms of entertainment, including sports, form part of our culture. Many disciplines in the arts and humanities and the sciences support this area.

### Current Alberta Infrastructure

The Cultural Facilities and Historical Resources Division of Alberta Community Development is responsible for museum services and related scientific activities, and is in the business of education, cultural preservation and cultural tourism. The funds spent provide for the operation of a network of 19 provincial museums, interpretive centers and historic sites, regulatory control over various developments to preserve heritage resources, assistance to hundreds of community-based heritage initiatives, and the Jubilee Auditoriums in Edmonton and Calgary. There are 22 public and 223 commercial art galleries and craft outlets in the province. The Alberta Crafts Council markets hand-made crafts made by approximately 8,000 artisans. Some 30 arts festivals are held annually, the largest being The Works in Edmonton and Visual Arts Week in Calgary. There are 46 professional performing arts companies providing an estimated 1,000 person-years of employment. Several live theater venues provide space for the companies and the Fringe gives opportunities to professional and amateur actors to perform. The leading arts activity of Albertans is attending theater. There are some 2,500 writers currently making an income from their writing. Thirty book publishing companies publish approximately 150 titles a year. Magazine publishers produce approximately 180 titles and account for nearly 600 jobs. There are more than 625 published freelance writers in the province. There are libraries in almost every community.

Sound recording is growing quickly with 11 full-time and 9 part-time studios operating in Alberta. There are several concert halls in the province that provide opportunities for performers. The Alberta Society of Artists, the Alberta Potters' Association and the Handweavers, Spinners and Dyers of Alberta have active programs and receive provincial funding.

## **Current Alberta Research Activities**

Research in this application area is concerned with the creative processes of artists, performers and writers. Arts and cultural industry development is being supported through the Alberta Foundation for the Arts. Federal support is through the Canada Council. Funding for research in an arts or cultural activity is often generated from sales of the products created. Multi-media products are prime examples of the increasingly blurred boundaries between film, music, performance and literary activities. The production of entertainment software and technology is currently an active research area. The Technology Based Learning Centre of Excellence provides a vehicle for Canadian designers and artists to evaluate new technologies and create integrated software tools. Partners include the Universities of Alberta and Calgary, Manitoba, Toronto, McGill, the Technical University of Nova Scotia, and the National Theatre School. nViews, a research project funded by Industry Canada, provides a framework and tools for the creation, use and management of multimedia information suitable for use by researchers.

## **National and International Scope and Context**

A dynamic arts and cultural community is influential in determining where people decide to live and work. Arts and cultural industries are responsible for generating \$23.8 billion and employing over 660,000 in Canada. The rest of the world knows about a region and its people through the cultural products created in this application area. Arts and culture industries contribute significantly to national economies. There is a growth in national and international sales and a growing trend toward co-production. Globalization of this area has increased the level of competition as well as the rewards for success.

## **Current Socio-Economic Impact**

Arts and cultural industries contributed \$1.3 billion directly, and \$0.6 billion indirectly to the Alberta GDP in 1992/93. The area accounted for 58,302 direct and 21,376 indirect jobs in the same year. Revenue from performance art alone was estimated at \$36.8 million in 1991. Non-resident travel surveys show that over half a million or 13% of the visitors to the province attended fairs and festivals. In 1992, arts festivals grossed \$7.6 million with an attendance of 1.2 million people. Productions by foreign motion picture companies shot on location in Alberta generated \$111 million of economic activity and created 1,847 jobs between 1988 and 1994. It costs \$20,000 to generate a job in the arts, compared to \$100,000 for a job in light industry and \$200,000 in heavy industry.

## **Attractiveness**

Given that Albertans will have increasing leisure time and more disposable income, this is a growth area. The products and services provided by the arts and cultural industries are varied. These products not only contribute to culture and the social wellbeing of Albertans, but provide an opportunity for us to see ourselves through the products created. The rest of the world can get to know about the province and its people through these same products. Some products are created for residents and tourists and new ones have the potential to attract more visitors to the province. In particular, there are opportunities for undertaking more research in products that document our heritage. The cost of doing business from Alberta is often high because of the distance to major markets. Retaining copyright is becoming increasingly important as multi-media products find their way into world markets.

Music and art are compulsory for all elementary school children and many students enrol in fine and performing arts programs in secondary schools. New communication technology advances have the potential to effectively teach or deliver these programs in areas of the province where there may be limited local expertise.

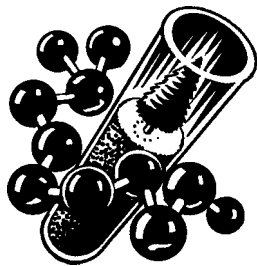
## **Feasibility**

Funding, marketing and investment assistance will be required to ensure the success in this application area. The challenge for the arts and cultural industries is to replace diminishing government support by creating partnerships with the private sector. The potential exists for growth in cultural expression, entertainment and communication as more products are created for the 'information highway'.

### 3. Biotechnology

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#### **Description of the Area and Key Supporting Disciplines**



Biotechnology is a discipline in its own right and, in addition, is an enabling technology for a variety of research application areas. It includes gene therapy, genetic engineering, xenobiotics, and pharmaceuticals and diagnostic tools. Medical biotechnology is used to develop pharmaceuticals and diagnostic tools. Biotechnology applied to agriculture has resulted in advances in biopesticides and bioherbicides, animal health and food processing. New pest, disease and herbicide resistant plant varieties are being developed. Herbicide resistant canola is already in commercial production. Animal biotechnology involves animal genetics and animal vaccines. Environmental biotechnology focuses on waste management, biomass, remediation and material re-use. Bio-industries in the health care, agri-food and the environmental sector are distinguished from their non-bio counterparts by a high level of research and commitment to innovation. Key supporting disciplines include immunology, forest science, pharmacy, pediatrics, zoology, chemical and bio-engineering, biochemistry, plant science, soil science, microbiology, genetics and information technology.

#### **Current Alberta Infrastructure**

The Fermentation Pilot Plant at the Alberta Research Council is a facility where companies can come for fermentation process development under contract. Interim manufacture is offered on a limited basis as a service. Clients are mainly small start-up companies. The Research Council also stewards the technology resources of Chembiomed and has developed a strategic alliance with Glycomed Inc. from the United States to develop and commercialize new carbohydrate structures for the treatment of inflammatory diseases. The Council has licensed the technology to Synsorb Biotech Inc., a new Alberta-based start-up company. The Alberta Heritage Foundation for Medical Research contributes about \$32 million annually to the research of more than 150 scientists in Alberta and elsewhere and Foundation funds have helped equip nearly 300 laboratories at the University of Alberta, the University of Calgary, and the University of Lethbridge. These laboratories and those associated with hospitals provide infrastructure for a broad spectrum of biotechnology research activities. AgrEvo Canada Inc., Alta Genetics Inc., Banner Pharmacaps, Biomira Inc., Briana Bio-Tech Inc., Canadiana Genetics Inc., Cominco Ag-Biologicals, DowElanco Canada Inc., Grow Tec Ltd., Isotechnika Inc., Kiseki Environmental Corp., Monsanto Canada Inc., Norac Technologies Inc., Norwest Soil Research Ltd., Prairie Biological Research Ltd., Raylo Chemicals, SynPhar Laboratories Inc., S.P.I. Diagnostics Inc. and S.P.I. Synthetic Peptides Inc., SYNSORB Biotech Inc., CV Technologies Inc., and Neurospheres Inc. are examples of biotechnology companies in the province.



## **Current Alberta Research Activities**

Chemical based research, genetic research, and research in the use of microbes is carried out. Alberta's research infrastructure and ability attracted industry funding of \$20 million in 1993. This investment in research is further enhanced by federal and other grant money. A number of companies are doing development research using the Alberta Research Council's Fermentation Pilot Plant and getting additional research support from the Biotechnology Department. Funding for 1996/7 for Council's Biotechnology Department is \$2.4 million. The Alberta Environmental Centre undertakes a number of research programs in environmental biotechnology. The Alberta Agricultural Research Institute funds research to improve the quality, safety and nutritional value of foods through testing, adapting and integrating new biotechnology applications of benefit to Alberta's producers and processors. The University of Alberta Faculty of Pharmacy and Pharmaceutical Sciences undertakes research in monoclonal antibodies for cancer therapy, cancer vaccines, gene therapy and drug delivery systems. The University of Alberta Biotechnology Centre in Agriculture, Food and Nutritional Science's activities in plant and crop biotechnology include projects related to potatoes, trees, wheat, canola, corn, alfalfa and forage crops. One project in food biotechnology explores food shelf-life preservation relevant to the meat industry. The University of Calgary Faculty of Medicine and the Centre for Advancement of Health both focus on biomedical technology. As well, the University undertakes research in plant biology and engineering, animal health and energy sector biotechnology. The University of Lethbridge has a plant biotechnology research group and at its Lethbridge Research Station, Agriculture and Agri-Food Canada conducts research in plant biotechnology, biopesticides/bioherbicides and animal health.

## **National and International Scope and Context**

Worldwide there are 3,000 to 4000 firms which utilize biotechnology in some aspects of their products and services. They have combined annual sales of \$15 billion and employ 200,000 people. These companies are primarily in the United States, Europe and Japan. Canada's bio-industry is composed of 506 biotechnology companies with 145 companies providing support to the industry. In 1993, estimated total sales were almost \$2 billion and exports \$750 million. The industry employs an estimated 8000 people. Companies focused on biotechnology applied to human health, form the largest single group and include manufacturers of pharmaceuticals, diagnostic and therapeutic products, and biologicals including antibodies, antigens and fine biochemicals.

## **Current Socio-Economic Impact**

Presently there are about 25 Alberta companies in biotechnology employing over 500 people. Alberta exports of over \$30 million annually are divided between animal and human products and technology.

## **Attractiveness**

The application of biotechnology to many sectors will contribute to economic growth and an enhanced quality of life. The use of biotechnological techniques can result in enhanced food sources, an improved environment, new specialty chemicals, drugs and vaccines, all for the benefit of society. Biotechnology applied to resource extraction and processing could have potential here. Many Alberta biotechnology companies are now approaching the critical stage of commercialization. With proper government encouragement and a positive investment climate, these companies could grow to become an important source of jobs and revenue. Biotechnology products and processes created in Alberta have an attractive export potential. Strategic partnerships between universities, research centers and private industry are flourishing in Alberta making investment in this research application area very attractive.

## **Feasibility**

Expertise built up through programs funded through The Alberta Heritage Foundation for Medical Research has resulted in the possibility of bringing together teams of experts in almost all biotechnology application areas. The facilities and expertise of the Alberta Research Council's Biotechnology Department reduce the capital costs associated with product and process development. The complex houses a scale-up fermentation pilot plant which acts as a bridge between laboratory research and the production of new products. It has attracted attention for its capability in the areas of microbiology, biochemistry, fermentation and scale-up, and plant tissue culture and physiology. There is no facility for gaining regulatory approvals in the production of veterinary or human health pharmaceuticals. Alberta companies would benefit having this element of infrastructure in the province. While many students are being educated in this field, given the intense international activity, shortfalls of highly qualified people with research, production, management and legal expertise are expected. Issues of technology transfer, intellectual property protection and regulatory matters, if not dealt with, can increase the cost and time to bring a new biotechnology product to market. Issues of ethics and safety may cause problems.

### **Description of Research Application Area and Key Supporting Disciplines**



Government itself can be considered to be a community service and it is important to examine how our society is governed. Maintaining law and order, conducting criminal and civil proceedings, carrying out the sentences of the courts, provision of legal services and access to legal aid, and the operations of correctional institutions are components of community services. Family and social services, child welfare and care for the handicapped and disadvantaged members of society are part of this area. Building and fire safety is achieved through the development and uniform interpretation and application of standards set out in the Alberta Building Code and Alberta Fire Code. The safety of persons using elevators, escalators and other fixed conveyances, ski lifts and amusement rides is assured through design reviews and inspections of new installations and inspections, and audits of existing, older installations. Standards for the maintenance and operation of such equipment are developed through the Canadian Standards Association and adopted as Alberta regulations. Issues that support workplace stability, productivity and innovation by encouraging better communication, understanding and cooperation between business and labour are also part of this area. Financial markets also can be considered part of the area. Disciplines related to justice, social welfare, consumer safety, and occupational health and safety are key to the support of this area.

### **Current Alberta Infrastructure and Funding**

The Alberta Law Reform Institute was established to promote law research and reform and to examine ways to increase the usefulness and effectiveness of the law. Research activities of the Department of Justice support its mission to ensure equality and fairness in the administration of justice. The department encourages research partnerships between the public and private sectors, and between various stakeholders in the justice system. The Department of Labour has a responsibility for occupational health and safety and activities aimed at preventing injuries and ill health resulting from employment. Plumbing and Gas Safety assists individuals, industries and municipalities to maintain safe installations including the conversion of vehicles to propane and natural gas motor fuels. The Fire Commissioner's Office promotes all aspects of fire protection and analyses fire loss reports for fire trends, problems and emerging issues. Training is carried out by the Alberta Fire Training School. Information Services provides research, statistical and policy support to meet the needs of the Department of Labour and the Labour Relations Board. The Alberta Labour Library makes available a wide variety of services and resources. The collection includes some 800 videotapes and films, 25,000 books and 500 periodicals.

Radiation Health and Safety works with medical and dental associations and industry groups concerning matters of public and worker exposure, radiation facility design, and handling and disposal of radioactive materials. The Alberta Boilers Safety Association is industry-run organization delivering pressure vessel safety services in Alberta. The Petroleum Tank Management Association of Alberta is also industry-run and delivers safety and environmental services.. The Labour Relations Board decides complaints and applications arising under the Labour Relations Code.

## **Current Alberta Research Activities and Funding**

Community services are derived from research in social welfare. A wide variety of research and related scientific activity projects are carried out. Some of these are analysis of Alberta crime statistics, public opinion polls, key correctional indicator and adult offender population reports for the Canadian Centre for Justice Statistics, research on specific offender populations, studies of municipal policing costs, reviews and analyses of provincial programs such as the victim impact statement program, photo radar, livestock theft and crimes compensation awards. The activities undertaken by Alberta Family and Social Services provide information on program performance and this is used for program development and to make changes in service delivery practices. The Alberta Law Reform Institute's projects are undertaken in close consultation with intended audiences. Alberta Justice provides an annual grant in support of the Institute. During 1993/4 four final reports, one report for discussion and one research paper were issued. Despite reduced funding the Institute remains confident in its ability to play a valuable role in legal reform. The University of Alberta and the Department of Labour are undertaking a Safe Communities pilot program with Fort McMurray which seeks to integrate health, safety and security both at work and in the home. Alberta Education's Special Education Branch is undertaking projects intended to help prevent and deal with violence among students, and student violence against school staff.

## **National and International Scope and Context**

Community services have an enormous effect on everyone. The United Nations promotes reforms in occupational health and safety and compares the performance of countries in providing employees with a healthy and safe workplace. Relative to other western industrialized countries and to the rest of Canada, Alberta's health and safety record is average, i.e. not poor, but not exemplary either. The same might be said of other activities in this research application area, however Alberta Education's new Career and Technology Studies program, when fully implemented, will ensure that students enter the adult workplace with a good base of safety knowledge and skills. Consumer products are traded globally on a large scale. Totaling hundreds of billion dollars annually, this sector is growing steadily. Products that are convenient to use and make life easier and which are sensitive to the environment are in demand. Consumer safety is important whether the product is exported or imported and affects the type of goods in demand.

## **Current Socio-economic Impact**

Alberta has a high wage, high productivity work force. Accidents in the work place or at home cause a drop in productivity. Currently some 50,000 person days are lost each year. Work hardening programs which are directed at getting the person back on the job, treat the problem after it has occurred. Opportunities for preventing accidents through, for example, more work site audits and the reduction of factors that induce stress, have not been fully investigated. Occupational demand studies and labour force modeling studies which take into account demographics might assist in making sure workers are available for new industries and for alerting educational institutions that changes need to be made in the teaching of skills to reduce the number of unemployed.

## **Attractiveness**

Much research is required to determine the most effective, efficient and cost effective manner to serve the interests of the public and business communities and, at the same time, reduce the public debt. Privatization, tax policy issues, etc., require careful study and have the opportunity to influence the business and social climate. The benefits of maintaining law and order in Alberta communities, conducting criminal and civil proceedings and carrying out the sentences of the court in a fair and effective manner go without saying. The provision of legal services to the Alberta Government, access to social programs administered by Alberta Justice, and access to legal aid to those persons who are eligible, are part of an effective legal system. The Department of Family and Social Services mission to help families be responsible and accountable and to keep children safe provides obvious benefits. Programs to reduce the number of children who suffer abuse or neglect at the hands of their caregiver, to reduce the incidents of spousal or senior abuse, programs to ensure dependent adults have assistance from competent guardians, programs to provide impoverished Albertans with basic needs for food, clothing and shelter and programs to reduce the number of employable Albertans who rely on government for income are desirable. Occupational Health and Safety, Technical and Professional Services programs, for example, in health and safety disciplines, hygiene, medicine, nursing and radiation health, ensure wellness in the workplace. Improvements in social programs can do much towards achieving the full potential and productivity of society. Business areas including financial/stock market, insurance, economics, banking, finance planning and corporate investment are important areas for research to encourage and sustain economic growth.

## **Feasibility**

Examples of projects that are feasible include evaluations of the Canada-Alberta Service Centers and of the Integrated Training Centers for Youth approaches. These demonstration projects would be jointly funded and managed by Human Resources Development Canada, Alberta Advanced Education and Career Development and Alberta Family and Social Services. The research would most likely be conducted by external consultants in conjunction with in-house staff. Other projects might explore program and operational options for a new integrated benefit for children to replace an array of existing programs, an evaluation of the delivery of children's services or an evaluation of the Urban Job Corps pilot project. This latter project aims to provide a program to assist those with significant employment barriers to make the transition to the competitive labour market. In these and other cases, the various departments (Health, Education, Justice, and Family and Social Services) and communities have the capacity to undertake the research. The findings of the research, while not commercial, have the potential to be shared with partners across Canada. Issues of volunteerism and the charging of user fees need to be addressed.

### Description of the Area and Key Supporting Disciplines



Architectural, engineering and construction services are used in the planning, design, construction and project management of residential, commercial, light industrial, health care and medical, educational, recreational, sport, cultural, hospitality, transportation and religious buildings and facilities, including municipal infrastructure, e.g. water, sewer, power, transportation, solid waste handling, etc. These services can be applied also to building programming, restoration and renovation, demolition and facility management. This area integrates with the energy area in hydrocarbon production and thermal power generation. It also integrates with the environmental area in the alteration of natural topography and water resource development. Cold weather construction, heavy construction, road building and pipelines, infrastructure support for forestry, oil sands mining construction and petrochemical plants, are focus areas. Civil, electrical and mechanical engineering, materials science and architecture are some of the core disciplines.

### Current Alberta Infrastructure and Funding

The universities and technical institutes teach civil engineering and construction technologies and have facilities to assist the construction industry. The Centre for Frontier Engineering and the Alberta Research Council have facilities to help some sectors of the construction industry.

### Current Alberta Research Activities

Little construction research is funded directly by the Alberta government. The universities in the province have established training and research programs of relevance to the construction industry. Research on high performance concrete is conducted at the University of Alberta and the University of Calgary. Steel structure research is studied at the University of Alberta. The Alberta Construction Industry Professorship in Construction Engineering and Management at the University of Alberta engages in research with collaborating companies in the field of productivity improvement for construction. The Alberta Research Council has testing laboratories and operates a pilot plant for panel board construction and testing. The Centre for Frontier Engineering Research does research on structures and materials under severe conditions, usually cold climates.

### National and International Scope and Context

The National Research Council's Institute for Construction Research, the Canadian Construction Materials Centre, the International Council for Building Research Studies and Documentation, Intelligent Sensing for Innovative Structures Canada, and Concrete Canada are examples of national and international organizations involved in construction research. The industry in the province competes with national and international companies in the United States and specific OECD countries. There is some competition emerging in newly industrialized countries. Specific barriers to international work include professional qualification recognition and differing environmental legislation, building codes and materials standards and specifications. World

trade in the area was estimated at over \$800 billion in 1990. Export opportunities are influenced by new trade policies, the ability to bring financing to the project, the blurring of the distinction between products and services and increased partnering by forming joint ventures and strategic alliances.

### **Current Socio-Economic Impact**

The construction component provided \$9.3 billion of services in 1994; international exports were estimated at \$1.9 billion. The construction industry has approximately 13,000 employers registered with the Workers' Compensation Board. Approximately 4,500 of these are registered companies under the Corporation Act. These firms hire nearly 80,000 full-time employees and another 15,000 workers during peak periods. Alberta's construction industry therefore is characterized by a large number of firms with a full-time staff of 20 or fewer people.

The Alberta architectural industry employs over 2000 people. The firms typically have fewer than 10 employees. Approximately 22,000 professional engineers practice in the province. Alberta's consulting engineering industry employs an estimated 6,500 people in approximately 500 firms with estimated annual billings of \$1.2 billion. The firms generally have fewer than 20 staff and many of these are single or dual disciplined.

### **Attractiveness**

Alberta's expertise in construction for severe weather conditions already is recognized internationally. New developments and applications of innovative products and construction procedures will result in better structures locally and increase the export of products and services. The use of computer models to optimize designs and assess safety, fire, structural stability and other risks and to optimize construction procedures to ensure compliance with design requirements at minimum costs can result in lower construction costs while maintaining safety, minimizing impact on the environment, and producing better quality products. Better technologies such as automated construction equipment, automated positioning systems, real-time monitoring and control will have most impact on current practices, especially in heavy construction applications. Similarly, new advanced products used during the construction process can increase productivity, reduce cost, and improve the quality of the constructed facility. There is a bigger payback to doing research at the concept and design stage of construction rather than the later stages of construction, operation and maintenance. New computer models could be of use here.

There are opportunities for research in prefab construction units for export, energy efficient construction materials and methods, and improved indoor-air quality. Changes made in communities and housing to accommodate the virtual workplace will help Albertans who increasingly will work from the home.

### **Feasibility**

Few small construction companies have engineers on staff and therefore are not in a position to utilize new technologies related to construction. The larger companies have engineers, but, in general, these are not research oriented. In addition, the open bidding system and the awarding to the low cost bidder make the introduction of new technologies difficult. The move to a BOOM (build, own, operate and maintain) philosophy is slowly changing the opportunities to introduce new technologies as the risks are shifted from the user of the structure to the construction companies. Much of the research infrastructure to support the construction industry, while available in Canada, is outside the province and therefore more difficult to access.

### **Description of the Area and Key Supporting Disciplines**



An educated and informed society is the basis for development in all other areas. Education and training services include the design, production and delivery of programs and materials in a wide range of subjects. Academic and training courses are delivered in the classroom, the workplace and in the home either directly, or through teleconferencing using multimedia presentations. Consulting services, the evaluation of training programs and the development of educational software and courseware are part of this area. Human resource development programs, job-related training and skills upgrading programs are offered for business, industry and public service clients. Programs at the secondary and post secondary level give students the opportunity to obtain Alberta credentials. Advanced education and career development programs serve the social, cultural and economic needs of Albertans. Life long learning is receiving more emphasis as the population ages and courses for seniors are very popular.

### **Current Alberta Infrastructure**

Basic education, early childhood services to Grade 12, prepares students for entry to the workplace or for further study in the post-secondary system. There are 66 school jurisdictions, nearly 2,000 schools and some 30,000 teaching staff providing a range of programs to more than half a million students. Alberta Education sets policies, determines curriculum and learning standards, and provides funding to school boards. Boards are responsible for delivering educational programs to students. The Alberta Distance Learning Centre in Barrhead is part of the basic education system.

Alberta's advanced education system has a total of 35 post-secondary institutions including 4 universities, 2 technical institutes and a province wide network of community colleges. The University of Alberta and the University of Calgary have over 30,000 and 20,000 students respectively and are major research centers. Distance learning programs are provided inside and outside the province. Athabasca University is the only university institution solely dedicated to this delivery mode. The 11 public and private, degree granting, colleges have over 30,000 full-time students. The Northern and Southern Institutes of Technology are among the largest in Canada.

It is estimated that approximately \$190 million of the Department of Advanced Education and Career Development operating grant to the universities goes to support the research infrastructure.

### **Current Alberta Research Activities**

Alberta Education's research activities focus on performance measurement and reporting, satisfaction surveys, and scanning and monitoring activities. The focus of research activities in Advanced Education is typically analysis of labour market statistics, analysis of demographic trends, support for the development of computer-based training material, policy studies, post secondary demand forecasting, development of an enrollment reporting system, surveys of apprentices to determine training needs, and labour market data collection and analysis. Research in the universities and technical institutes is directed at improving teaching and education methods. Of course, the universities and technical institutes do research in all disciplines, and much of the work is done in partnership with industry.



## **National and International Scope and Context**

Large numbers of people globally have not and will not achieve their potential. Many countries have limited financial resources to provide educational services and products. International aid agencies are increasingly stressing the importance of education and training in developing countries and this will generate new opportunities for Alberta's private and public sector organizations. Overseas opportunities supported by the Canadian International Development Agency (CIDA) and the World Bank assist Alberta public and private institutions in becoming involved in international development and technical cooperation. In 1990 and 1991, CIDA disbursed \$375 million on education and training. It is estimated that the World Bank has cumulative lending commitments of \$6 billion for education training.

Alberta's education and training services are highly regarded internationally. Programs developed by the Alberta Tourism Educational Council are receiving worldwide recognition and awards, and many of Alberta's post-secondary institutions already are actively engaged overseas. Alberta benefits greatly from Canada's image in the global marketplace as a provider of reliable quality products and services. There is increasing competition for educational products worldwide, especially from the United States, the United Kingdom, and Australia.

## **Current Socio-Economic Impact.**

Education is correlated with all aspects of human endeavour. Research performed at Alberta universities adds to the knowledge on which social, economic and scientific/technical progress is made. The performance of basic research is critical to the training of highly qualified manpower. As demand for educational software/courseware and multimedia products increases, there will be opportunities for growth in specialized support services. The export of education and training services and products provides another source of funds at a time when government budget allocations for education are declining. Value is added to the export of Alberta products by including education and training support services. The export of education and training products creates international goodwill and often opens the door for broader and longer-term trading relationships.

## **Attractiveness**

Education changes to meet the changing needs of society and the individual. Research in education and training will improve student learning at an affordable cost, ensure that all students have access to a high quality core program, and create a system where decisions are made in local schools with the involvement of parents and the community. Key elements include providing high quality learning opportunities, and developing and implementing measures to assess, report on and improve educational performance. Research efforts will facilitate the effective and efficient delivery of quality educational programs to all Alberta students, thus contributing to the development of a skilled and capable workforce, and subsequently, a strong provincial economy. Programs to align educational programs with job opportunities are attractive given the current climate where jobs are scarce even for well qualified graduates. The introduction and use of computers is changing the way in which disadvantaged students learn, and advances in this field can provide opportunities for them to lead productive lives. Life long learning enriches the lives of all Albertans. Basic behavioral and sociological research on how to train people to work effectively with each other, and studies of teamwork, co-operation and conflict resolution, can increase corporate and government productivity and reduce stress related health problems and poor work performance.

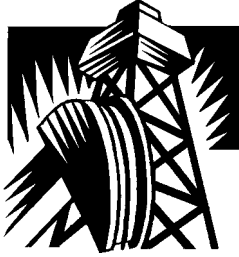
## **Feasibility**

Alberta has nationally recognized institutions of learning and the current capacity for R&D is considerable in many fields. Education has traditionally been directed at resident populations; however, knowledge about the learning process is changing. It is becoming apparent that computer generated multi-media will revolutionize instruction. More students at every level are using computers and the potential for developing specialized and improved learning tools for the use of our students and for export is great. Changes in knowledge are occurring rapidly and it is becoming more difficult to prepare students for the future and to retrain the workforce.

## 7. Energy Production

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### Description of the Area and Key Supporting Disciplines



This research application area is defined primarily to encompass processes required for the production of energy. The equipment required by the various processes is covered under Energy Products. Therefore the area includes resource evaluation and mapping, in situ oil sands reservoir process development, oil sands mining and extraction, heavy oil recovery process development and operations, conventional oil exploration and recovery, enhanced oil recovery, natural gas recovery, coal mining, hydrogen and renewable energy processes, and transportation. Electricity production from thermal and hydro power plants, and processes to produce bio-fuels are part of this area. Work on greenhouse gases in recovery operations is also included. Chemistry and chemical engineering, geology and petrophysics, mechanical engineering, electrical engineering and materials science are a few of the key supporting disciplines.

### Current Alberta Infrastructure

The Alberta infrastructure for research in energy production includes the universities, Alberta Sulfur Research Ltd., the Alberta Research Council, the Centre For Engineering Research, the Canadian Centre for Mineral and Energy Technology (CANMET) Western Research Centre, the Petroleum Recovery Institute, the Computer Modelling Group, the Canadian Energy Research Institute, and the Alberta Environmental Research Centre. Major company research laboratories are operated by Shell Canada, Imperial Oil, Syncrude, D. B. Robinson and Associates, Hycal Energy Research, Novacor Research and Technology, Nowsco and other service companies. There are several research alliances. The Alberta Department of Energy (ADOE), the Alberta Research Council (ARC), CANMET and 12 industries participate in the AACI Research Program for the development of in situ oil sands production technologies. This program is industry led and is one of four technology nodes of the Canadian Oil Sands Network for R&D (CONRAD). Other alliances are the National Centre for Upgrading Technology and the Petroleum Technology Alliance of Canada.

A large number of companies recover natural gas for domestic use or for power generation. There are a number of coal mining companies operating in Alberta. There are 2 investor owned (TransAlta Utilities Corp. and Alberta Power) and 2 municipality owned (Edmonton Power and the City of Medicine Hat) electricity generating utilities in Alberta. Their transmission systems form the Alberta Interconnected System (AIS). The total installed generating capacity is 7,687 megawatts (Mw) from coal-fired (5,704 Mw), natural gas fired (1,153 Mw) and hydro (795 Mw) power plants. The Small Power Research and Development Program licenses wind and small hydro (35 Mw) generating projects. In addition there is industrial on-site generation capacity of 753 Mw. AIS is interconnected to Saskatchewan and British Columbia Power.

## **Current Alberta Research Activities**

The energy research programs funded by Alberta Energy, and led by the Energy Research Council, cover a range of activities in heavy and conventional oil, bitumen, natural gas, hydrogen, coal and non-conventional resources. The in situ oil sands programs involve reservoir process development, artificial lift and other operations refinements. Oil sands programs include mining, extraction and transportation aimed at making it possible to develop ore bodies remote from the main plant site as well as programs designed to meet air quality regulations and disposal of extraction plant tailings. Heavy oil studies are focusing on reservoirs where steam cannot be used. The conventional oil research program is directed at advanced finding methods, horizontal well drilling and completions, formation damage control and fluid handling technology. Research into the development of new drilling and production techniques is stimulating the design of more productive oilfield equipment. Further refinements in three-dimensional survey equipment, measurement-while-drilling (MWD) instruments, and horizontal drilling machinery are raising drilling capacity. Companies are doing research into the use of coiled tubing for well servicing and drilling operations. Technology which prevents the sanding of wells that was developed in the AACI Program is in a field demonstration phase. Processes in enhanced oil recovery that warrant development are reservoir conformance improvement with gel foam, mobility control for foam, carbon dioxide processes, and hydrocarbon miscible process enhancements. Research into partial upgrading, emulsions and the addition of diluents and carbon dioxide for pipelining bitumen is being undertaken to improve the transportation and marketing of bitumen.

Natural gas production research includes water abatement studies, gas and gas product recovery by carbon dioxide and nitrogen injection, enhanced recovery from low pressure, low permeable reservoirs, carbon dioxide emissions re-use, and coal bed methane potential.

The Alberta Coal Research Program is designed to enhance domestic and international markets for coal, to reduce emissions of gases, liquids, solids and trace elements from coal use, and to find new uses for Alberta coals. Studies in improved mine site reclamation, fly and bottom ash and carbon dioxide utilization are carried out to reduce the environmental impact from the production and use of coal. Areas of interest are improved coal and coke quality, super cokes, coal analysis at the mine face, and coal preparation plants. The Alberta Hydrogen Program promotes research and technology development aimed at more efficient methods of generation, transportation and use, and developing technologies to increase the hydrogen/carbon ratio of Alberta's fossil fuels to meet environmental requirements. New commercial uses for hydrogen are studied also. The development of a thermal hydrogen sulfide dissociation technology has reached the small scale field demonstration stage. Waste hydrogen from a plant in Edmonton is being transported 25 km to a hydrometallurgical plant in Fort Saskatchewan in a pilot pipeline.

Wind generation of electricity for on-site use or connection to the grid, small hydroelectric projects at irrigation and flood control dams, solar photovoltaic generation for remote locations requiring small amounts of power, and ethanol from cereal grains are examples of renewable energy projects.

## **National and International Context and Scope**

In Canada, provincial governments have ownership and regulatory management responsibilities including resource development policy. In Alberta, the Department of Energy leases mineral rights to the private sector and collects an owner's share of resource production in the form of a royalty. The government relies on market forces to determine the timing and nature of resource development and marketing. This is reinforced by international trading commitments through the General Agreement on Tariffs and Trades and the North American Free Trade Agreement.

Alberta's oil sands deposit is one of the largest in the world which rivals the Middle East in available hydrocarbon. Alberta is recognized as the world leader in commercial oil sands production and associated technology development. To further develop their own oil sands, several countries have cooperation agreements with the Alberta Oil Sands Technology and Research Authority and the Alberta Research Council. Alberta's expertise in this field is evidenced by the recent relocation of the United Nations' Institute for Training and Research Center for Heavy Crude and Tar Sands from New York to Edmonton. Alberta's extensive oil sands resources are supporting Canada's energy needs, currently providing 21% of Canada's needs. Enhanced oil recovery from Alberta's reservoirs supplies an additional 10%. Alberta's oil sands development is lead by multinational companies. The producers of Alberta's low sulfur, high reactivity coals have earned a reputation for delivery of consistently high quality coal. Alberta supplies about 12% of the natural gas consumed in the United States. Sulfur, a product from the purification of natural gas is widely exported for production of fertilizers and use in the chemical industry. Air quality concerns associated with energy consumption are being addressed through the Clean Air Strategy.

## **Current Socio-Economic Impact**

Alberta's energy industries are the largest contributors to the provincial economy with annual expenditures of more than \$20 billion. Oil, gas and petrochemicals represent 62% of Alberta's exports, amounting to some \$14 billion annually. In 1993, petroleum production, refining, pipelining and distribution, and sales provided direct employment of approximately 22,000 and indirect employment of 20,000. Coal exports are \$500 million annually. The coal industry currently employs 2,500 directly and 5,000 indirectly in Alberta.

## **Attractiveness**

A continuing technology development effort directed at new seismic and sub-surface survey techniques, improved in-place oil recovery, and new ways of recovering bitumen from Alberta's oil sands deposit will ensure cost competitiveness and result in a sustainable wealth-generation capability of the industry for many decades. Commercially oriented R&D by the private sector is integrated with government involvement in more basic pre-competitive research, thus ensuring that technology is available when needed and that it is utilized within a reasonable time. Technology development will give industry the ability to supply Alberta with cost competitive energy and hydrocarbons for domestic use and for export. Newer technologies related to hydrogen fuel cells, laser fusion and possibly geothermal energy have attractive long term research potential.

## **Feasibility**

The transfer of technology in this area has been demonstrated with success for many years. Given the presence of well trained engineers, and an excellent, proven research base, new exploration, production and upgrading technologies for fossil fuels will be rapidly exploited by the industry. Environmental matters remain an issue.

### Description of the Area and Key Supporting Disciplines



Broadly speaking energy products include equipment and services for exploration, production, transportation, distribution, storage, refining and processing of Alberta's fossil fuel resources and value added products derived from additional processing. Products include prospecting equipment, geophysical data processing and interpretations, drilling rigs and tools, wellhead equipment, turbines, gathering and transmission systems, and batteries. Other products are ethane, propane and butane, which are used as petrochemical feedstocks, and sulfur which is used in the chemical industry in products ranging from pharmaceuticals to fertilizers. Fertilizers are produced also using ethane-based ethylene, methanol and ammonia. Steel production utilizes Alberta's metallurgical coal, and new steel technologies are opening up markets for semi-soft coking coals. Electrical power is produced from Alberta's thermal coals. Industrial inorganic chemical production includes carbon black, activated carbon, chlorine, sodium chlorate, caustic soda, hydrogen peroxide, hydrogen sulfide, hydrochloric acid, carbon dioxide and sulfuric acid. Organic chemicals manufactured include monomers and polymers, paints and varnishes, soaps and cleaning compounds, rust inhibitors, catalysts and other specialty chemicals. Refined petroleum products include transportation fuels, heating oils, asphalt, petrochemical feedstocks, kerosene and lubricants. Chemists, chemical, manufacturing and mechanical engineers, and materials science specialists are key to the support of this area.

### Current Alberta Infrastructure and Funding

The National Centre for Upgrading Technology (NCUT) has Alberta Energy, the Canadian Centre for Mineral and Energy Technology, and the Alberta Research Council as members. The research program focuses on the development of technology aimed at reducing the costs of upgrading heavy oil. Participants include in situ oil sands operators and research institutions such as the Centre For Engineering Research (C-FER), the Universities of Alberta and Calgary and consulting companies. The manufacturers of oil and gas field equipment in Alberta produce a wide variety of machinery and components used in oil and gas field exploration, drilling and servicing wells, producing and processing oil and gas in the field, sour gas processing, pipeline transmission and distribution. Products include geophysical prospecting equipment, drilling rigs and ancillary tools, cementing and well-fracturing units, pumping and down-hole equipment, dehydrators, separators, treaters and other field processing components.

There are 14 major petrochemical and chemical fertilizer producers in Alberta. With the exception of Novacor Chemicals, Cominco, Methanex Corporation and Sherritt Inc., the producers are typically subsidiaries of multinational corporations (Dow Chemical, ICI Canada, Union Carbide, Geon Company, Celanese Canada, etc.). The Oil and Gasoline Testing Laboratory of the Alberta Research Council provides services to the industry by ensuring that standards for various petroleum products are being met.

## **Current Alberta Research Activities**

Most of the funding for equipment research comes from the private sector. The program in bitumen and heavy oil upgrading receives some public funding and is aimed at increasing product quality to meet more stringent motor fuel specifications and converting bitumen to useable products. Fundamental studies on novel upgrading technologies are examining lower severity refining processes which can accept bitumen froth as a feedstock. Alberta Sulfur Research Ltd. undertakes studies in the handling and uses of this by-product of the sour gas industry. New uses for sulfur, in fertilizers and as a concrete or asphalt extender, are under development. Westaim is developing coatings for reactor tubes to prevent coking during processing of hydrocarbons whether in refineries or chemical plants.

## **National and International Scope and Context**

The world output for oil and gas field equipment is estimated at US \$30 billion per year. Growth in the area of gas and oil equipment will remain high with much of the business directed to suppliers of exploration and development drilling equipment, processing plants and transportation systems. Activity in North America is high, and increasing in South America, Africa, the Middle East, the Commonwealth of Independent States, the North Sea and Asia. Many of the major oil companies are expanding their budgets for foreign operations. The privatization of state-owned and controlled petroleum corporations is increasing competition for investment capital and providing an opportunity for domestic companies to export products. The worldwide market was \$30 billion for oil and gas exploration and production equipment and \$15 billion for services in 1993. Canadian suppliers have the potential to capture 5% of that market. Only 7% of the sales of Canadian refined petroleum products were to markets outside the country. The United States is the largest producer, consumer and exporter of petrochemicals. Major petrochemical markets for Canada include the United States, Western Europe, Asia and Latin America. Imports, mainly from the United States, were \$170 million. Canadian firms supply and export advanced petroleum equipment such as horizontal drilling motors, sour gas processing equipment, and cold weather technologies for the industry.

## **Current Socio-Economic Impact**

Alberta's energy industries are the largest contributors to the provincial economy with annual expenditures of more than \$20 billion and with direct and indirect employment of some 175,000. The petroleum industry provides one-quarter of total provincial revenues. About 1,850 companies in Alberta provide services to the industry. There are 150 geophysical companies, 100 drilling companies, and 66 service rig contractors. About 650 companies provide services and supplies to the industry. Approximately 200 trucking companies and over 700 supply and rental stores serve the industry. There are approximately 250 oil and gas equipment manufacturers in Alberta employing approximately 4,400. Additional employment is generated by local machine shops which manufacture component parts and assemblies under subcontract. Alberta's third largest manufacturing industry is the chemical and chemical products industry. In 1993 it directly employed 9,200 people, and accounted for \$1.6 billion in exports. The natural gas-based petrochemical industry accounts for more than 85% of the total exports. Industrial inorganic chemical production was \$301 million in 1993.

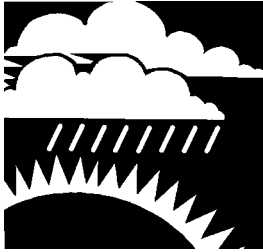
## **Attractiveness**

Energy and energy products are fundamental to the ability of any industrial society to function effectively. Alberta is a leader in the development and use of advanced technology in the resource industries. Alberta's feedstock reserves are enormous and the key is to add value. Research in energy products ensures Alberta meets the needs of the local industries, remains competitive, and supplies products for the global marketplace. New catalysts can change the economics of production. Industry is involved in the identification of research needs and priorities. Co-funding of research is desirable at all stages of the development cycle but the government can assume a larger share of the research costs for longer range projects. Assistance can be provided in organizing multi-client projects on topics of interest to broad sectors of the industry enabling smaller companies to participate at an affordable cost. The potential exists to increase the export of equipment and value-added petrochemical products. Additional supplies of sulfur will become available if large scale production of hydrogen by dissociation of hydrogen sulfide becomes feasible. Studies of new uses for sulfur will benefit the industry.

## **Feasibility**

The capacity for R&D in this area is considerable and the potential for new developments in equipment using advanced materials will decrease costs of energy production. There are also opportunities for production of new products based on petrochemical feedstocks, especially plastics and advanced composites.

### **Description of the Area and Key Supporting Disciplines**



To protect, enhance and use our environment wisely it is necessary to understand how the air, land and water resources are or may be affected by human activity. Almost all other research application areas are directly linked to the environment. Activity in many areas affects the environment and conversely, the environment affects the area. Forest sustainability depends on genetic improvement of trees, insect and disease control, wildfire management, forest growth and yield studies, soils studies and silviculture equipment development. Protection and maintenance of healthy habitats and ecosystems ensures fish and wildlife sustainability. The maintenance of a system of protected recreation areas is included. The area covers waste management, recycling, wastewater treatment, and drinking water and surface and groundwater quality assessment. Environmental health is included and research is done in industrial sectors that have the potential to impact on the environment and are subject to environmental protection criteria. Remote sensing and computer mapping using satellite, airborne and ground-based systems have a wide range of applications in many areas. Disciplines key to the area are many and range from law and life sciences, to computing sciences and chemistry.

### **Current Alberta Infrastructure and Funding**

Alberta Environmental Protection obtains R&D services internally, from the Alberta Environmental Centre, the Alberta Research Council, the universities and the private sector. The partnership between Alberta Agriculture, Food and Rural Development and Alberta Environmental Protection supports the sustainability of the agriculture and food industry. 'Sustainable Forest Development' is a Network of Centers of Excellence which focuses on preserving the ecological variability and biodiversity of forests while ensuring that Canada continues as the world's leading exporter of wood pulp, newsprint and softwood lumber. The University of Alberta manages the project cooperatively with the Universities of Calgary, British Columbia, Montreal, Laval, and Quebec and government research laboratories such as the Alberta Environmental Center, the Canadian Forest Service and the National Hydrology Research Institute. Other participants are Alberta-Pacific, Daishowa, Weyerhaeuser, Alberta Newsprint Corporation, Canadian Forest Products Ltd., Lakeland Peat Moss Ltd., Sungro, Weldwood, the Forest Engineering Research Institute of Canada, Forintek Canada Corp., the Pulp and Paper Research Institute of Canada and the Canadian Oilsands Network for Research and Development. The Environmental Appeal Board resolves appeals with respect to the Environmental Protection and Enhancement Act. The Natural Resources Conservation Board reviews non-energy projects that affect Alberta's natural resources. The Tire Recycling Management Board stewards the responsible management of scrap tire resources. The Environmental Services Association of Alberta has 360 member companies including pollution control equipment suppliers and consulting firms. The Canadian Environmental Technology Advancement Corporation with headquarters in Alberta assists companies in the application, development and commercialization of environmental technology for world markets.



## **Current Alberta Research Activities and Funding**

The Alberta Environmental Protection Program addresses sustainable management of Alberta's air, land, water, and forest resources, and ensures that environmental protection and pollution control standards have a solid scientific basis. Specific examples of research related to stewardship of Alberta's natural resources are the development of a habitat suitability index model for aspen stands, the development of an aerial spruce budworm spraying technology for Alberta's forests and climate, the development of a new system for evaluating various forest fire suppression strategies for environmental impact, and the production of improved seed for reforestation. Examples of research to assist in sustaining fish and wildlife populations and habitats include evaluation of fish mercury contamination in reservoirs, evaluation of hardwood logging practices on furbearing animals, and studies of winter-kill in gamefish. Current strategies with Alberta Agriculture include the development of sound pest management practices, research on biological control of weeds, and disease management research in cereals, oilseeds, forages and special crops. Other projects include studies of the impact and management of feedlot runoff, recirculating systems for aquaculture, research and field investigations into the hazards of petrochemicals and sour gas for livestock, an evaluation of the impacts of pesticides, trace organics and heavy metals on the environment, and the development of methods of restoring productivity to highly contaminated lands.

## **National and International Scope and Context**

The world market for environmental products and services was \$200 billion in 1992. The primary export market for Canadian environmental goods and services is the United States accounting for 80% of the \$1 billion in exports. Canada's domestic market is approximately \$11 billion. There are approximately 4,500 environmental industries and service companies employing 150,000. In Alberta, the environmental sector consists of approximately 800 companies employing about 8,000 workers and generating \$600 to \$700 million annually in revenue. Complying with rigorous but fair environmental protection requirements assists industry in marketing their products, reduces potential liabilities and can enhance borrowing capabilities and enhance competitiveness. International trade is often tied to compliance with environmental standards. There is considerable potential for market growth over the short, medium and long term.

## **Current Socio-Economic Impact**

Environmental research helps secure strong, viable and sustainable industries. By ensuring that forest harvest levels are within the annual allowable cut and that reforestation to provincial standards is done, the forest industry will continue to contribute to Canada's exports of forest products and create jobs. Viable natural ecosystems promote tourism. Adequate supplies of good water are a factor in agricultural and industrial development as well as in human health.

## **Attractiveness**

Understanding the ecosystems in Alberta and the interplay and effect of human activity with and on them are crucial to effective and sustainable management of our natural resources and our quality of life. To ensure that our resource-based economy can continue to thrive, science and research based guidelines and regulations are necessary. The economic benefits of environmental research are felt in many research application areas. Industries, particularly resource industries, agriculture, tourism, and health are prime examples of those areas affected. Research leads to management practices which minimize environmental impact yet provide increased user opportunities. For example, a direct benefit of drinking water monitoring has health protection benefits, including healthcare cost savings. There are better opportunities for enhanced hunting, fishing and recreational experiences in a well managed environment. Pollution prevention is more desirable than pollution control. Environmental programs have public credibility and sustainable development ensures a viable long-term economic base. Opportunities for research into the use or disposal of solid and liquid agricultural wastes, and the treatment and disposal of oil field waste such as drilling fluids, contaminated soil, spilled oil and chemicals are considerable. So too is research into waste reclaiming and filter manufacturing, improved valves and control systems to reduce emissions from gas plants, and noise control in areas of urban encroachment. Ecosystem research and management is an emerging field and remote sensing and geographic information systems could have application here. New understandings of the relationship between people and the physical parameters of their environment will help solve problems of indoor air quality, thermal comfort, lighting and acoustics in building design. Remote sensing technologies have rapidly growing commercial applications. Risk assessment and management research will influence public confidence and believability. Research information is likely to be applied locally although many of the findings could have application in other parts of Canada and, in particular, in countries with similar climatic conditions.

## **Feasibility**

Alberta is a recognized leader in hazardous waste management, recycling, forest fire technology and prevention, environmental effects monitoring and reclamation. R&D in these fields has benefited from cooperative ventures between government agencies such as the Alberta Environmental Centre and the Alberta Research Council and private industry. The partnerships between Alberta Environmental Protection and other government ministries to foster R&D allows the sharing of expertise and facilities. These partnerships optimize the use of resources and provide an enhanced return on R&D investments. Because concern for the environment is a relatively recent area of research, the likelihood of discovering new approaches to solve environmental problems, and conserve and protect natural habitats is quite promising. The effects of declining biodiversity, ozone depletion, greenhouse gasses, oxides of sulfur and nitrogen, and climate change are problems that will affect many activities. Increasing urbanization and aboriginal issues relating to resource management require attention.

### Description of the Area and Key Supporting Disciplines



This research application area includes forestry and agriforestry, building materials, equipment and supplies. Pulp and paper industries, producers of dimensional and specialty lumber, engineered building products and panelboard manufacturers, and related machinery, equipment, and supply and service companies are competitive, modern and environmentally advanced. Quality products, such as pulp with high brightness and lumber for home building, are in demand in North America and overseas. The industry is working to attract investment in value-added manufacturing of Alberta timber resources and the utilization of wood residues in products like particle board and medium density fiberboard. The industry is committed to improving forest management and adopting new environmental technologies to use recycled fiber and reduce effluent emissions. Transportation issues, particularly the movement of products by rail, concern the industry. Forestry sciences and chemical and mechanical engineering are some of the disciplines key to the support of the area.

### Current Alberta Infrastructure and Funding

Lands managed for forest resources cover one half or 350,000 square kilometers of Alberta. Over half this land has commercially viable forests. The pulp and paper producers are expanding capacity and moving into value-added products such as fine paper. There is a solid base of producers of value-added lumber and engineered wood products in the province. Two new oriented strand board (OSB) plants will come on line soon and the existing medium density fiberboard (MDF) mill will complete an expansion. In addition, Alberta's first laminated veneer lumber mill is expected to be fully operational this year. The industry/government Cooperative Overseas Market Development Program coordinates regulatory and market initiatives. The Wood Panel Bureau Alliance consists of the Structural Board Association, Canadian Particleboard Association, Canadian Hardwood Plywood Association, the federal government, the provinces of Alberta, Ontario and Quebec, and industry. It addresses issues related to market development of OSB, particle board, MDF and hardwood plywood. The Alberta Research Council operates a Wood Composite Laboratory, a Panel Board Pilot Plant and a Forest Products Testing Laboratory accredited by the Standards Council of Canada. The University of Alberta runs a Structural Beam Laboratory. The University of Alberta and the Northern Alberta Institute of Technology have training programs in forestry and undertake research.

## **Current Alberta Research Activities and Funding**

The Alberta Forest Research Advisory Council sets R&D priorities for several laboratories. Their members are drawn from the federal and provincial governments, the Alberta Research Council, the University of Alberta, Forest Engineering Research Institute of Canada, Forintek, the Pulp and Paper Research Institute of Canada, the Alberta Forest Products Association, and industry. The Mechanical Pulping Consortium Research Program is managed by 3 Alberta companies, the Alberta Research Council, and Alberta Economic Development. Their goal is to improve the environmental performance of current mechanical pulping industries and to develop new pulping technologies. The Pulp Mill Process Control Partnership focuses on the application of artificial intelligence systems to improve process control in the manufacture of pulp. Its members are from the University of Alberta, the Forest Industry Development Branch of Economic Development and Tourism, and industry. The Alberta Research Council's panel board pilot plant and forest products testing laboratory develops new and improved products and processes for clients. Several joint venture research projects are in progress with industry. Forintek, Canada's national wood products laboratory, carries out research nationwide. It has 163 members from industry, the federal government, the provinces and research agencies. The Alberta Forest Products Association and the Forest Industry Development Branch sit on the Board of Directors. Members have access to the results of the program. In 1993-4 \$3.5 million was spent on 41 R&D projects which created 414 jobs, \$162 million in investment, and \$76 million in added sales. A special straw pulping process, being conducted with Dupont Canada, Quantel Engineering, the Vegreville Environmental Centre and New Fibres Inc., will utilize an agriculture waste to produce a feed material for fine paper and fiber board. The industry is committed to improve forest management practices through initiatives such as the Alberta Forest Products Association's *ForestCare* program.

## **National and International Scope and Context**

Relatively strong prices are expected to continue for most products. Pulp prices have recovered and the medium-term outlook remains positive despite increasing supply. Softwood lumber markets should remain profitable. Panelboard demand is strong; however, new capacity will result in stronger competitive pricing. Strength in commodity markets will benefit the service and supply sector of forest products industry. Alberta's industries have extensive capacity and expertise for servicing Western Canada and the United States Pacific Northwest.

## **Current Socio-Economic Impact**

The forest and building products sector is the fourth largest economic sector in Alberta behind energy, agriculture and tourism. Shipments for 1996 are estimated to be \$4 billion, with exports accounting for an estimated \$2.5 billion. Estimates place direct employment in Alberta's primary and secondary forest industries at 21,500 with a similar number of indirect jobs. Almost \$4 billion in investment has occurred in the forest products sector since 1986. There are 300 primary and 700 secondary wood processing companies. Ten pulp and paper mills produce over 2 million tonnes annually from a mix of new and recycled fiber, primarily for markets in

the United States, Asia Pacific and Europe. Some 300 value-added wood and panelboard producers manufacture dimension and specialty lumber, engineered building products and panelboard worth \$1.2 billion. Almost 600 secondary wood product manufacturers and 200 non-wood building product suppliers ship goods worth an estimated \$800 million to North American markets. Related machinery, equipment, supplies and services worth \$1.5 billion annually are purchased by the industry.

### **Attractiveness**

There are opportunities to develop faster growing trees and improve seed stock using biotechnology. Research into stress physiology and survival of out-planted tree seedlings has potential economic benefit. The development of value-added new products and the application of new processes can improve the industry's performance and increase exports. This is true for the pulp and paper and related supply and services companies. Engineered wood composites and value-added products increase the utilization of Alberta's forests by developing products from under-utilized fibers. Improvement of effluent treating systems and the expanded application of zero-effluent technology for kraft mills will benefit the environment. Innovative environmental technologies will ensure that the resource is well managed without damage to the environment. Expanding export and domestic markets will create opportunities for products from timber resources and wood residues.

### **Feasibility**

Over 1000 companies are ready to implement cost saving devices, new products and processes and to adopt new technology. Alberta's universities, the Alberta Research Council and related research institutes have the expertise to address the needs of Alberta's forest industry. The overmaturity of our forests can be an impediment to future developments.

### Description of the Area and Key Supporting Disciplines



Information from research is used by industry, health service providers, health stakeholders and the public to improve the health system and develop new products. Basic and clinical research, as well as the research of allied health professionals, is contributing to the development of new medical devices, health informatics, pharmaceuticals and healthcare products. These products are used in hospitals and institutions, in homecare, in laboratories and in public and industrial safety. Health services are provided by laboratories, hospitals, community health agencies, continuing care services such as nursing homes and insurance providers. Health technologies include drugs, devices, equipment and procedures used in the maintenance, restoration and improvement of health. Environmental health is a developing area. Some of the disciplines key to the support of this area are medicine, pharmacy, biochemistry, biotechnology and psychology.

### Current Alberta Infrastructure

The Alberta Heritage Foundation for Medical Research (AHFMR) was established in 1980 with an initial investment of \$300 million and in 1995 was worth \$681 million. It contributes about \$30 million annually to the research efforts of more than 150 scientists in Alberta. Foundation funds have helped train hundreds of students and provide equipment for nearly 300 laboratories in the Universities of Alberta and Calgary. AHFMR is also under contract to Alberta Health to manage the Health Services Research and Innovation Fund, which provides \$800,000 in research grants annually to examine the development, delivery, organization and management of health services. It also manages the Alberta Mental Health Research Fund which has an annual budget of \$600,000 and the Health Technology Assessment Unit. Cancer research has funding of \$2.8 million annually and with the Alberta Cancer Board strengthens cancer research funding through partnerships with industry.

In Edmonton there is a network of a half-dozen health care research facilities, including the Cross Cancer Institute and the Walter C. Mackenzie Health Sciences Centre. The University of Alberta has an international reputation for medical science, biochemistry and immunology research and new strengths in lipids and lipoproteins, cancer and neuroscience. The biomedical research program has funding of \$48 million including approximately \$10 million from industry. In Calgary the University of Calgary's Faculty of Medicine works closely with the Foothills Hospital and the Tom Baker Cancer Centre. Training is also carried out by the Northern and Southern Institutes of Technology, Mount Royal College and Grant MacEwan College.

Alberta has about 40 manufacturing companies producing medical electronics, analytical and diagnostic products, disabled and rehabilitation equipment and services, health informatics, health waste management and chemicals. These firms of 5 to 15 employees generate an estimated \$35 million in annual sales of which 80% are exports. Total employment is 250. There are numerous medical assay and radiology laboratories. There are approximately 30 health care services companies and associations. Healthcare Opportunities Metro Edmonton and the Calgary Association for Medical Products are two examples.

## **Current Alberta Research Activities and Funding**

Research activities range from biomedical to prevention and cure of diseases, and effectiveness of health services. Some examples include, the management of pain in patients with particular emphasis on children, information about Alberta youth and substance abuse and family, demographic and peer pressure factors, the development of a "high-resolution digital teleradiology" system to transmit medical images from isolated centers to specialists in urban centers, a device to diagnose sleep disorders, a system to link family physicians throughout Alberta, a program on the law and ethics of the new genetics in medicine, a community health research program on local needs and services to help Regional Health Authorities, and a pilot project to provide educational support and support services to families of brain-injured individuals using teleconferencing technology. University of Alberta has research groups in Protein Engineering, Bacterial Diseases and Neuroscience in the Network of Centres of Excellence Program. The University's Alberta Diabetes Group, world leaders in transplanting insulin-producing islet cells, was named one of six North American Centres of Excellence by the Juvenile Diabetes Foundation International. The Alberta Cancer Board identifies new initiatives in the development of an Alberta Gene Therapy Infrastructure Program, a Provincial Cancer Clinical Trials Network, and the establishment of a \$60 million Cancer Research Endowment to expand and strengthen the existing core cancer research program.

## **National and International Context and Scope**

In 1994 the world market for medical products was US \$86 billion with the United States dominating nearly every field. The industry in Europe specializes in narrowly defined niche markets and Japan appears to be concentrating on products for the elderly.

Canada is one of the world's leading consumers of medical products importing over 80% of the products it uses. In 1991, the Canadian market was valued at \$2.6 billion, imports accounting for \$1.6 billion of this total. The medical/healthcare industry in Canada consists of 800 companies producing 1,500 categories of products. One hundred of these firms are affiliates of foreign-owned multinationals. Health and medical research tends to be national and international in nature.

## **Current Socio-Economic Impact**

Good mental and physical health is necessary for a productive and positive society. Poor health has negative economic implications. For every dollar the Alberta Heritage Foundation for Medical Research invests, at least three or four dollars in external funds from public and industry sources are attracted to Alberta. Currently, some 142 AHFMR supported researchers are working in universities, hospitals and affiliated institutions of the community and 229 students and postdoctoral fellows are in training. The Foundation contributions go towards funding for salaries, training and equipment. Companies producing medical products are export oriented with sales less than \$1 million and fewer than 20 employees. Health research is an extremely important activity given the current restructuring of the health system. Results of this research may lead us to manage the health system differently. The primary goal is the improvement of the development and delivery of health services. Commercialization and product development also are expected as a result of the government's investment in health research. Improvements in the social, economic and environmental sectors also will contribute to maintaining good health. Diseases such as AIDS reduce the workforce and make it more difficult to support an aging population.

## **Attractiveness**

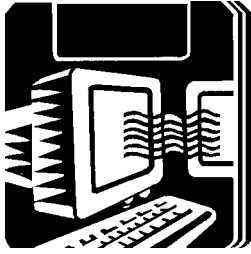
Research to support informed decision making, through monitoring and assessing the performance of the health system and health outcomes province wide, will continue to safeguard the health of the public. Research in health informatics dealing with issues of access, confidentiality, efficiency and efficacy will develop a system to manage specific chronic and acute illnesses and help provide early identification of commercial opportunities for Alberta companies. The Alberta Heritage Foundation for Medical Research supports a community of researchers who generate knowledge that improves the health and quality of life of Albertans and people throughout the world. New healthcare products, new tools and patentable techniques are emerging from the laboratories of AHFMR supported scientists. Research in aging related disorders will have increasing application. There are opportunities for the medical products industry because under current trade agreements, Alberta has emerged as an appealing gateway to the large North American healthcare market. Research on health, lifestyle, and nutrition will benefit the medical area directly and most other areas indirectly.

## **Feasibility**

The likelihood of new discoveries in the health and medical area is considerable because of, for example, developments in biotechnology and new knowledge in how genes function. Highly skilled health scientists, researchers and technical personnel, and a well developed research, science and technology infrastructure exist in Alberta. The current R&D capacity is unusual for a province with a small population and is acclaimed as one of the top medical research centres in North America.



### **Description of the Area and Key Supporting Disciplines**



Information and communication are essential to business and society. Information services include interactive services, software development, hardware and electronics, and information processing and storage. Communication services include networks, phone systems and information dissemination. The electronics and telecommunications industry manufactures electronic parts and components, instrumentation and control devices for measuring, sensing and recording. Electronic design and subassembly services range from printed circuit board layout to prototype development. Computers and peripheral equipment manufacturers produce mainframes, minis, workstations, personal computers and terminals, printers, plotters, mice and various types of scanners, and data or image storage devices. Application specific processor boards and data communication boards are also part of this area. Telecommunications, cable, wireless and satellite equipment companies manufacture products for transmission, switching, and distribution of voice, data and video information over private and public networks. Telephone, paging, telegraph, broadcasting and television companies provide telecommunication services. Reproduction equipment, visual aid equipment and multimedia are part of this area. Software products have applications in almost all areas of industry, business, healthcare, education and communication. Electrical engineering and computing sciences are just two of the disciplines which support this area.

### **Current Alberta Infrastructure and Funding**

Alberta's Learning Network, designed to deliver multimedia programs via cable, television, satellite, telephone, and wireless service providers is being established to assist in the education and training needs in schools, post-secondary institutions, libraries, media centres, and museums. Advanced technology institutes in Alberta are involved in transferring technology to industry. The Alberta Microelectronics Centre (AMC) offers a broad range of services including consulting and feasibility studies, microelectronics prototype development, technology assessment, application specific integrated circuit design fabrication, and solid state microsensor R&D and prototyping. TRLabs is a not for profit research consortium of over 12 industries, 5 universities, the federal government and the governments of Alberta, Saskatchewan and Manitoba. Through a network of laboratories, research in telecommunications focuses on networks and systems, network access, photonics, and wireless technologies. Future convergence of telephone and cable companies will provide additional opportunities for both industries.

The Universities of Alberta and Calgary Computing Sciences and Computer Engineering Departments undertake research and training in the area. The Alberta Research Council has an active Advanced Computing and Engineering Department and a Joint Research Venture Program which provides funds for transferring technology to industry. AGT and Ed Tel deliver telecommunications services as do radio and television companies throughout the province. Cable television services are available to over 90% of the province. The Electronic Test Centre provides testing and certification services to the industry.

## **Current Alberta Research Activities and Funding**

Research in this area is directed to the development of electronic hardware, software, and telecommunications. Much of the basic and precompetitive research and development is funded by the federal government and industry through PRECARN, the National Sciences and Engineering Research Council (NSERC), the Canada/Alberta Partnership Agreement, and the Networks of Centres of Excellence. More applied research is funded through joint industry-government partnership such as the TRILabs consortium, the Alberta Microelectronic Centre or Alberta Research Council joint ventures. The Canadian Network for the Advancement of Research, Industry and Education (CANARIE) is key to the development of the information highway. Its goal is to connect researchers and educational communities across Canada with a high-speed broad band highway and upgraded gateways to the Internet and other international networks. Several Alberta companies will benefit from investment for Phase II research activities estimated to be over \$400 million.

The Western University Research Consortium on High Performance Computing and Networking (WURCNet/Wnet) is a consortium of companies and institutions dependent on access to high performance networks. Its goals are to connect western universities with high speed networks, to develop network applications, to promote collaboration between producers and consumers of networking and computing and to include projects in healthcare, seismic telecommunications, theater visualization and distance education. Key Alberta parties include HPC Inc., AGT, Ed Tel, and the Universities of Alberta and Calgary.

Alberta Economic Development is contributing \$2.7 million to research activities through support for TRILabs, AMC and the Alberta nodes in the Network of Centres of Excellence. Indirect support to research is provided through operating grants to Universities, a portion of which can be allocated to R&D.

## **National and International Context and Scope**

The international information technology industry is composed of the US \$300 billion computer sector and the US \$144 billion telecommunications sector. The semiconductor industry has \$90 billion in annual sales, the magnetic storage market exceeds \$55 billion and the computer hardware industry passes \$148 billion in sales annually. North America accounts for 47% of the world information technology market followed by Europe at 32% and Asia Pacific at 18%. Competition in the software/computing services industry is intense and the market volatile. The technology is rapidly changing, even 'leap frogging' into new generations of products. The incredible growth of the Internet allows for the near-instantaneous dissemination of information on a global basis is rendering location inconsequential and is reshaping the manner in which business is conducted. Software/computing services companies are export oriented. The largest export market for Alberta industries is the rest of Canada (64%). The largest international market is the United States (24%) followed by Europe (5%) and Asia (1%).

## **Current Socio-Economic Impact**

The economy in information and communications has undergone a significant transformation because of the opening of flexible and decentralized global and regional markets, lower transportation, communications and data processing costs, and the emergence of information and information management as an important strategic and economic resource. The transmission of information is crucial to economic growth. The electronics and telecommunications industry in Alberta has approximately 220 companies engaged in electronic design and manufacturing. In 1993, some 7,460 people were employed in manufacturing electronic and telecommunications products. The value of industry shipments was \$1.46 billion, with 88% of the products being exported outside Alberta. Small firms having sales of less than \$1 million and employing fewer than 10 people characterize the industry. There are 39 telecommunications manufacturing companies employing over 3,700 with sales revenues of \$3.7 billion of which 80% is exported. There are 8 telecommunications service providers employing over 10,000 Albertans with annual revenues of \$1.5 billion. Northern Telecom, Novatel Communications Ltd., JRC Canada Inc., and Computing Devices Corporation are global players operating in Alberta. AGT Ltd. and Ed Tel had combined annual revenues of \$1.57 billion and employed almost 10,000 people in 1993. Based on a 1991 survey, about 1300 Alberta software/computing service companies employ over 14,000 people and have total revenues of the order of \$600 million.

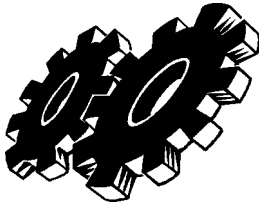
## **Attractiveness**

Research in wireless communications can result in delivery of services to remote sites and products with export potential. The number of content and knowledge based industries in Alberta is increasing. New products and services increase the competitiveness of Alberta companies and produce export markets. Each product or service has its own specific benefit and ability to capture a market. For example the Alberta Research Council's Health Informatics System will coordinate healthcare information with a group of high usage healthcare consumers and provide early identification of commercial opportunities. Alberta has an attractive climate for telecommunications R&D through its combination of highly educated graduates, connections with the universities, existing R&D infrastructure and manufacturing facilities in the province. Nanotechnologies have future applications for silicon machined components and have the potential to revolutionize products in other areas. This is a clean industry which can employ many people. In addition, our geographic isolation is not a great handicap.

## **Feasibility**

Government researchers in information technologies work with companies and service providers to develop new products and services. Alberta Research Council employees, for example, work with end-user companies to apply advanced information science to business processes. Areas of current focus are advanced media and learning technologies, health informatics, communications and network applications, pattern analysis and machine intelligence, process automation and robotics, integrated manufacturing and computer network applications developments that will assist Alberta companies. The combination of government, industry and academia is very effective in the area of telecommunications. The potential and capacity of R&D in Alberta was a factor in Novatel's decision to site its world-wide mandate wireless system manufacturing system in Calgary together with its Wireless Centre of Excellence. The ready access to the world's information sources makes it feasible to undertake projects that previously would have been too time consuming and too expensive. Ethical concerns and concerns regarding privacy and theft could delay some developments.

### **Description of the Area and Key Supporting Disciplines**



Manufacturing is the process of converting raw materials into finished goods and includes the design, marketing, servicing and recycling of the products. It provides the tools to produce products from other research application areas. The manufacturing industries produce food and beverages, rubber and plastic products, leather goods, textiles and clothing, furniture and fixtures, and paper and allied products.

They do printing and publishing, recover primary metals, do metal fabrication, produce machinery and transportation equipment, and electrical and electronic products. Minerals and petroleum, refined petroleum and coal products, and chemicals and chemical products are produced by the industry. The use of advanced materials such as specialty metals, ceramics, olefin polymers, and composites in the manufacturing process offers new possibilities that stem from characteristics that enhance strength, withstand greater heat and provide greater flexibility than conventional materials. Material substitution and leading-edge processes such as thixomolding and pultrusion are changing the properties and performance of many products. Information and systems integration, such as robotics and machine vision, and supporting software are changing operations and materials handling methods. Disciplines that support this area include chemistry, chemical and mechanical engineering, and computing and cognitive sciences.

### **Current Alberta Infrastructure and Funding**

The manufacturing industries in Alberta are predominantly small to medium sized enterprises. The Alberta Research Council's Manufacturing Technologies and Advanced Computing Departments have the capability to provide rapid prototyping, engineering services and intelligent manufacturing systems. Council's Forest Products Laboratory is accredited by the Standards Council of Canada. The Laser Institute provides a wide range of laser technology services to industry. The development of automated inspection systems, the development, use and application of laser sensors and materials processing are examples of such services. The Westaim Agreement which brings together the Alberta and federal governments and Sherritt Inc. for R&D and commercialization of advanced materials technologies and processes has laboratory and pilot plant capability which are being used to develop a number of promising new products and processes. The Centre For Engineering Research has facilities to investigate the effects of cold climates on a variety of products, particularly those used by the oil and gas exploration industry.

The Industrial Polymer Centre fosters the growth of the polymer industry. Training institutions ensure a highly skilled work force. For example, the Northern Alberta Institute of Technology offers a Plastics Engineering Technology program and the University of Calgary has a Manufacturing Engineering Division, a Nortel Chair in Intelligent Manufacturing and the Hewlett-Packard Intelligent Manufacturing Laboratory. The Universities of Alberta and Calgary have industrial design groups.

## **Current Alberta Research Activities and Funding**

Research in this area focuses on the development and substitution of new materials, the development of new equipment and its integration with computer technologies, and new product design. Research done by Westaim will receive \$7.5 million in 1996/97. Research projects underway include antimicrobial coatings for biomedical applications, electroluminescent flat panel displays, aluminum nitride substrates for electronics, silicon nitride ceramic cutting tools, coking-resistant coatings and nickel- and cobalt-based battery materials. Some examples of projects carried out at the Alberta Research Council include production of thixomolded magnesium parts, monolithic ceramics, and geomembranes, use of plasma spray and thermal spray coating technologies, production of elastomers and new rubbers, bronzing of metal parts, application of cermets (metal/ceramic composites), composite weld overlays and advanced joining technologies. The University of Calgary's Human Performance Laboratory is carrying out research for several manufacturing industries. Research on loads on the lower extremities, especially the feet, has led to the better design of shoes.

## **National and International Scope and Context**

The world market for advanced materials is expected to be \$100 billion by the year 2000. The United States and Japan are the world leaders, with strong participation from Europe. The Intelligent Manufacturing System (IMS) is a multinational cooperative R&D program focused on the next generations of advanced manufacturing technologies. This industry-led program involving industry, academia, research institutes and government will give Canadian participants a window on world developments in advanced manufacturing and a chance to entrench the leadership they already enjoy in particular areas. The world wide demand for different components of integrated manufacturing systems (industrial robots, sensors, programmable logic controllers and CAD/CAM systems) was estimated at \$66 billion in 1994. Because Alberta's manufacturing population consists of a large number of smaller companies that design and market their own products, industrial cooperation, strategic alliances with companies, universities, research institutes, and governments at home and useful linkages with industry researchers abroad is necessary for products to meet international standards and gain international market access. There is a shift of global manufacturing bases from developed to developing countries.

## **Current Socio-Economic Impact**

In 1994 the value of manufactured shipments was \$25 billion, an increase of nearly 20% from 1993. Manufacturing has remained at between 8.5% and 10% of a consistently growing GDP for the past five years. There were 103,900 employees in manufacturing in Alberta in 1994 just over 10% of the work force. Manufacturing accounted for \$7.7 billion or about 30% of Alberta's exports in 1994. Manufacturing exports were forecast to grow by an additional 8% in 1995. The industry is dominated by companies that process the province's natural resources, however, some diversification into areas downstream from raw materials is occurring. The Alberta plastics and advanced materials and processing industry is growing because of the indigenous petrochemical industry. Over 300 companies are operating in the province.

## **Attractiveness**

Marketing and marketing research is important for the conduct of any consumer business and better market assessment would assist in identifying winners and losers in the global economy. Alberta's manufacturing industry is gradually building on strengths developed in recent years. Improved processes and new products will improve the competitiveness of the industry by not only increasing exports but also providing import replacement. There is major growth potential in high tech products. New developments in advanced metals and alloys, advanced ceramics, advanced polymers and advanced composites are changing the products that are being manufactured by making them more resistant to wear and corrosion, and less expensive to produce and to use. The introduction of robotics and intelligent manufacturing systems into the industry is already resulting in more efficient factories and economical order quantities of one are being achieved. New CAD/CAM technologies offer opportunities to enhance the rapid development and manufacture of new products. The changes brought about by telecommunication technologies allow sourcing and supply to be done on a global scale. More electronics are being incorporated into many products and there is potential for manufacturing specialized products which will have large world-wide markets. Short product life cycles can provide opportunities for many industries. Alberta has a world-class federally-funded defence research laboratory with extensive international contacts. Research and development in niche defence products and services can provide opportunities for the manufacturing industry. Risk assessment tools for decision support will help companies make good spending decisions.

## **Feasibility**

Basic research at the universities provides considerable support for applied research. The expertise that exists at the Centre For Engineering Research, the Alberta Research Council and at Westaim can be further built on to introduce advanced materials technologies to this industry. The Alberta Microelectronics Centre and the Advanced Computing and Engineering Department at the Alberta Research Council can provide new approaches to automation and control during manufacturing. The Laser Institute has the capability of developing new computer controlled approaches to manufacturing processes involving cutting and shaping. Although there have been significant government investments in support infrastructure for Alberta's manufacturers, the elements are fragmented and not readily accessible to business. To raise the level of competitiveness of Alberta's manufacturers and create awareness of new technology and its benefits, exposure to state of the art facilities and equipment, and increase in the use of appropriate advanced technologies, an Advanced Manufacturing Institute is needed. A further missing component in Alberta that would assist manufacturing industries is an Institute for Machinery Research and Development. Many large industries and government departments are downsizing and, given financial support and tax incentives, those let go have opportunities to establish small to medium manufacturing companies with the potential to diversify the economy and create more jobs. Atom by atom buildup of materials and micro/nano machining are feasible future directions for this industry.

### Description of the Area and Key Supporting Disciplines



A small amount of a variety of precious metals, base metals, rare earths, metallic minerals, and industrial minerals are produced in Alberta. There is potential for the development of uranium deposits. There is also potential for the extraction of calcium, magnesium and potassium from formation waters and recovery of metallic minerals from by-products of the oil sands industry. Other non-energy minerals are surface mined, such as salt, limestone and dolomite, clays, sand and gravel, for use by Alberta's industries. The construction, chemical and paper industries in particular rely heavily on the availability and accessibility of certain industrial minerals in the province. Other industries rely on the development of innovative technologies to improve existing operations. Research will encourage new and diversified mineral-based enterprises. Disciplines such as geology and earth sciences, mining, civil and mechanical engineering are key disciplines supporting the area.

### Current Alberta Infrastructure and Funding

The University of Alberta, the University of Calgary, the Alberta Geological Survey and the Geological Survey of Canada are all active in the province. The industrial and metallic mineral resources of the province are partially mapped and evaluated. The availability of such minerals along with low-cost energy can form the basis of new industrial activities in Alberta. The Alberta industry mostly produces lower value industrial minerals. Sherritt however is an exception and produces nickel and cobalt from imported concentrates. Alberta has a large number of highly trained engineers, geologists and geophysicists with the potential to focus on mineral exploration and development.

### Current Alberta Research Activities and Funding

The geological research done in this area is dwarfed by that done in the energy area. However, the universities do develop new geological theories and models, undertake studies into new mineral exploration technologies, new production/extraction technologies, and new upgrading, refining, or value-added technologies. Producers of metallic and industrial minerals do limited research. Sherritt again is an exception and has active research programs in mineral processing. Solvex undertakes research into the extraction of minerals from oil sands tailings and is presently building a plant in Alberta. Alberta's cement, and brick and tile companies do some research to improve their products.

### National and International Scope and Context

The internationally traded minerals and metals are dominated by international companies. These metals and higher value commodity minerals compete on the basis of delivery and reliability of supply. Specifications are standardized and the primary basis of competition is price. Lower value industrial minerals and mineral

products such as sand and gravel, limestone, cement and cement products are produced near consuming centers and not traded internationally to any great extent. For these commodities, transportation is a significant component of delivered cost and local suppliers are relatively insulated from international competition. Alberta is a very small player in exported minerals, but in common with other provinces has a major activity in locally used industrial minerals.

### **Current Socio-Economic Impact**

Total non-fuel exploration expenditures in Alberta in 1992 were less than 1% of the Canadian total. Total industry shipments in 1991 were just over \$750 million. Of this, over \$700 million consisted of industrial minerals and mineral products, of which only 5% were exports; less than \$50 million consisted of metals, most of which were exports. Canada's total production of metallic minerals and metals was nearly \$10.5 billion. Despite these figures, Alberta probably has the potential to have a larger metallic minerals industry. Prospectors have been staking claims in many parts of the province.

### **Attractiveness**

Economic benefits to Alberta from this application area can result from the increased production and export of minerals and value-added mineral products, the development and export of new mineral exploration technologies or services, new mineral production technologies, and new mineral upgrading/refining technologies. However, geological and resource evaluation studies are necessary to determine the mineral potential of the province and attract exploration and development. Without such information there is little incentive for the minerals industry to increase its efforts in the province. A regional mapping program for mineral potential, quaternary geology studies and drift prospecting, geophysical and geochemical exploration, and commodity profiling will enhance the Mineral Information System. Selected technical investigations may be warranted to improve the efficiency of current extraction operations and develop technologies for specific applications. One such application is the recovery of titanium and zirconium and alumina from oil sands tailings. Research in processing technology to improve ways of upgrading indigenous resources, if successful, would result in the replacement of costly imported materials by those from Alberta. Phosphate and glass-grade silica are examples of minerals that are imported because local supplies require upgrading or more efficient extraction.

### **Feasibility**

The metallic minerals and metals sector offers great opportunity to contribute to economic growth. Lack of operating mines means only that economic deposits have not been found, not that they don't exist. The likelihood of new resource discoveries is high, given the current state of knowledge. We have the advantage of having good geology schools and a well qualified and well staffed geological survey. Emphasis however is on the oil, gas and coal resources and the geology of the sedimentary basin. Technologies for the exploration, production and upgrading of some metals are mature. For others, research, for example using biotechnology extraction techniques, could mean the establishment of a new industry. Environmental impacts of mining and the reclamation of mine sites are a concern.



### **Description of the Area and Key Supporting Disciplines**



The activities of people traveling to, and staying in places outside their usual environment for less than a year for leisure, business and other purposes is defined as tourism. Broadly speaking there is ecotourism, cultural tourism, adventure tourism and rural tourism. The parks and recreational facilities, hotels, restaurants, transportation and hospitality arrangements, museums and historical resources, galleries, and concert halls, and festivals are all part of attracting non-resident tourists and of encouraging Albertans to see the sights and sounds of their province. Key supporting disciplines include hospitality, archeology, geography and transportation sciences.

### **Current Alberta Infrastructure and Funding**

Alberta offers internationally recognized tourism destinations, natural scenic beauty, diversity of landscapes and friendly, safe cities. Since 1988 \$390 million has been invested in tourism projects assisted by the Tourism Development Branch. Several groups are actively involved in promoting tourism in Alberta. These include the Alberta Tourism Partnership, Alberta Tourism Industry Association, Alberta Urban and Rural Municipalities, Alberta Environmental Protection, and Alberta Community Development.

### **Current Alberta Research Activities**

The Community Tourism Action Program has allowed private sector operators, not-for-profit groups and municipalities to invest in new and expanded tourism products valued at over \$150 million. An interim evaluation of 900 projects showed 2,128 person years of employment. Many examples of research assisting tourism could be mentioned; two follow. Research in paleontology and museum display methods has resulted in The Dinosaur World Tour. This exhibition, organized by the ExTerra Foundation, travelled to Osaka, Japan where it was seen by over a million people and grossed over \$24 million. Rocky Mountain Golf-Alberta, a golf package promoted through trade, consumer and media programs in the Pacific Northwest and Southern United States attracted over 2,640 travellers and over \$524,000 in revenues.

### **National and International Context and Scope**

The World Tourism Organization estimates global tourism receipts at \$2.79 trillion in 1992. With a growth rate of 4% per year it makes it possibly the largest industry in the world today. The tourism industry is one of the largest industries in Canada. In 1992, tourism contributed more to the Canadian economy than agriculture, mining, forestry and fisheries combined. Statistics Canada and Tourism Canada estimates that tourism contributes nearly \$30 billion to the Canadian economy. Approximately \$6 billion of this amount comes from 16.3 million international visitors, mostly from the United States (80%), Europe and Asia Pacific. International tourists tend to spend more per person per day than Canadians and Albertans while travelling in Alberta. Japan is Alberta's third largest tourism market and in 1993, some 121,700 Japanese tourists spent \$112 million in the province. The current recession does not appear to be slowing the growth of this major market.

## **Current Socio-Economic Impact**

With the exception of energy and agriculture, tourism leads all other industries in terms of economic impact. Approximately one-half of tourism receipts (\$1.45 billion) are from non-residents; the balance (\$1.67 billion) comes from Albertans travelling in their own province. Other Canadians spend \$682 million, Americans \$384 million and others \$388 million. Total non-resident revenues equal \$1.45 billion. In 1993, visitor expenditures of \$3.12 billion generated an estimated \$1.1 billion in tax revenues for federal, provincial and municipal governments.

The industry employs approximately 100,000 both full- and part-time workers. Travelers in the province have a direct effect on employment in the retail and service sectors.

## **Attractiveness**

Appropriate research studies will improve our ability to present and market, focus on, and improve attractive tourism destinations and activities allowing Alberta to capture a larger proportion of the national and international tourism market. Tourism Development activities and services are primarily client driven. Money is used for data collection in response to client needs for assistance. The key focus is land/construction related, market-driven information that can improve the local business climate or trigger investment in Alberta's tourism industry. Clients include resident and non-resident tourism developers, investors and entrepreneurs, as well as municipalities and tourism associations. Tourism is a high risk business investment where there is little front-end equity or debt financing available to conduct feasibility assessments. The regulatory approval process for development on Crown lands requires extensive market, environmental and business support information which usually requires the generation of new data, and the compilation and coordination of existing data, to support investment decisions and development approvals.

Joint partnerships between government and industry are necessary to increase tourism markets, attract non-Canadians, and compete on a global scale.

## **Feasibility**

Alberta has the natural attractions and the skills to increase tourism in the province. There is a need to market the area better. The tourism industry has the opportunity to cooperatively fund marketing initiatives with a variety of partners. The Canadian Tourism Commission provides a challenge to match the federal government's contribution of \$50 million. The Tourism Alliance for Western and Northern Canada is being established with funding from government and industry for cooperative marketing studies. The new Alberta Tourism Partnership is also based on a cost shared structure and will identify research requirements, undertake research into tourism products and markets. Joint activities with neighbouring provinces and states in initiatives such as "The Trail of the Great Bear" and the "Team Yellowhead" projects are feasible and Alberta Community Development has initiated reciprocal exchanges with Montana for information sharing and program initiatives in heritage resources aimed at future joint marketing ventures. The World Tourism Organization estimates the industry will grow at a rate of 4% a year worldwide. Considering Alberta's potential to develop new tourist destinations this rate of growth seems conservative. Environmental/ecosystem concerns need to be taken into consideration in any growth scenario.

### Description of the Area and Key Supporting Disciplines



Public transportation, on- and off-road vehicles, road, rail, water and air transportation systems, commercial transport operations, and aeronautics are part of transportation and often are inter-related. For example, commercial transport operations depend on the highway, rail and airline systems in the province. The systems must ensure the safety of the travelling public. Reduction of excessive wear and tear on the roads, and disaster emergency preparedness and recovery are included in this area. Topographic, aerial, hydrographic, soil, traffic and accident surveys are conducted to support planning, design construction and programming activities related to the transportation infrastructure. The data are used in policy and engineering decisions to establish provincial standards for materials, devices, products and logistics used by the transportation industries.

### Current Alberta Infrastructure and Funding

Alberta has an extensive and cost-effective intermodal transportation infrastructure. This includes road and rail systems linked to all parts of Canada and the United States as well as excellent air service to both Canadian and international destinations. Alberta Transportation and Utilities is the authority for 13,800 km of primary highways. Alberta's municipal governments are responsible for approximately 15,000 km of secondary highways and some 130,000 km of local municipal roads. Several bus companies operate in the province and there are a number of taxi companies. The Canadian National and Canadian Pacific Railways run national rail systems connecting Alberta industries that produce bulk products to national and international markets. There are 370 km of locally-owned railroad track under provincial jurisdiction. Rail connections to west coast ports play a key role in Alberta industries' export trade as evidenced by the fact that more than 40% of the goods shipped from the port of Vancouver originate in Alberta. There are 85 airports in the province, including 2 international airports.

### Current Alberta Research Activities and Funding

Alberta Transportation and Utilities' applied research program is undertaken jointly with other provincial transportation departments, other Alberta government departments, major cities, research agencies and industry. The program is aimed at improving the development, maintenance and operation of highways, bridges, airports and ferries in Alberta. Using in-house personnel, the private sector or university resources, a variety of projects are undertaken. Cooperative research at the national or interprovincial level is negotiated through the Research and Development Council of the Transportation Association of Canada (TAC), Transport Canada, or the National Research Council. One such program is the Canadian Strategic Highway Research Program/United States Strategic Highway Research Program (SHRP), where, over a period of 8 years, a total contribution of about \$400,000 has provided access to the results of a \$156 million research program. In 1995 two test sections of highway were constructed in Alberta to demonstrate the field performance of SUPERPAVE mix designs under the SHRP Asphalt Program. Departmental expenditures in science and technology for technical surveys such as topographic, aerial, hydrographic, soil, traffic and accident surveys, for special services and studies directed toward the establishment of provincial standards for materials, devices and products, and for information services are \$5.92 million.

## **National and International Scope and Context**

The aerospace industry is global in nature with the United States having 58% of the market. The United Kingdom, France, Germany and Italy have a combined share of 34% while Canada and Japan have 4% each. Canada is a strong player in the industry employing 59,000 and having sales approaching \$8.4 billion. Ontario and Quebec account for approximately 90% of sales. Alberta has \$170 million in sales and accounts for approximately 2% of the aerospace industry. Much of the production is devoted to civilian markets including regional airlines, business aircraft users and general aviation manufacturers. The Canadian industry invests about 10% of sales in R&D, which is less than the United States. Canada works closely with The Institute for Transportation Research and Education and the Center for Transportation in the United States because of shared interests. Space systems and applications are distinct from, but relevant to communications and manufacturing. National governments tend to manage this area.

## **Current Socio-Economic Impact**

Aerospace, including remote sensing, contributes to Alberta's industrial diversification. About 60 companies target niche markets and employ over 2,000 people. With a pending upswing in the aviation and aerospace industries, Alberta can expect to see an increase in aerospace employment.

Failure of any part of the transportation system through delay or accident can have economic consequences in terms of damage to goods or injury to people.

## **Attractiveness**

Transportation is out-sourcing a range of functions to the private sector and reinvesting the savings into strategic highway infrastructure through partnerships with industry. Protecting Alberta's transportation infrastructure and the safety of those who use the system requires that the province stay abreast of new technologies and applies them to improve its operations. Expected results will include a reduction in highway collision rates, increased safety for commercial vehicles, reduced risk of accidents involving dangerous goods, and municipalities fully prepared to respond to disasters and emergencies. Ensuring private contractors meet maintenance standards, reducing weight overload damage to roads and bridges, and highway user satisfaction with outsourcing will result in the efficient movement of people and goods in the province. Alberta's climate is similar to many northern regions and transportation research and development can have application in many countries. Research in low gravity is in its infancy but can indirectly benefit a number of industries.

## **Feasibility**

Alberta's well trained work force and supporting infrastructure means that new and specialized technologies can be adopted easily. The transportation industry is able to respond quickly to market needs and access to new technologies will result in the industry remaining competitive. Global positioning systems and geographic information systems have the potential to change how larger transportation companies operate and lead to intelligent highway systems and vehicles. Smaller companies, however, often lack the necessary capital to grow and market their products and services and there is a lack of large component suppliers who have the financial resources to assume more risk. As the aerospace industry equipment and services industry becomes more automated and moves to intelligent manufacturing systems, the R&D potential and capacity will increase.

