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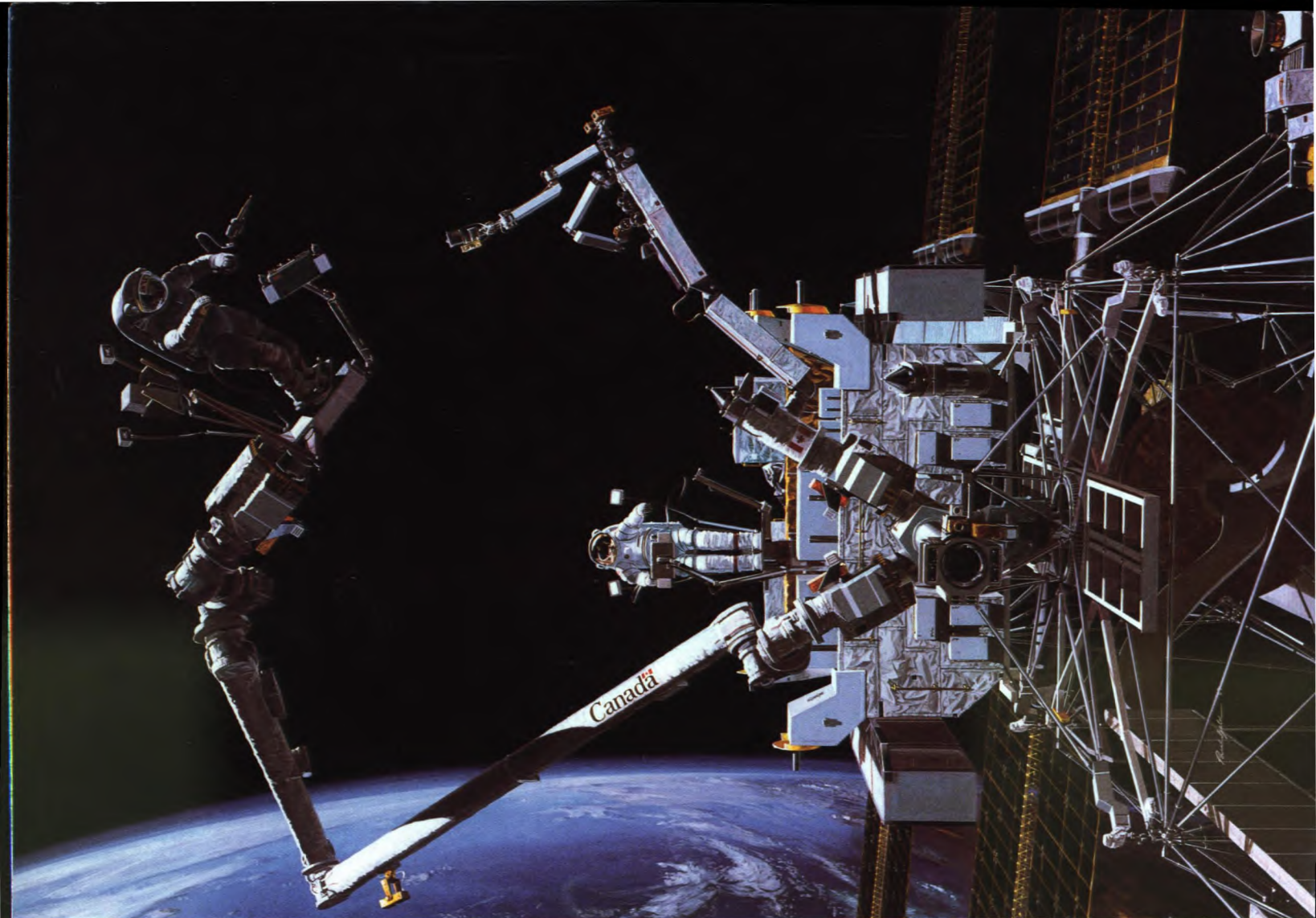
# Partners in Science and Technology

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## A Longstanding Tradition of Cooperation

From the ocean depths to the vast expanse of outer space, Canada and the United States have a long and fruitful record of cooperation in fields of science and technology. World events, close proximity, shared precious resources and the innate desire of Canadians and Americans to forge a better life, have made such cooperation all the more desirable and, indeed, inevitable.

Each country has benefitted from the free flow of ideas, technology and highly qualified personnel. In industry, higher education, services to the public and defence, partnerships have greatly enhanced the standard of living in both countries and their readiness to meet the challenges of the future.

From the beginning, collaboration has been the key. One of the earliest examples is in the field of weather forecasting. In 1871 the U.S. Congress established the National Weather Service (NWS), and the following year, Canada and the U.S. initiated the formal exchange of daily weather data.

Canada was the third country in the world — after the United States and the Soviet Union — to place a satellite in orbit. Launched by a NASA rocket in 1962, Canada's Alouette I satellite provided both countries with over 10 years

of important scientific information about the behaviour of the upper atmosphere in the northern latitudes.

A century of close collaboration has allowed each country to specialize in aspects of science and technology which it considers vital to its own growth and development. As a result, Canadian scientists and engineers now lead the world in many fields.

The high level of scientific and technological activity in Canada is good news for America. Canada is America's largest customer for its high-technology exports. From computers to chemicals, Canada and the United States are each other's largest trading partner.

Canadian technology-based firms provide a large market for U.S. goods and services. Canada imports over three-quarters of its high technology purchases — over \$16 billion in 1987 — from the U.S. In the field of aviation, for example, American companies provide from 36 percent to 66 percent of the components used to make Canadian aircraft and avionics.

At the same time, Canadian industry has proved itself to be a reliable supplier of products and components to U.S. companies and governments. High-tech Canadian goods and services are crucial ingredients in many American products and industrial capabilities.

One of Canada's best known exports, the remote manipulator, Canadarm, is a joint development of Spar Aerospace

*Artist's view of the Mobile Servicing System, Canada's contribution to the International Space Station Freedom.*

Ltd. and the National Research Council of Canada. This critical piece of equipment is installed on all U.S. Space Shuttle orbiters.

For decades, Canadian and American universities have closely collaborated in science, technology and education. Many distinguished Americans — among them the current Science Advisor to the President, Dr. D. Allan Bromley — were educated in Canadian graduate schools.

Industrial science and technology links are also strong. Boeing, McDonnell Douglas and IBM are three of many American firms which operate plants in Canada. The output of these plants — finished products, components and sub-systems — provides an important source of revenue for the parent firm. These plants also allow U.S. firms to tap into advanced Canadian research and development capabilities.

The new Canada-U.S. Free Trade Agreement (FTA) will undoubtedly enhance industrial cooperation between us. Canadians look to the FTA as a way of stimulating mutually beneficial opportunities for enhanced collaboration in science and technology-based enterprises.

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## In Industry

Canadian scientists and engineers have been especially active in those fields where science and technology have proved important to the development of Canada's natural and human resources.

Many recent Canadian technological achievements have been made possible by increased research and development activity in industry. The proportion of Canadian R&D funded by industry has grown steadily in recent years.

### TELECOMMUNICATIONS AND REMOTE SENSING

Canada's unique geography has provided the impetus for a telecommunications industry of international calibre. Building on Canada's need for swift, long-distance communications, firms such as Northern Telecom, Mobile Data International and Telesat have become world leaders in aspects of telecommunications technology.

Canada's Northern Telecom, for example, was the first to introduce an all-digital telephone switch. Another Canadian firm, Mobile Data International, provides mobile data terminals to fleet operators around the world, such as Federal Express. Canada was the first country to operate a geo-stationary domestic satellite system. Telesat operates Canada's Anik telecommunications satellites.

MacDonald Dettwiler (MDA) is one of the world's leading suppliers of turnkey remote sensing ground stations. MDA scientists have pioneered in the development of commercial systems for mapping Earth from space.

### HEALTH CARE

Health care is a field in which Canadian firms have long excelled. Connaught Biosciences, for example, is one of the world's leading developers and suppliers of human vaccines. One Connaught product, ProHiBitD, is the first in the world to offer protection against bacterial meningitis.

A Montreal firm, IAF BioChem International Inc., was awarded the prestigious gold award for invention in the 1989 Canada Awards for Business Excellence. IAF received the tribute for the invention of an AIDS diagnostic kit, which uses a mixture of synthetic peptides as the antigenic material.

Many leading American pharmaceutical firms operate research laboratories in Canada, in order to draw upon the pool of highly trained manpower.

Pharmaceutical R&D among Canada's largest companies increased 30 percent to \$164.5 million from 1987 to 1988. In 1989 expenditures were expected to reach \$211 million, more than double 1987 levels.

### ENERGY

Atomic Energy of Canada Ltd. (AECL) has pioneered in the peaceful use of nuclear energy. Its CANDU nuclear reactor, which uses an original heavy water principle, has the best safety record and is the most cost-efficient in the world.

Hydro-Québec is a world leader in the transmission of electricity over long distances. A new alloy developed in its laboratories — Hydroloy — was selected by *R&D Magazine* as one of the top 100 innovations in 1989. Hydroloy reduces erosion in hydroelectric turbines.

For decades, U.S. industries and citizens have relied on secure supplies of electricity generated in Canada. New plans call for Canadian producers to apply state-of-the-art technology to install additional, environmentally sound generating capacity in the 1990s, in order to bolster the North American power grid.

### MANUFACTURING

As the scale of world manufacturing and trade grows in the 1990s, many Canadian firms will be looking to form new technology and marketing alliances with companies in the U.S.

A growing number of U.S. multinational companies are awarding their Canadian subsidiaries mandates to develop, manufacture and sell products worldwide, on behalf of the parent company. U.S. firms such as Pratt and Whitney have chosen to build on the scientific and technological expertise of their Canadian divisions to exploit world markets.

### TRANSPORTATION

Canada's transportation industry is a leading supplier of sophisticated equipment to U.S. operators. A good example is UTDC Inc., which recently supplied the Florida Department of Transport with eighteen bi-level commuter rail coaches for service linking downtown West Palm Beach and Miami.

*Aircraft component testing at a National Research Council laboratory.*

## AWARD WINNERS

Today, many Canadian firms rank among the world's best at developing and applying science and technology. Each year, leading Canadian inventions and innovations are showcased by the Canada Awards for Business Excellence. Companies recently singled out for tribute include:

**Virtual Prototypes Inc.** Development of a breakthrough technology for rapid prototyping of control and display systems.

**Alcan International Limited.** Development of an aluminum-air fuel cell system.

**Hymac Ltd.** Development of a 24-megawatt (32,000-horsepower), two-stage pulp refiner with independently controlled refining zones.

**Diffrauto Ltd.** Development of "D Sight," a machine-vision-based system for the measurement of surface quality.

**International Road Dynamics Inc.** Development of a Weigh-In-Motion system for road vehicles.

**Sub Aquatics Development Corp.** Development of a passenger submarine.

**Canfor Corporation.** Development of Ecobrite, a non-toxic, anti-stain chemical for the treatment of lumber.

**University of Guelph.** Discovery of PRESPONSE, a vaccine against pneumonic pasteurellosis in cattle.

National Research Council







## In Higher Education

At the base of Canada's wide-ranging capability and performance in science and technology lies one of the most developed systems of publicly funded postsecondary education in the world. There are a total of 266 colleges and universities to serve its population of 26 million. Canadian per capita expenditures on higher education are also among the world's highest.

The free flow of ideas and highly qualified personnel between the two countries has been a cornerstone of university life in Canada and the U.S. Many Canadian and American scientists and engineers have received training in each other's country.

At the heart of Canada's university research capability is the Natural Sciences and Engineering Research Council of Canada (NSERC), Canada's counterpart to the U.S. National Science Foundation (NSF). As Canada's largest single agency in support of university research, NSERC plays a key role in the development of a strong research base and in forging closer links among all players in the Canadian research arena.

Canadian university researchers cooperate with their American colleagues across many fields. In fact, when it comes to research papers which are internationally co-authored, they work with American scientists almost as much as with all the rest of the world's scientists put together.

Such partnerships are paying off handsomely. In 1989 a team of University of Toronto scientists working at Toronto's Hospital for Sick Children, together with colleagues at the University of Michigan, pinpointed the genetic defect which causes cystic fibrosis. The discovery of the gene means it will soon be possible to identify carriers and ultimately provide counselling to couples at risk.

The Canada-France-Hawaii Telescope (CFHT) is a shining example of cooper-

*Digital image of the Vancouver area, generated from Landsat V and Spot satellite data. The image was processed on MacDonald Dettwiler's MERIDIAN Image Analysis and Mapping System, and plotted on its FIRE 240 film image recorder. Landsat source data courtesy of the Canada Centre for Remote Sensing. SPOT source data supplied by Spot Image, copyright CNES 1987.*

ation. Situated atop the mountain of Mauna Kea in Hawaii, CFHT is a joint project of Canada, France and the University of Hawaii. The University donated the telescope's site and support facilities, while Canada and France shared the costs of construction. University astronomers from the three countries share time on this important instrument.

Canadian universities already perform one-quarter of all research and development in Canada, and interest in university-industry collaboration is growing.

Partnerships with industry will highlight the Canadian university research scene in the 1990s. Many Canadian universities have added a new role — the transfer of technology — to their traditional teaching and research function.

Canadian university researchers have been responsible for many important industrial technologies, from photo-degradable plastics which begin to decompose when exposed to sunlight, to the laser plasma mass spectrometer, which is used to detect ultra-trace impurities in materials.

With the support of Canadian industry and provincial and federal governments, an innovative system of centres and networks of research excellence is being put into place. These new research alliances cover such diverse disciplines as protein engineering, ocean production enhancement and neural regeneration. The Canadian operations of U.S. firms are free to participate as equal partners in these centres and networks, subject to the centres' policies on intellectual property.

## The Tradition Continues

The trust and partnerships which have grown up between Canadian and U.S. scientists over the years promise exciting new opportunities for the future in areas as diverse as fundamental research and space technology.

### HIGH-ENERGY PHYSICS

Canada and the United States are studying their possible collaboration in two exciting science projects for the next century. The Superconducting Supercollider (SSC) is an American project in which Canada has been invited to participate. Similarly, Canada would invite American researchers to join in the Kaon Factory which has been proposed by the TRIUMF consortium headquartered in British Columbia, should the project proceed.

This year Canada and the United States agreed to become partners in the Sudbury Neutrino Observatory (SNO). Housed deep in a nickel mine in Sudbury, Ontario, SNO will permit Canadian and American scientists to measure the flow of neutrinos — a class of elusive, high-velocity sub-atomic particles — from the sun.



*The three doctors who found the defective gene that causes cystic fibrosis, left to right, Lap-Chee Tsui of Toronto, Francis Collins of the University of Michigan and Jack Riordan of Toronto, with Ashley Dryer, who has cystic fibrosis.*

### SPACE STATION FREEDOM

Canada's contribution to the international space station will be the all-important Mobile Servicing System (MSS). MSS will be one of the first elements launched on the Shuttle. A mobile "space crane," MSS will use highly sophisticated robotics and artificial intelligence to help astronauts construct and service the station. MSS is valued at over US \$1 billion. It will build on the expertise in Canadian industry, university and government laboratories.

### RADARSAT

Canada's Radarsat remote sensing satellite will be the world's first operational satellite to use synthetic aperture radar technology. Capable of penetrating clouds, Radarsat will provide 24-hour-a-day coverage of the earth's surface for polar navigation and resource management. The U.S. contribution will be a rocket launch to place Radarsat in a polar orbit. In return, Canada will guarantee exclusive data rights to a U.S. company for the American market.

*In industry, government and higher education, Canada's science and technology capabilities form the basis for stronger partnerships with the United States in the future.*



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Environment Canada



Above, Environment Canada's "oil from sludge" pilot plant in Hamilton, Ontario. Below, the National Research Council of Canada's wind tunnel.



National Research Council

## In Government

As part of their mandate to promote social and economic development, Canadian government departments and their laboratories and research institutes are in the forefront of research across many scientific disciplines. For decades there has been close collaboration with scientists in the U.S.

### NATIONAL RESEARCH COUNCIL

The largest of the Canadian government's research enterprises is the National Research Council of Canada (NRC). Established in 1916, NRC now operates science and engineering laboratories across Canada, in fields as diverse as building construction and plant biotechnology. NRC operates a set of national facilities which include wind tunnels, low-temperature facilities, test aircraft and simulators, and offshore and coastal wave basins, to name a few. From its inception, NRC has worked closely with the U.S. science community and the U.S. National Institute for Standards and Technology (NIST). NRC and NIST have worked out an agreement which recognizes the equivalence of Canadian and American measurement standards. The effect of the agreement will be to promote trade among firms in the two countries.

In another collaborative venture, NRC's National Aeronautical Establishment is working closely with the U.S. Federal Aviation Administration on a project designed to improve the instrument-handling quality of helicopters.

NRC's Biotechnology Research Institute will be working with a Montreal firm, IBEX Ltd., to develop a unique filtering system for cleansing blood after open-heart surgery and haemodialysis. The forerunner research to the IBEX project was conducted at the Massachusetts Institute of Technology.

## THE ENVIRONMENT

Canadian government research efforts are especially strong in the area of the natural environment. Canada and the U.S. share a 5,525-mile border, and the need for joint research, standard-setting and regulation has never been greater. In partnership with their counterparts in the U.S., Canadian government scientists and engineers are tackling some of the most pressing of the shared problems, such as acid precipitation, soil degradation, hazardous wastes and global warming.

An outstanding example of Canada-U.S. public sector cooperation is the International Joint Commission (IJC), which was established in 1909. The original mandate of the IJC was to administer the Boundary Waters Treaty. The Great Lakes Water Quality Agreement, which governs the shared water resources of 40 million Canadians and Americans, was signed in 1972. Since the establishment of the IJC, over \$8 billion has been spent by Canadian and American governments — federal, provincial and state — on research and engineering aimed at improving water quality. But more work remains to be done. The IJC is currently overseeing the development of a remedial action plan for each of the areas of concern.

While the environmental and economic effects of acid precipitation on forests, fisheries and water quality are now acknowledged, concern over their effect on children's health is just surfacing. A \$6-million study being conducted by Health and Welfare Canada and Harvard University will monitor the lung capacity of children living in areas with high levels of acid rain. Fifteen thousand children in six Canadian and 18 American cities will be monitored.

A Canadian "clean technology" is attracting international attention. Environment Canada scientists have developed a technique for producing fuel oil from sewage sludge. Canada alone spends \$100 million a year disposing of sludge, a by-product of treatment processes for industrial and municipal wastes. The new process could reduce the need for ocean dumping and landfilling of sludge and thereby revolutionize the way cities around the world cope with their wastes.

Environment Canada also operates the World Ozone Data Centre, which for the past 20 years has collected data from a global network of measuring stations. Environment Canada researchers were instrumental in establishing the scientific evidence which led to the adoption of the Montreal Protocol to curb the use of chlorofluorocarbons. Canada has set as a national objective the complete elimination of ozone-destroying CFCs within ten years.

### OCEANS AND THE SEABED

Understanding and managing the ocean resources is of prime importance to Canada. Canada borders on three oceans — Atlantic, Pacific and Arctic — and has the longest coastline in the world. The livelihood of many Canadians depends upon the health of the oceans.

Canada supports six ocean science centres. The largest are the Bedford Institute of Oceanography (Dartmouth, Nova Scotia) and the Institute of Ocean Sciences (Sidney, British Columbia). These institutes undertake a range of studies, with the combined help of physicists, chemists, biologists and oceanographers.

Canadian earth scientists are actively involved in the Ocean Drilling Project (ODP), in partnership with a consortium of 10 U.S. institutions. ODP probes the Earth's history by examining the composition of rocks deep below the ocean floor.

For over 40 years the Department of Energy, Mines & Resources has been conducting research on the rich resources of the polar continental shelf. One unique project makes use of a floating island 2.4 miles wide x 4.8 miles long to house a research base from which scientists study the water and floor of the polar sea. The advantage of the island — a gigantic slab of freshwater ice — is that it provides a stable platform for researchers atop an ever-shifting ocean of water and ice. The ice island will drift for decades, circling the Arctic Ocean and passing through U.S. waters.

Energy, Mines and Resources Canada



Aerial view of Canada's ice island camp.

### FORESTS

The forest industry is of great economic importance to Canada. Just recently, scientists at Forestry Canada laboratories were first in the world to regenerate an entire conifer tree from a single cell. This major new application of biotechnology will provide the means to rapidly create multiple copies of elite trees for commercial forests.

Forestry Canada is working with the U.S. National Forest Service and NASA in a project that will apply expert computer systems to the prediction, detection and monitoring of forest fires. This innovative use of computers will help prevent massive forest fires such as the one that destroyed large parts of Yellowstone National Park in 1988.



Canada

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