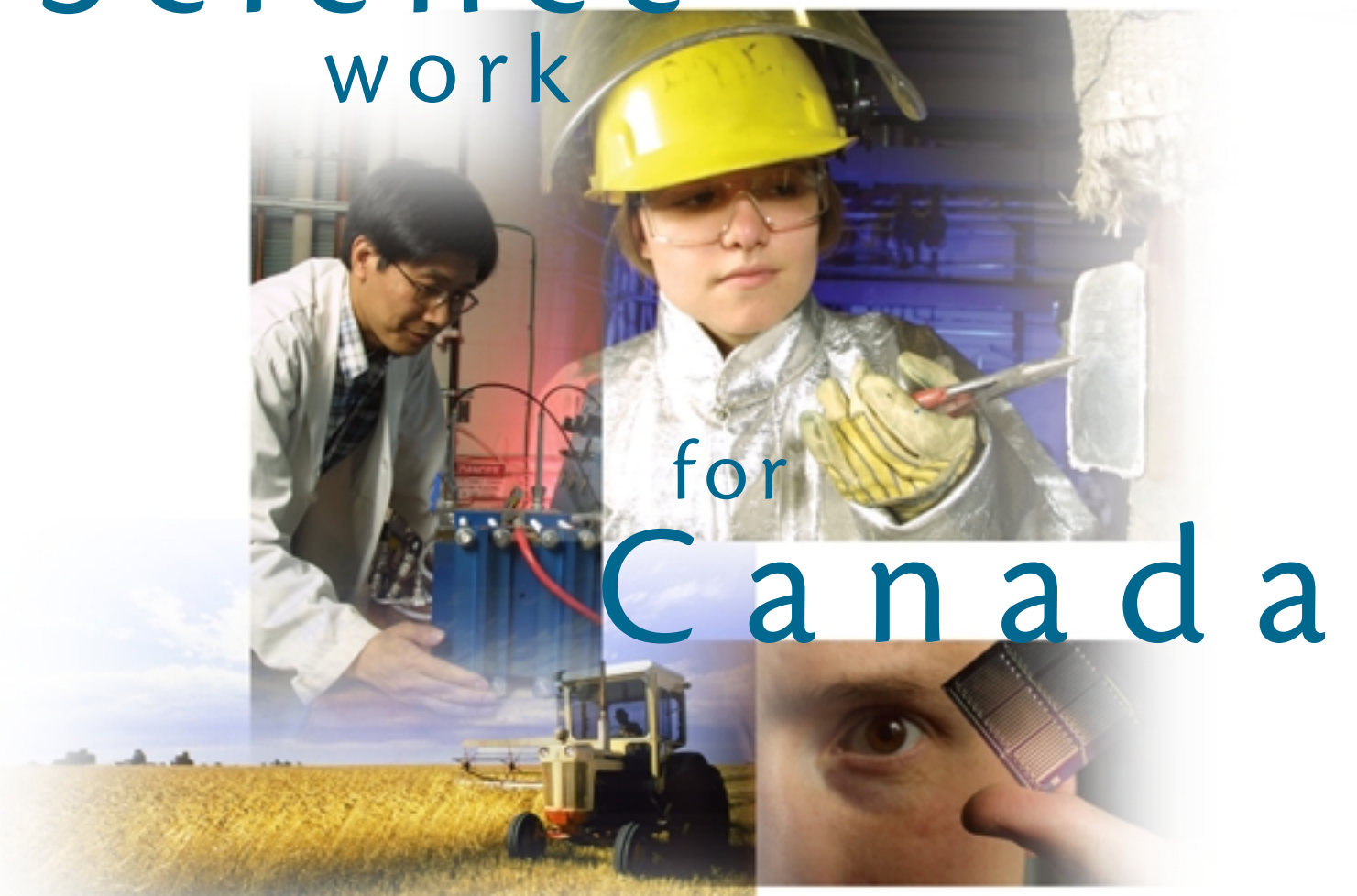
NRC·CNRC

From Discovery to Innovation...

Science at work for Canada



NRC Annual Report
2001-2002

National Research Council Canada
Conseil national de recherches Canada

Canada

NRC is the Government of Canada's leading resource for scientific research, development and technology-based innovation. Its outstanding people help turn ideas and knowledge into new products, processes and services, creating value for Canada.

As an organization with global, national, regional and local presence, NRC is a keystone of Canada's innovation system. NRC works hand-in-hand with partners from industry, government and universities to help ignite the spark of innovation in communities across the land and to give Canadian companies a competitive edge in today's marketplace.

NRC operates world-class research facilities as well as information, technology and innovation support networks from coast to coast.

In all, NRC is present in over 90 communities across Canada through its network of research institutes, technology and innovation centres, the NRC Industrial Research Assistance Program and the Canada Institute for Scientific and Technical Information.

NRC's impact extends even further through the thousands of partnerships, networks, collaborations, and national and international committees it is involved in.

NRC's work spans the innovation spectrum from scientific discoveries at the very frontiers of knowledge to technology commercialization. For over eight decades, NRC has successfully forecast Canada's opportunities and adapted itself to meet national priorities as well as the needs of its clients and partners.

It has organized forces around key sectors, such as biotechnology, information and communications technologies, aerospace, manufacturing, construction, ocean engineering and others.

National Research Council Canada

Science at work for Canada

Annual Report 2001-2002

NRC has moved boldly into important new fields, such as genomics, fuel cells, bioinformatics, high-performance computing, photonics, nanotechnology, and environmental and sustainable development technologies.

NRC is focused squarely on Canada's future and is committed to helping build the nation's knowledge and innovation capacity, and providing the tools to succeed in the knowledge economy.

For more information visit our Web site at: **www.nrc-cnrc.gc.ca**
or contact NRC at: **1-877-672-2672**

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Science

Recognized globally for research and innovation, NRC is a leader in the development of an innovative, knowledge-based economy for Canada through science and technology.

This Vision is founded on five strategic pillars:

Outstanding people – outstanding employer

Recognition as a leading research organization distinguished by creativity and innovation

Excellence and leadership in R & D

Integration of public and private strengths to create new opportunities and meet national challenges for Canada

Technology clusters

Development of the innovative capacity and socio-economic potential of Canada's communities

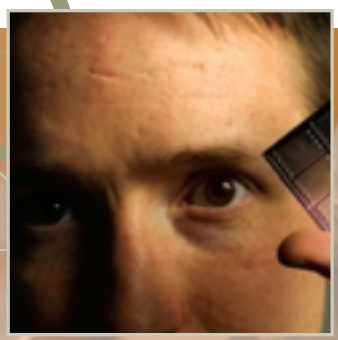
VISION 2006

Value for Canada

Commitment to the creation of new technology-based enterprises, technology transfer and knowledge dissemination to industry

Global reach

Access to world-class science facilities, as well as global research and information networks. Stimulation of enhanced international opportunities for Canadian firms and technologies.



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2001-2002 marked a year of significant growth and outstanding achievement for the National Research Council as it moved forward rapidly with imaginative new initiatives and programs designed to build Canada's innovation capacity in the 21st century. In early 2002, NRC launched its *Vision 2006*, a far-reaching strategic framework that defines NRC's purpose, priorities and plans to serve the interests of Canada, Canadian industry and all Canadians.

We live in a world governed by change – a world where change seems to accelerate more each year. The world of science and technology is dominated by an unprecedented convergence of fields, disciplines and sectors. Scientific fields that were once distinct and diverse are now merging and many of the frontiers of science and technology are inherently multi-disciplinary in nature. Science is entering into the domains of the very fast and very small where new laws and principles hold sway and much remains to be discovered. Canada's quest to be a world leader in the knowledge-based economy is generating fresh thinking and new ideas about the role of community-based innovation and mechanisms for transferring technology and knowledge from the labs to the marketplace. The NRC Vision addresses these forces of change.

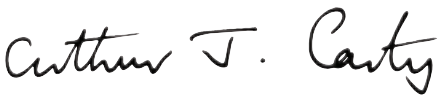
The commitment of the federal government to move Canada into the top five R&D performers in the world and to make Canada one of the world's most innovative nations is the foundation for NRC's Vision and its contributions.

In *Vision 2006*, NRC has set a deliberate and strategic course. *Vision 2006* recognizes Canada's need to meet the challenges of innovation. It positions NRC on the leading edge of discovery and enhances its capacity to put knowledge to work for Canada. The Vision focuses directly on NRC's role in fostering innovation through national, international and community-based collaborations and partnerships. *Vision 2006* is about the goals, the commitment and the rewards of seeing "Science at Work for Canada."

President's message

A Vision for Canada and all Canadians

Dr. Arthur J. Carty



NRC's contributions in 2001-2002 helped move this Vision into reality – through leading-edge discoveries, technology breakthroughs, building community-based technology clusters, generating value for Canada through the creation of new business enterprises, technology commercialization and global reach.

NRC staff are the foundation of this Vision. It is their talent and creativity that will give the Vision life. This Annual Report is the story of their achievements on behalf of Canada.

"Our objective should be no less than to be recognized as one of the most innovative countries in the world. Achieving this will require a comprehensive approach, and the support and participation of all governments, businesses, educational institutions and individual Canadians… An innovative economy is essential to creating opportunity for Canadians."

Speech from the Throne
JANUARY 30, 2001

"The impact of S&T in this new century shows no signs of diminishing. The challenges that face our planet… economic and health disparities, the environment, the sustainable development of natural resources, bioterrorism, human health and disease… all depend for their solution on sustained public investment in research and innovation… The federal government has clearly recognized the important roles that science and innovation can play in underpinning future economic growth. It has also recognized its central role and the opportunity in developing and sustaining a research enterprise that is connected to broader social and economic objectives."

Investing in Excellence, 1996-2001
A Report on Federal Science and Technology

National Research Council Canada

Science at work for Canada

Research and innovation are critical to Canada's future economic growth and an improved quality of life for all Canadians. Canada must become known as a nation of innovators, one in which all sectors of society can benefit from a globally focused, networked and innovative knowledge economy. But innovation does not simply happen – it requires long-term and strategically directed investments in research, people, infrastructure, networks and relationships.

One of Canada's important challenges is to unleash the value inherent in knowledge and innovation organizations like NRC. The key to achieving this is an innovation approach that mobilizes the public and private sectors, while integrating the elements of innovation at the international, national and community levels. There must be sustained and focused investments from all sectors for the creation of new knowledge and its use in Canadian industry. This effort must span the research spectrum, from basic discoveries that advance the frontiers of knowledge, to the transformation of knowledge into new products, services and technologies for world markets.

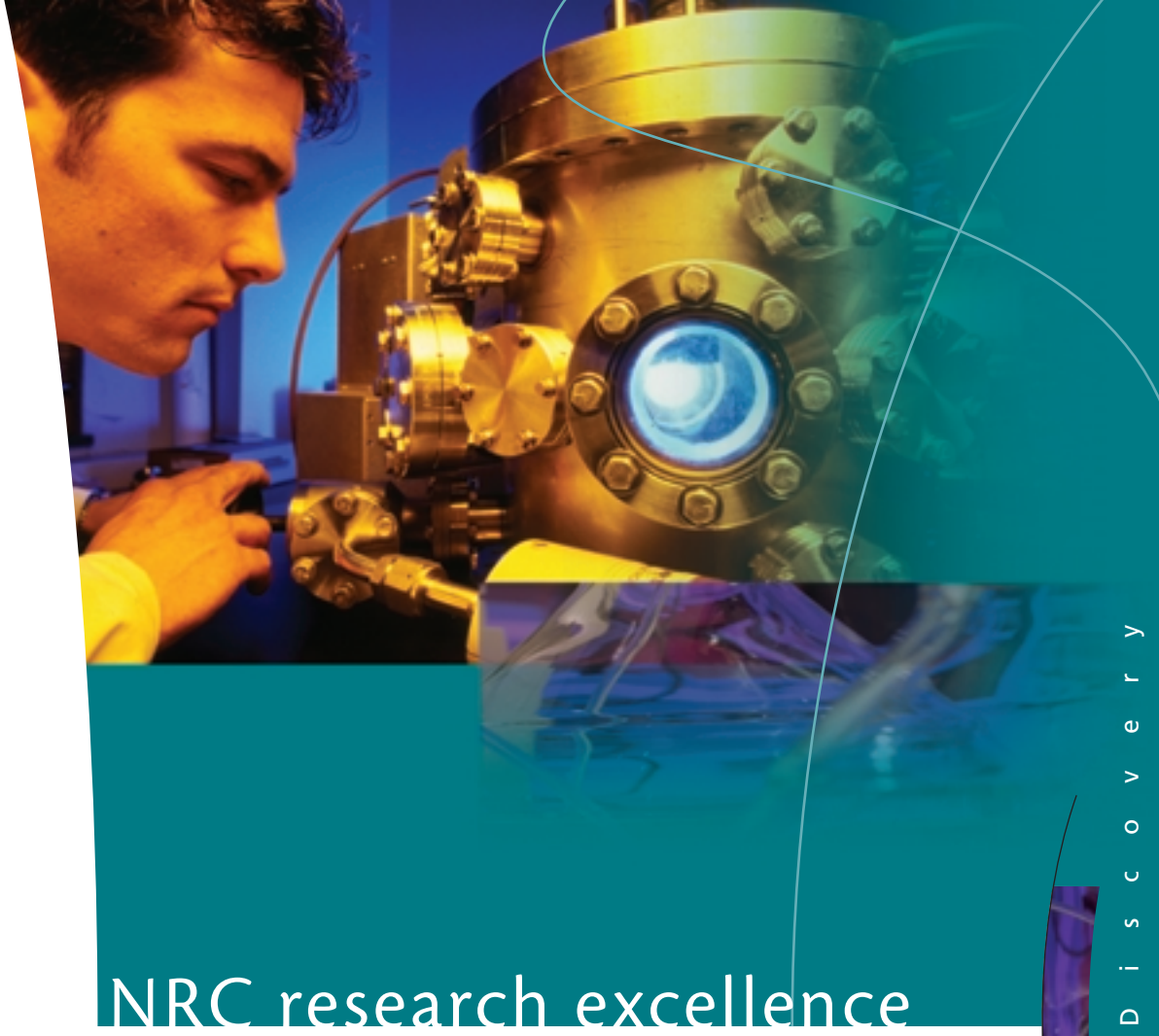
With the launch of its *Vision 2006 – Science at Work for Canada*, NRC is committed to providing leadership in Canadian innovation and creating long-term benefits for Canadians.

NRC will play a key role in helping Canada become one of the top five countries in the world in research performance and develop the knowledge foundation for the industries of tomorrow.

Working with industry, academia, and government, NRC will increase the effectiveness of its innovation systems by fostering national and international networks, and community-based technology clusters.

Such efforts will help better Canada's quality of life, improve the environment, protect health and create new sources of wealth.

Canada



NRC research excellence

At the frontiers of discovery

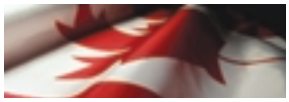
"Research and development are key to the innovation process – not only industrial innovation that leads to wealth creation, but also innovation that leads to improvements in the quality of life."

Report of the Expert Panel on Canada's Role in International Science and Technology
JUNE 2000

Today's research creates tomorrow's opportunities. Leading-edge research and development is at the very core of NRC's *Vision 2006* and NRC's contributions to Canada and all Canadians. Working in collaboration with industry, government and academic partners, NRC pursues strategically focused R&D to help build Canada's innovation and technology capacity, support Canadian industry, to seek solutions to national challenges in health, climate change, the environment, clean energy and other fields, and lay the knowledge foundations for Canada's future growth.

"Innovation is the process through which new economic and social benefits are extracted from knowledge… Knowledge has become the key driver of economic performance."

Canada's Innovation Strategy:
Achieving Excellence – Investing in People, Knowledge and Opportunity



Building national R&D capacity

NRC makes strategic investments in R&D facilities, programs and networks in every part of Canada. It is the home of unique national science and engineering facilities, Canada's national science library, and Canada's source for science-based national measurements and standards. NRC also plays an important role in major national science facilities, initiatives and programs, helping build Canada's reserves of knowledge – the newest currency of our economy. NRC's contributions to national infrastructure create new opportunities and leverage Canada's R&D investments.

In 2001-2002, NRC made a number of major contributions to building Canada's R&D infrastructure and capacity. Among the highlights:

NRC – National Institute for Nanotechnology

NRC moved forward on the establishment of its National Institute for Nanotechnology (NINT), a $120 million world-class facility to be located on the campus of the University of Alberta in Edmonton. This new research facility is a unique collaboration between the Government of Canada, represented by NRC, the province of Alberta and the University of Alberta.

NINT will be multi-disciplinary in scope, integrating NRC and partner strengths in physics, chemistry, engineering, biotechnology, informatics, pharmacy, medicine and new materials. The research program will build on NRC's and the University of Alberta's existing world-class nanosciences and nanotechnology R&D strengths. Initially, NINT will direct its

NRC – Core strengths for Canadian R&D

- 18 research institutes
- 6 advanced technology and innovation centres
- Sustained research in critical sectors: biotechnology, manufacturing, information and communications technologies, aerospace, construction, nanotechnology, photonics, astronomy and astrophysics, fuel cells, ocean engineering, and others
- National S&T knowledge and information resources
- Local, regional, national and international S&T networks, partnerships and collaborations – access for Canadian R&D to the world
- National standards, codes and measurements, related R&D and services.

efforts toward developments in biotechnology, energy, and information and communications technologies, including:

- "Lab-on-a-chip" nanotechnology – integrating biology with electronics to build biosmart devices
- Quantum and molecular computing – the next generation of computing technologies
- Nano-engineered devices with new surface properties, such as biocompatible medical implants and fuel cell catalysts
- Protein and DNA tools that produce self-assembled devices
- Genomics, materials sciences, and instrumentation research.

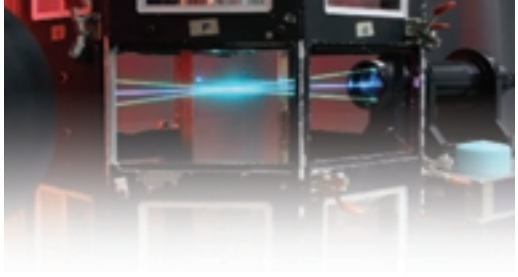
NINT, when completed, will feature a 12,000 square metre research and industry partnership facility, 150 permanent, highly skilled research jobs, a program for 45 guest workers from industries and universities each year, and training opportunities for some 275 post-graduate and post-doctoral researchers annually. Overall, NINT will provide unique R&D collaborations, exchanges, and facility-sharing arrangements for researchers from NRC and the University of Alberta.

New aerospace facilities and research directions

NRC moved forward with its new Aerospace Manufacturing Technology Centre (NRC-AMTC) to be located on the campus of the Université de Montréal, and its new Gas Turbine Environmental Research Centre (GTERC) in Ottawa.

Construction of the NRC-AMTC will begin in 2002, with funding of $46.5 million over five years. This centre will work with aerospace industry partners to develop core competencies in modern manufacturing methods that promise significant industry-wide cost savings while maintaining quality, reliability and performance. The centre will employ up to 100 staff and guest workers in four major research programs.

Construction of the GTERC, funded at $23.4 million, will also begin in 2002 with completion in 2003. The centre will help Canada's aerospace industry develop next-generation gas turbine engines to run at high altitudes and low temperatures, in compliance with strict environmental and safety standards.



Manufacturing technologies for the future

NRC established a new virtual materials processing laboratory at its Industrial Materials Institute in Boucherville (NRC-IMI). The facility combines the latest computer technologies with a top research team to develop tools needed by the manufacturing community of the future.

With an investment of $2.1 million, this initiative enables researchers to develop next-generation automated design and manufacturing tools for such sectors as aerospace and automotive.

NRC – National facilities and fundamental R&D infrastructure

- National astronomical observatories & data systems; access to international astronomical facilities
- National metrology facilities
- Canadian Bioinformatics Resource
- Canadian Centre for Housing Technology
- Virtual environment technology centres
- National aerospace facilities – wind tunnels, fixed & rotary wing research aircraft, Aerospace Manufacturing Technology Centre (under construction), Gas Turbine Environmental Research Centre (under construction), structures and materials testing facilities, engine test cells
- Ocean and marine engineering test facilities
- Aluminium Technology Centre
- Canadian Hydraulics Centre
- Centre for Surface Transportation Technology
- High-throughput screening, DNA sequencing, and microarray facilities
- Large-scale protein purification facility
- Marine Biosciences and Aquaculture Research Station
- Nuclear magnetic resonance imaging facilities
- Ultra-fast laser laboratory
- NRC – Canada Institute for Scientific and Technical Information (NRC-CISTI)
- Industry partnership facilities… and many more.

In all – some 400 S&T laboratories and facilities for Canadian R&D and innovation.

"NRC National Reach – Local Touch"

In addition to their national mandates, NRC's institutes, innovation and technology centres, IRAP, CTN, and CISTI, provide a visible and valued federal government presence and access point for industry and universities in over 90 locations across Canada.

NRC – Contributions to Canada's major R&D initiatives & programs

Sustained investments in R&D help advance knowledge and develop technologies for Canada's future. NRC works in research fields of strategic national importance:

- TRIUMF – Tri-University Meson Facility
- Sudbury Neutrino Observatory
- Canadian Light Source
- Grid and High Powered Computing (HPC)
- Nanotechnology R&D
- NRC – National Fuel Cells Program
- National security – chemical, biological, radiation and chemical threats
- Genomics and health R&D – supporting the Canadian Biotechnology Strategy
- Special Interest Groups, Network Centres of Excellence (NCEs) and Federal Innovation Networks of Excellence (FINE)
- National Guide to Sustainable Municipal Infrastructure
- Photonics R&D and manufacturing technologies
- And many more.

Contributions to the Canadian Light Source – probing the unknown

NRC scientists are making key contributions to the Canadian Light Source (CLS) in Saskatoon, Saskatchewan. For example, researchers from the NRC Steacie Institute for Molecular Sciences (NRC-SIMS) are actively involved in planning research for the Far-Infrared Beamline at CLS. They will address such issues as: how energy flows among different parts of a molecule; what the nature and the forces are among atoms and molecules; how metal atoms bond to other chemical groups; and what the properties of carbon chain molecules are and why astronomers find so many of them in outer space. Beamline-based studies of surfaces and other interfaces with high spatial precision will help in the development of miniature optical and biochemical sensors.

Photo: Todd Korol for the University of Saskatchewan

Renewing NRC's Canadian Bioinformatics Resource (CBR)

Worldwide growth in life sciences, genomics and biotechnology will accelerate rapidly in coming years creating a pressing need to organize and analyze the large data sets that are fundamental to research in these fields. To prepare for the challenge, NRC has undertaken a comprehensive restructuring of CBR, earning recognition by the Sun Corporation as the "NRC Sun Centre of Excellence in Distributed Bioinformatics" – one of just six Sun Centres of Excellence worldwide.

Top: The "Perfect Spiral Galaxy," captured with a new instrument of NRC design at the Gemini North Telescope; **Right:** NRC contributions to new software for the FUSE satellite will help extend the mission from three to five years; **Bottom:** This giant gas cloud found by NRC researchers could lead to a new understanding of the interstellar medium.

Advances in basic sciences

Astronomy and astrophysics – our gateway to the stars

NRC conducts leading-edge research in astronomy and astrophysics, and provides the Canadian astronomy community with access to major astronomical facilities in Canada and internationally. NRC is also a world leader in the development of advanced instrumentation and works to transfer the knowledge and technologies it develops in astronomy and astrophysics to other disciplines.

Cold cloud casts big shadow

Researchers from the NRC Herzberg Institute for Astrophysics (NRC-HIA) have uncovered a cold, hard fact that could leave prevailing theories about the interstellar medium (ISM) in the dust. They have found and accurately measured the temperature of a giant gas cloud in the ISM that is 6,000 light years across with a mass 20 million times greater than the Sun. As reported in *Nature* (July 2001), this is the first finding of a super-massive interstellar cloud composed primarily of very cold atomic hydrogen. This finding opens up new areas for investigation and could force astronomers to re-examine their understanding of the ISM and its role in the life cycle of stars and galactic evolution.

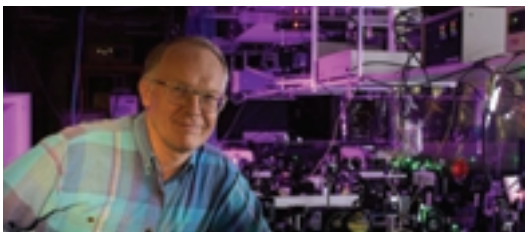
Orbiting FUSE repaired – from Earth

Without ever leaving the ground, NRC astronomers and engineers have helped devise an innovative recovery scheme for the Far Ultraviolet Explorer Satellite (FUSE). The spacecraft was launched in 1999 on a joint mission between NASA, the Canadian Space Agency (CSA) and the French Centre national d'études spatiales. Its mission is to study the rich FAR UV spectrum, inaccessible by the Hubble Telescope. FUSE was designed to last three years but, midway during its second year, ring laser gyroscopes began to fail, affecting navigation control and threatening to push the Canadian Fine Error Sensor (FES) far beyond design limits. The Canadian team, including CSA contractors at ComDev and the University of Toronto, and NRC-HIA worked to devise new software to track stars drifting across the FES field of view. NASA has now approved the FUSE mission to operate for five years.

Perfect image of a "Perfect Galaxy"

Scientists captured a remarkable first light image of galaxy NGC 628 – the "Perfect Spiral Galaxy" – in Pisces, with a new state-of-the-art instrument at the Gemini North Telescope on Hawaii's Mauna Kea. The instrument that took the image, GMOS or Gemini-Multi-Object Spectrograph, is the result of seven years of design and construction by an international project team led by NRC-HIA.

Molecular sciences – the small things are key



NRC conducts cutting-edge research in selected areas of molecular sciences that have the potential to stimulate entirely new or emerging sectors of the Canadian economy. Strategic molecular sciences research fields for NRC include: nanoscience, chemical biology, laser science, molecular interfaces, organometallic chemistry, and their related technologies.

Tiny storage medium – major industry impact

Despite their tiny size, or perhaps because of it, unique structures called nanotubes are already being explored for commercial applications, such as video displays. A new NRC research program is focusing on characterizing, modifying and producing nanotubes on a large scale. One project is already looking at the potential of carbon nanotubes as a hydrogen storage medium for future fuel cell applications.

NRC also opened a new laboratory in 2001-2002, for the production of large amounts of single-walled nanotubes. New nanotubes have been developed, with patent applications filed and a new NRC spin-off company in the works.

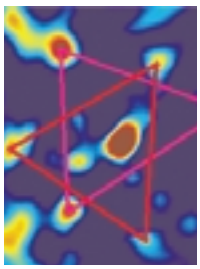
Making molecules measure themselves

Breakthroughs by NRC researchers have demonstrated the possibility of having a molecule measure its own structure. In this ultra-fast phenomenon research, using attosecond electrons for molecular probing, an electron is pulled from the molecule by a strong field, only to be driven back when the field reverses its direction where it diffracts from the parent ion. Since diffraction occurs within about one femtosecond (one-quadrillionth of a second), the structure of the neutral molecule can be imaged. This has great potential for structure determination of non-crystalline molecules, particularly large biomolecules.

Unique nanotechnology research facility on the way

NRC initiated a $1.4 million project to design and construct a new neutron reflectometer facility at its Canadian Neutron Beam Laboratory in Chalk River. Scheduled for completion in the fall of 2003, the facility will support nanoscale structure analysis in partnership with universities. The facility will not only generate new knowledge, but also focus on the development of innovative products for the emerging nanotechnology industry.

Neutron holography breakthrough – new avenues for materials studies



The combined efforts of NRC and Atomic Energy Canada Limited staff at the Chalk River laboratory in atomic-resolution holography resulted in new developments in the use of neutrons for the study of materials.

The science of measurement

New knowledge in every field almost always depends on metrology – the science of measurement. Virtually every experiment requires quantification of attributes, such as mass, length, voltage or chemical concentration. Today, metrology faces new and exciting challenges from fields such as nanotechnology, where quantities and distances to measure are vanishingly small. The science of metrology continues to push these boundaries.

NRC, through its Institute for National Measurement Standards (NRC-INMS), develops state-of-the art instrumentation for custom measurement and carries out extensive research both in-house and in partnerships worldwide.

Time to a half a million billionth of a second

NRC-INMS is part of a small group of scientists worldwide that is contributing to a new, revolutionary way of making connections between time signals and the oscillation of light waves by using ultra-fast laser systems. Pulsed optical lasers allow time to be divided up into smaller and smaller increments with an accuracy that paves the way for new directions in science and measurement, including optical atomic clocks and a closer probing of the limits of current scientific theories of the universe.

Measuring hole positions – improved high-tech device quality

Researchers have devised a custom non-contact method to measure the hole position and diameter in miniature fibre-optic connectors – to 100 nm uncertainty. This work is particularly important to manufacturers and users of micro-sized devices, and should lead to improved quality for Canadian high-tech sector products.

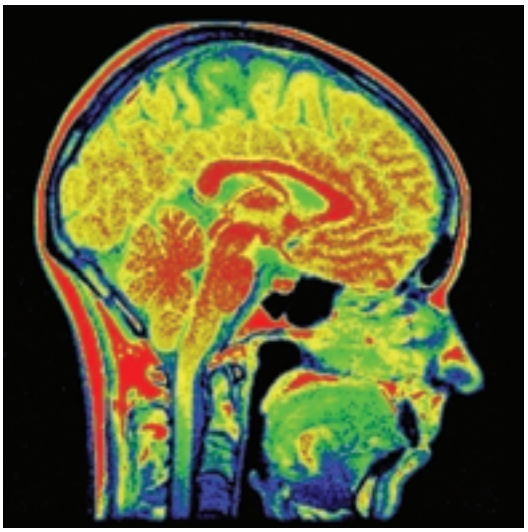
Advances in biotechnology

Biotechnology is a vital field of R&D for Canada. NRC has organized its biotechnology strengths into a strategic group including plant biotechnology, marine biosciences, biotechnology research, biodiagnostics and biological sciences. NRC's capacities in other fields – such as IT, new materials, manufacturing technologies, nanotechnology, metrology and others – are coupled with dedicated biotechnology resources to address critical issues in health, the environment, agriculture and other fields of importance to Canadians. Working with public, private and academic organizations, NRC made significant biotechnology R&D breakthroughs in 2001-2002.

Saving lives – new test for colon cancer

A new, inexpensive, non-invasive and almost foolproof test developed at the NRC Institute for Biodiagnostics (NRC-IBD), could prevent thousands of deaths through earlier detection of colon cancer. The test, which involves analysis of stool samples using a magnetic resonance spectroscopy machine linked to special computer software, is 98 percent accurate.

Until now, screening techniques were only 50 to 75 percent accurate. Costs are also much less (about $25) compared with the current diagnostic technique, endoscopy, at more than $1,000 per patient. To move the technology quickly into commercial use, NRC entered into negotiations with a German company to produce the equipment, while a new NRC spin-off company will sell the software and technique to hospitals.



New technique to evaluate spinal cord injury and function

NRC-IBD has developed a non-invasive functional magnetic resonance imaging (fMRI) technique that can be used to assess spinal cord function and evaluate spinal cord injuries or changes that result from disease and treatment. Researchers can record fMRI images to "see" changes in the distribution of oxygenated blood that tell them how the spinal cord is functioning. There are now some 35,000 Canadians living with spinal cord injuries.

Algal bloom monitoring system

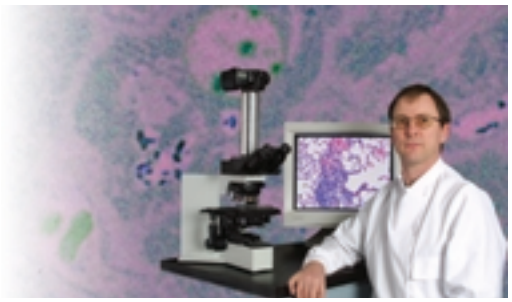
Researchers at the NRC Institute for Marine Biosciences (NRC-IMB) are developing an optical sensing system to detect harmful algal blooms and monitor coastal zones to improve coastal management. A Canadian company, Satlantic, is working with NRC to develop the system for sales in France, Ireland, the United States and South Africa.

Better canola – better markets

Scientists at the NRC Plant Biotechnology Institute (NRC-PBI) have developed canola seed with far less anti-nutritional substances – sinapine and the seed phosphorus storage compound, phytate. This important scientific advancement will be commercialized through conventional breeding and selection of superior cultivars. Dow AgroSciences will use the research as the basis for breeding improved canola cultivars, a superior product that will provide the company with an important competitive advantage.

Combating the threat of bioterrorism

Following a global competition, the U.S. National Institutes of Health (NIH) awarded a $2 million grant to a team from NRC for research to support the overall effort to combat bioterrorism. The funding will be used to develop a vaccine against a highly virulent bacterium recognized as a potential biological warfare agent. NRC's success was due in large part to its patented novel vaccine delivery system and its demonstrated expertise, facilities, and equipment for cutting-edge vaccine research.

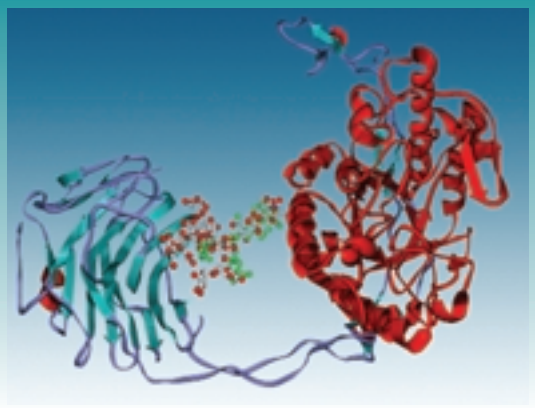


Decontaminating explosive soils

Researchers at the NRC Biotechnology Research Institute (NRC-BRI) have developed soil quality guidelines for TNT-contaminated soils. These tools will help environmental risk assessors and managers of sites contaminated with explosives to determine "how clean is clean." The work, carried out in collaboration with the Defence Research Establishment in Valcartier and government agencies from the United States, the United Kingdom and Australia, will facilitate the management of munitions-contaminated sites, such as military training areas as well as production and disposal sites.

Protein folding – better understanding of diseases

Molecular biologists from the NRC-BRI, working in collaboration with McGill University, have moved a step closer to understanding exactly how proteins are folded and how a particular molecular machine, known as the calnexin cycle, actually "chaperones" the activity. This finding has important implications for diseases, such as cystic fibrosis, hereditary emphysema and other genetic diseases. Decoding the structure of calnexin, a key protein involved in protein folding and quality control, is the culmination of a ten-year research effort by the team.



Advances in engineering and construction

NRC's R&D in engineering and construction focuses on the needs of Canada's aerospace, construction and ocean engineering communities – key sectors for Canada's economic growth and prosperity.

NRC's aerospace R&D

The aerospace industry remains one of the major industrial success stories for Canada. The manufacturing component of the industry currently stands in third place in the world in terms of sales. Canada is a world market leader in regional and business aircraft, commercial helicopters, gas turbine engines, landing gear, flight simulators, and aircraft guidance and control systems. The NRC Institute for Aerospace Research (NRC-IAR) has served this vital industry sector for over 50 years with leading-edge research and development services.

Safer landing gear coatings

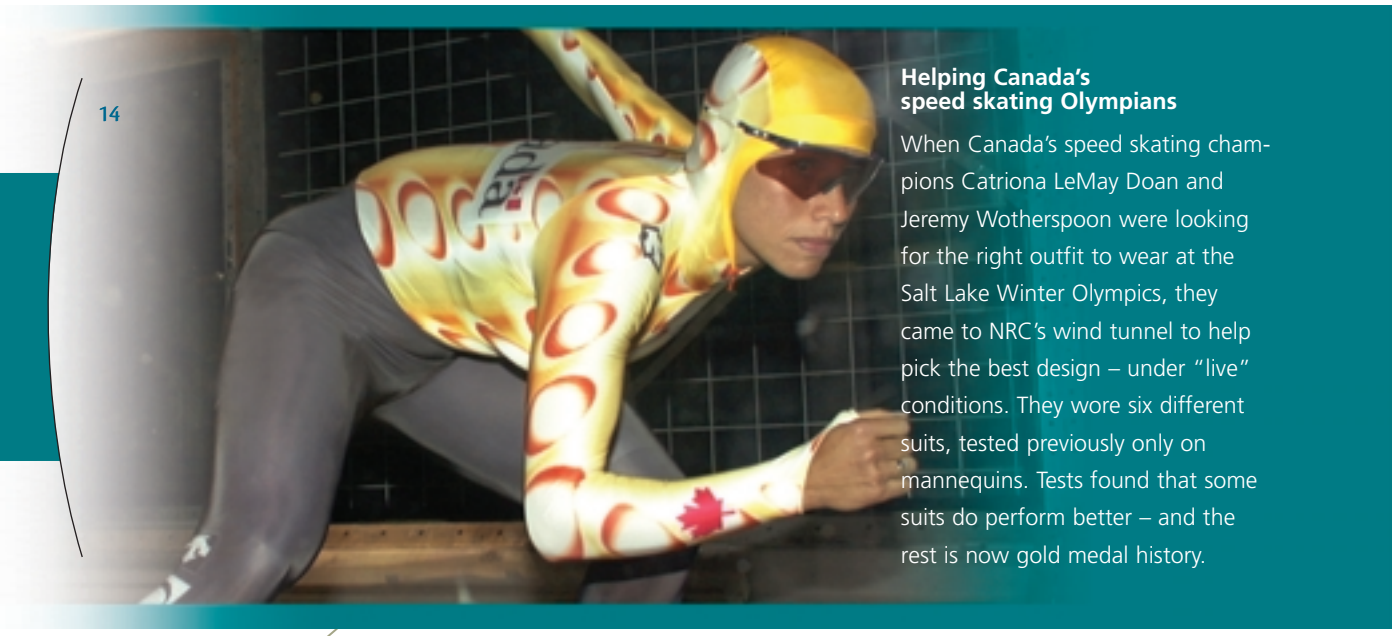
From stainless steel cutlery to prosthetic hip and knee replacements, chromium has become a part of our daily lives. In its solid form, chromium is harmless. But hexavalent chromium – a form associated with the electroplating process that produces the hard coating protecting aircraft landing gear components from corrosion and wear – is carcinogenic and can cause a host of health problems. The best alternative technology to chromium is a deposition of a cermet (ceramic/metal composite) coating that is better for the environment and offers potential cost and time savings. Working in partnership with Orenda Aerospace Corporation, Vac-Aero International, the Department of National Defence and NRC-IMI, NRC-IAR is evaluating new cermet coatings to develop the coating process, processing conditions and product quality.

Dynamic model test for world's longest cable-stayed bridge

Scientists at NRC-IAR successfully completed high-Reynolds number testing in its wind tunnels of a dynamic model of the Stonecutters' Bridge scheduled for construction in Hong Kong. Aeroelastic testing conducted for this project was used to break new ground in bridge aerodynamics. The bridge will be the longest cable-stayed bridge in the world when completed.

Measuring greenhouse gases

NRC's aerospace team has a long history of research related to climate change and the environment. In the second year of a program funded by the Canadian Climate Action Fund, the team used its expertise and experimental Twin Otter aircraft to successfully measure the spring burst of N_2O from agricultural lands in Eastern Ontario and Northern Saskatchewan. N_2O is an important greenhouse gas with 310 times the warming potential of CO_2, and one that might be controllable through modified farming practices. The research addresses Canadian targets established in the Kyoto Protocol.



Helping Canada's speed skating Olympians

When Canada's speed skating champions Catriona LeMay Doan and Jeremy Wotherspoon were looking for the right outfit to wear at the Salt Lake Winter Olympics, they came to NRC's wind tunnel to help pick the best design – under "live" conditions. They wore six different suits, tested previously only on mannequins. Tests found that some suits do perform better – and the rest is now gold medal history.

New aircraft maintenance and repair technology for industry

Working with the United States Air Force, the Department of National Defence and CMP Ltd., NRC-IAR has made substantial progress in using a retrogression and re-aging heat treatment process to increase the corrosion resistance of selected aluminium alloys. The major beneficiary will be Canadian aircraft maintenance and repair organizations, most of which are SMEs, since the new technology will open new markets.

NRC's construction R&D

The construction industry is one of Canada's largest, with over 850,000 people employed by some 215,000 firms. Comprised primarily of small companies, innovation in this sector poses special challenges. R&D and construction codes and standards are critical to this sector to lower transaction costs, facilitate technology diffusion and help reduce trade barriers to improve industry access to global markets.

New cement – cleaner environment

The manufacture of cement generates carbon dioxide and produces millions of tonnes of cement kiln dust (CKD) annually in Canada. The accumulated CKD may contain extremely alkaline materials and heavy metals, such as lead and cadmium, and has been unusable in cement manufacturing. The NRC Institute for Research in Construction (NRC-IRC) has produced blended cement containing significant amounts of CKD that demonstrate excellent strength characteristics. They are working to encapsulate and chemically bind trace metal elements in CKD to keep them from leaching.

Understanding water pipe corrosion – better city infrastructure

Each year, cities in Canada and the U.S. experience thousands of failures in small grey cast-iron pipes. Now, thanks to a three-year collaborative research project with the American Water Works Research Foundation, NRC-IRC is working to build a new understanding of the effects of corrosion pitting on the performance and failure of these pipes. Findings from the research will help utility managers in making decisions about repair and replacement of water mains and make for safer and more cost-effective water supplies for Canadian municipalities.

Burning up the town – in the name of science

The abandoned town of Kemano, B.C., has gone up in flames and NRC was on hand to take full advantage of the research opportunities hidden in the smoke and fire. Kemano was a company town built by Alcan to support a regional hydroelectric station. When the station was automated, the town became obsolete and was donated to B.C.'s fire services for fire research and training. The 40 abandoned houses filled with donated furniture and props made an ideal, full-scale experimental fire research site. Working with the B.C. Fire Commissioner's Office, NRC's research team completed two rounds of tests. The first studied the response of smoke detectors in the homes, while the second evaluated the performance of residential plastic sprinkler systems. The lessons learned will help protect Canadians from fire for years to come.

Reducing aircraft noise in homes

NRC-IRC researchers have developed a computer tool that lets the user hear how noise changes within a building as an aircraft passes by. The tool allows the user to assess the effects of changing a building location and construction details on the acoustic comfort of occupants. City planners and developers can now optimize the use of the valuable real estate around airports as well as assess the impact of airport extensions, new airplanes and changes in air traffic patterns.

NRC's ocean engineering R&D

NRC works with marine regulatory bodies, marine system designers, manufacturers and operators and the defence community to ensure that Canada's ocean engineering businesses and operations are safe, environmentally friendly and competitive. Research at the NRC Institute for Marine Dynamics (NRC-IMD) provides industry with a unique concentration of knowledge, facilities and technologies to solve engineering challenges related to Canada's ocean environments.

Bergy bits and bumper cars

NRC-IMD carried out a field program to investigate the impact of ships colliding with small icebergs in 2001. At NRC's request, the Captain of the CCGS Terry Fox commanded a voyage that went against everything he'd been trained to do: he deliberately rammed his 88-metre vessel into small icebergs. NRC used the icebreaker like a high-tech bumper car to gather first-hand information on the effects of collisions with bergy bits – house-sized icebergs that are hard to see in rough weather and often go undetected. As oil and gas development and tanker traffic off Canada's east coast increases, the information from this research will help oil companies better design tanker hulls. It will also help define the guidelines that set out the sizes of "bergies" that are safe to strike and the speeds at which ships can safely travel.

With the strongest icebreaker hull in the Canadian Coast Guard's fleet, the CCGS Terry Fox was the perfect vessel for NRC's ice-ship interaction research.

NRC continued its research into lifeboat evacuation capabilities. Research included an evaluation of the "Twin Falls Davit" system used on floating and fixed installations to determine the best height of deployment, platform clearance and orientation.

Technology

Wave impact and scaling – better ship design and safety

Ocean waves exert a variety of loads on ships' hulls. Accurately predicting these loads helps researchers understand the amount of load a ship's structure is able to withstand. NRC-IMD is working with DND's Defence Research Establishment Atlantic to study hydrodynamic load data, using numerical simulations applied to a naval frigate and a vehicle ferry. The objective is to help ship designers meet requirements for maximum strength with minimum weight and cost in 2001.

Safer lifeboat evacuation and rescue research

An NRC research program to evaluate lifeboat evacuation capabilities as a function of weather conditions and to develop appropriate measures of performance, moved into its final stages in 2001-2002. Studies assessed the entire lifeboat launch process – from lowering and splash down to sail away – and evaluated the performance of an evacuation system used on a fixed petroleum installation. As a result of this research, NRC has applied for a patent for a launch-wave synchronizing technology. The research will also be used in the development of new performance-based regulations for evacuation systems.

Advances in information and communications technologies

The information and communications technologies (ICT) sector contributes some $58 billion to Canada's GDP and represents more than 6 percent of the total economy. In 2000, the sector employed over 580,000 people, nearly 4 percent of economy-wide employment. ICT expenditures on R&D reached over $5 billion in 2001, accounting for more than 45 percent of total private sector R&D in Canada. NRC's R&D continued to play a vital, cross-sector role in 2001-2002 with major advances in hardware, software, information processing, and fundamental enabling and next-generation technologies.

Human-computer interaction program underway

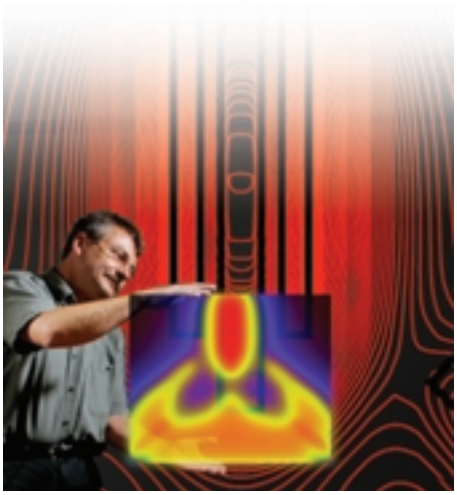
The NRC Institute for Information Technology (NRC-IIT) has set up a multi-disciplinary human-computer interaction (HCI) program, bringing together expertise in human factors, computing science, information science, experimental psychology and cognitive psychology. Research is now underway with the private sector, government and universities to investigate key issues in HCI. NRC is also spearheading the initiative to form a national HCI research community. One project has already resulted in the "Nouse" program, which allows people to use a camera to control a computer mouse by moving their head. A number of prototype applications have been developed that have potential for the gaming industry, persons with disabilities and surveillance.

Tele-oncology project for New Brunswick

NRC-IIT's e-Business team in New Brunswick is helping deliver a major health research initiative with four hospital corporations, three Aboriginal communities, the province's Department of Health and Wellness, the Université de Moncton and others. Researchers are working to develop an efficient, comprehensive cervical cancer screening system in the province to reduce the incidence and mortality of this disease.

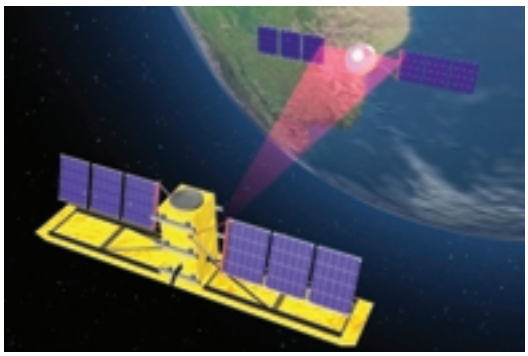
"Nanospintronics" – opening new horizons for IT and electronics

Researchers at the NRC Institute for Microstructural Sciences (NRC-IMS) have invented a new type of nanoscale transistor based on "spintronics." The device employs a new principle for controlling and switching electrical current based on electron "spin." The new transistor is made from a "quantum dot" – a type of electrical well or mound that holds only a few electrons. While this breakthrough cannot yet be incorporated in any practical device, the research opens the way for quantum computing and, further down the road, optical memory. If the potential of quantum dots and nanospintronics is realized, an incredible amount of information could be contained in one device and then programmed to interact with other such devices – ushering in a world where the computing power now contained in a series of computers could be contained in a single, very small and inexpensive device.



ROSA success opens new doors for Canada in space exploration

Using technology developed by NRC-IIT, MD Robotics made a technological leap in the area of visual perception and autonomous service of space vehicles as part of the ROSA – Remote Operation with Supervised Autonomy – project. The new technology positions Canada as the leading partner in intelligent visual surveillance in space missions. In this project, robotic equipment demonstrated intelligent autonomy while operating remotely in space. The new technology holds great economic potential since spacecraft components can be upgraded or reconfigured rather than replacing whole satellites.



3D laser scanning technology tested on space shuttle

NRC's internationally recognized 3D laser scanning technology underwent its first on-orbit testing aboard NASA's Space Shuttle. Researchers successfully demonstrated that a prototype could automatically track moving targets and operate under the extreme lighting conditions found in space. The development and testing of this new technology marked another milestone in Canada's ongoing contributions to space exploration. The first Canadarm and the current space vision system – used in some 20 past missions – are both products of NRC research. This new 3D technology has the potential of becoming the new "eye" of Canadarm II. The new 3D laser camera marks a scientific breakthrough. It is the first laser tracking system that can simultaneously digitize in 3D, detect surface defects, track geometrical features in real time and remain immune to extreme lighting conditions.

Cutting costs – reducing wear for the resources sector

The NRC Innovation Centre (NRC-IC) in Vancouver is helping Canada's resources sector cut costs by reducing wear and tear on equipment. Working on behalf of the Mining Wear Resistance Materials Consortium – an affiliation of NRC, two universities and nine private firms from Australia and Canada, including oil sands giant Syncrude, the researchers are unravelling the mysteries of friction and wear. This R&D has a major impact, allowing firms that mine the oil sands, for example, to cut their overall production expenses significantly.

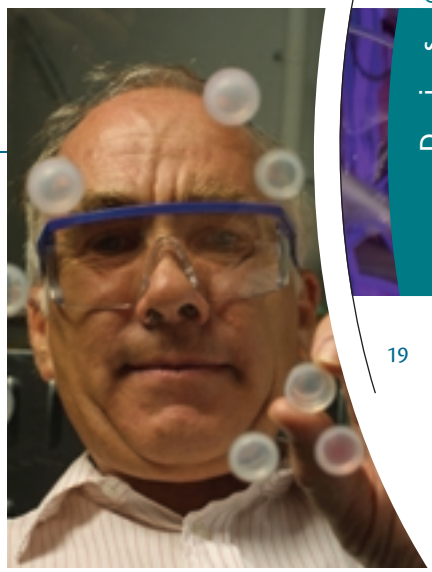
Image courtesy Syncrude Canada Ltd.

Advances in manufacturing

Manufacturing remains one of Canada's major economic forces, touching virtually every sector of the economy. NRC's R&D programs are targeted to help manufacturers increase their competitiveness and improve the commercial viability of products and services. The programs also help manufacturers create and adapt to new technologies, materials and processes, and meet their environmental responsibilities.

Refining processes for food industries

Researchers at the NRC Institute for Chemical Processes and Environmental Technologies (NRC-ICPET) collaborated with Montréal-based Colarôme Incorporated, helping the company improve its processing system for refining food grade colours from vegetable extract. Process modifications included replacing a biological processing stage with a physico-chemical stage. The modifications, successfully implemented on-site, reduced the number of process stages, decreased processing time by 33 percent, and improved product quality.



Artificial cornea research moves forward

NRC-ICPET researchers, working in collaboration with the University of Ottawa's Eye Institute and other partners, are developing new biosynthetic polymers for use in tissue engineered (TE) corneas. The challenge is to develop a family of synthetic materials that can be made into TE corneas strong enough for transplantation, transparent enough to mimic natural corneas, and resistant to biodegradation and rejection by the body's immune system. So far, they have developed a series of biosynthetic polymers that can be tolerated by living cell tissue and modified to improve the strength of the material and cell adhesion. They have advanced cell biology to the point where both nerve cell and blood vessel ingrowth were demonstrated. And, the team has been successful in developing procedures that allow the production of transparent, collagen-based polymeric materials to produce artificial corneas.

Environmentally friendly, efficient insulation

Researchers at the NRC Industrial Materials Institute (NRC-IMI) have helped RTICA Corporation bring a new thermal and acoustical insulation to market. The new insulation is made of 100 percent recycled plastic, has a 25 percent better thermal insulating efficiency than conventional fibreglass and cellulose insulation, and poses no health risk to installers or users. RTICA Corporation has spun off a new company to commercialize this NRC technology.

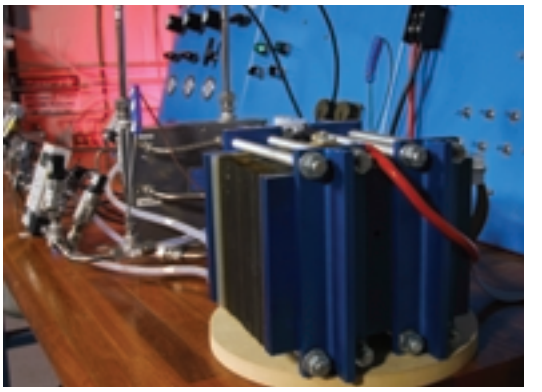
Prototypes for mine design

Researchers at the NRC Integrated Manufacturing Technologies Institute (NRC-IMTI) have developed a design and manufacturing process for constructing prototypes and models of mine design and their operational components. This is a brand new application for rapid prototyping that opens the door for many other potential applications in mining and natural resources exploration.

Advances across-the-board in fuel cells R&D

NRC's National Fuel Cells Program combines strengths and expertise from across its institutes and centres in 12 R&D initiatives targeted to help the development of this emerging industry in Canada. Working in partnership with industry, universities and public organizations in Canada and abroad, the program integrates R&D efforts in materials, engineering, fuels and fuel processing, prototyping, systems testing and evaluation, and systems technology evaluation. In 2001-2002, NRC made advances on a number of key fronts in fuel cells R&D:

- The fabrication and production of new cathode materials that offer possibilities for higher performance materials for both the fuel cell and batteries industries
- Developments in oxide and bi-metallic alloy coatings for electrodes for organic acid and direct methanol oxidation that promise improved removal of organic pollutants and direct methanol fuel cells
- Development of a first-generation micro fuel cell as part of NRC's Micro Fuel Cells Program – a collaboration of NRC institutes, Simon Fraser University and its newest partner, the Micro-Nanotechnology Research Centre of Tsinghua University, China
- Development of an analog multiplexer and differential amplifier technique that can scan every cell voltage of a fuel cell stack – a breakthrough that allows fuel cell performance monitoring and improved fuel cell safety
- Development of a novel, multi-stage, non-mechanical hydrogen compressor that can replace traditional mechanical gas compressors, leading to reduced costs and more economical fuel cells
- Invention of a new modelling and simulation tool for the design and development of fuel cell-based hybrid power systems – a development with wide application for fuel cell developers and utility companies
- Research into the potential use of farm wastes such as pig manure, as a biomass-based source of fuel for fuel cells.



Innovation

Value for Canada

Taking technology to market

"Canada must become more innovative if we are to continue to build on our economic and social foundation…We need to find ways to create knowledge and bring it to market more quickly…"

The Honourable Allan Rock
MINISTER OF INDUSTRY

Research creates new ideas and advances the frontiers of knowledge. To put this knowledge to work, it must be transformed into new technologies, new products and new services for the global marketplace.

Research turns money into knowledge… innovation turns knowledge into money.

NRC promotes innovation and creates value for Canada in many ways. It not only enhances Canada's R&D performance, it also develops and uses the cornerstones of wealth creation – new technologies and technology-based enterprises, technology transfer mechanisms, and knowledge transfer and dissemination systems. NRC strengthens Canada's innovation system, works to attract foreign direct investment in technology-based firms,

"An innovative economy is driven by research and development… To secure our continued success in the 21st century, Canadians must be among the first to integrate new knowledge and put it to use."

Speech from the Throne
JANUARY 30, 2001

and helps build the innovation capacity of Canadian businesses.

In all its programs and activities, NRC takes an aggressive, entrepreneurial approach to stimulate the innovation that Canada and Canadian firms need to succeed in the global knowledge economy. The approach is designed to gain the most benefit and leverage from the knowledge and technologies NRC generates. It ensures that NRC can work effectively to meet industry needs and match the capabilities of firms taking technologies to the market. From collaborative R&D through to licensing, the creation of new enterprises, and industrial research assistance and support, NRC supports wealth creation through innovation.

NRC : Innovation snap shot 2001-2002
Creating value through NRC technologies

Discoveries
- 180 patent applications
- 65 patents issued

Technologies transferred to the marketplace
- 51 licenses signed
- licensing revenue – $3.8 million
- 256 active license agreements

Research partnerships
- 362 collaborations with industry
- 152 collaborations with universities
- 186 collaborations with other public organizations

New companies created*
- Capital Laser Inc.
- Ionalytics Corporation
- NavSim Technology Inc.

* nine companies in spin-off pipeline

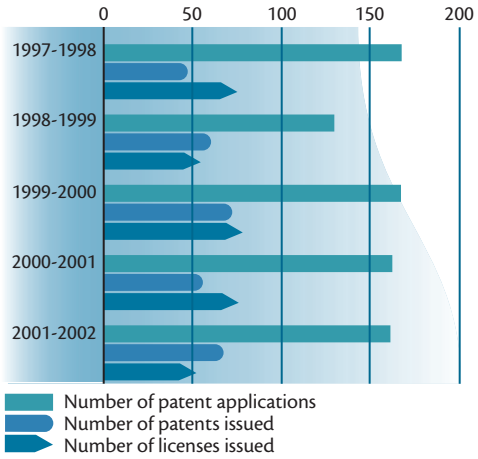
NRC industry partnership facility (IPF) and incubation program
- 71 companies incubating at NRC
- New IPFs under construction: Fredericton, Boucherville, Saskatoon, Penticton, Vancouver, Victoria. Planning underway for IPFs in St. John's, Halifax, Winnipeg, Edmonton.

Intellectual property

The importance of new knowledge, managed effectively by organizations as intellectual property (IP), has grown dramatically in the past decade. Original discoveries, know-how, software and new technologies – protected by patent or copyright – are the foundations for new products, process innovations and commercialization in the world's marketplaces.

To ensure its new discoveries make the most impact in terms of value creation for Canada, NRC chooses the best route to develop and exploit its knowledge resources. Over the past several years, NRC has developed a collection of proven IP management tools and practices that guide the evaluation, protection, exploitation and transfer of technologies to receptor firms. As a result, annual NRC patent applications have grown more than 50 percent over the past five years, and licensing of these discoveries has continued apace.

NRC patents and licenses



Collaborations and partnerships

One of the best ways to transfer knowledge is through collaborative research. NRC teams up with industrial and university partners to create new technologies and improve existing products and services.

NRC partnerships and agreements

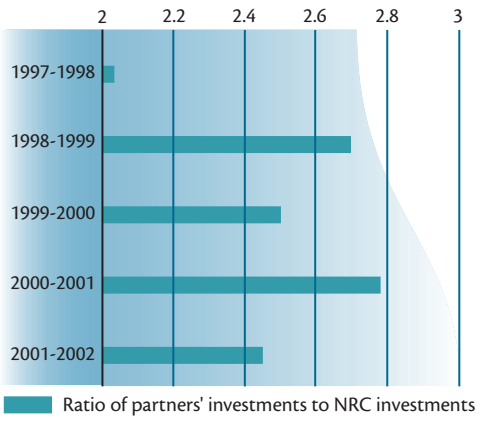
Under such agreements, both sides share funding and management of medium-to-long-term research. Partners are engaged early to ensure that projects align with their needs, the needs of the marketplace and NRC needs. Partners work side-by-side with NRC researchers, increasing the technical expertise of the firm, ensuring that NRC is plugged into marketplace realities, and improving the odds for commercial success. Collaborations range from projects with single companies to multi-partner arrangements with small and larger firms, as well as university partners and all three levels of government.

Over the past five years, NRC partnerships with industry have doubled, those with public organizations have nearly tripled, and those with universities have grown five-fold. The value of agreements and collaborations reached some $401 million in 2001-2002.

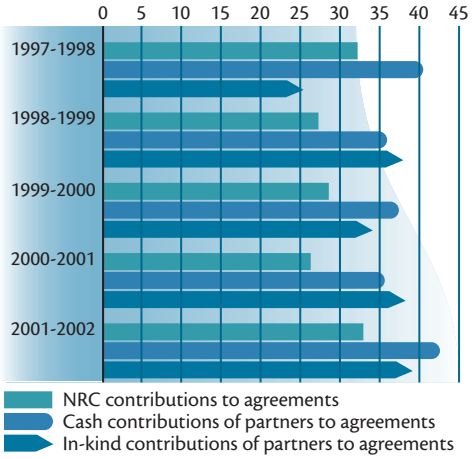
With its long-standing track record for excellence in R&D and new technology creation, opportunities to collaborate with NRC are of great interest to industrial and other partners. The investments made by NRC are heavily leveraged on behalf of taxpayers. In fiscal year 2001-2002, partner contributions totalled 2.48 dollars for each dollar invested by NRC.

Intellectual property (IP) is frequently generated through collaborations. Often, NRC, on behalf of the Government of Canada, retains the IP, while partners hold licenses (some exclusive) negotiated in advance to exploit and manage the technology. When it is in the best interests of both parties, IP may be assigned to the partner organization.

Leverage impacts of NRC investments



Contributions to NRC agreements ($ millions)



Licensing

In moving its discoveries to the marketplace, NRC seeks out industrial firms best positioned to exploit the technologies it has developed. License agreements are generally granted in return for up-front payments and/or royalties based on sales. Often, licensing agreements arise from collaborative research; in such cases the terms of the agreement reflect a client's contribution in developing the technology. A single technology may also be licensed to several clients for different fields of application. In all cases, licensing revenues flow back to NRC – benefiting Canadians. NRC reinvests these revenues in its R&D programs to continue the cycle from discovery, to innovation, to market – creating new economic wealth for Canada.

In 2001-2002, NRC formalized 51 licensing agreements and received revenues from licensing of just over $3.8 million.

NRC had a number of successful research collaborations and licensing arrangements in 2001-2002, as the following examples demonstrate.

NRC and Imperial Oil maximize use of scarce resources

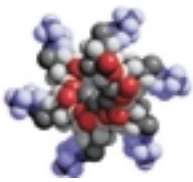
Imperial Oil Ltd. signed a license agreement with NRC to use NRC-ICPET's patented fluid coker feed nozzle technology for petrochemical processing. The system, jointly developed with Syncrude Canada Ltd., was originally intended for oil sands processing in coker reactors to increase the yield of synthetic crude oil. However, as an alternate application, Imperial Oil has incorporated the technology in its Sarnia operation to upgrade lower quality residuals from the primary refining process in a similar coker. The result is reduced waste and up to 20,000 bbl/day of a value-added, higher-grade petroleum product, representing at least a one percent increase in coker liquid yield.

NRC licensing revenues ($ thousands)

1995-1996	1,154
1996-1997	802
1997-1998	2,121
1998-1999	1,685
1999-2000	1,117
2000-2001	4,904
2001-2002	3,840

TOTAL LICENSING REVENUES FROM INTELLECTUAL PROPERTY

Meningitis-C vaccine approved for Canada



On January 14, 2002, NRC and its partners – Shire Biologics and Baxter Corporation – celebrated the launch of a major breakthrough in vaccine technology with the approval by Health Canada of the Neis Vac-C vaccine developed at NRC. Neis Vac-C is a new, highly effective vaccine that protects people of all ages, including children as young as two months of age, against Meningitis-C. The vaccine's capacity to effectively protect very young children, the group hardest hit by Meningitis-C, sets Neis Vac-C apart from traditional vaccines used in North America. The vaccine was originally launched in Britain and will continue to be introduced in other parts of the world in 2003-2004. This NRC vaccine technology generated a single royalty payment to NRC of almost $3 million – the highest ever made to a federal government organization.

Broadband Visual Communications – reaching out across Canada

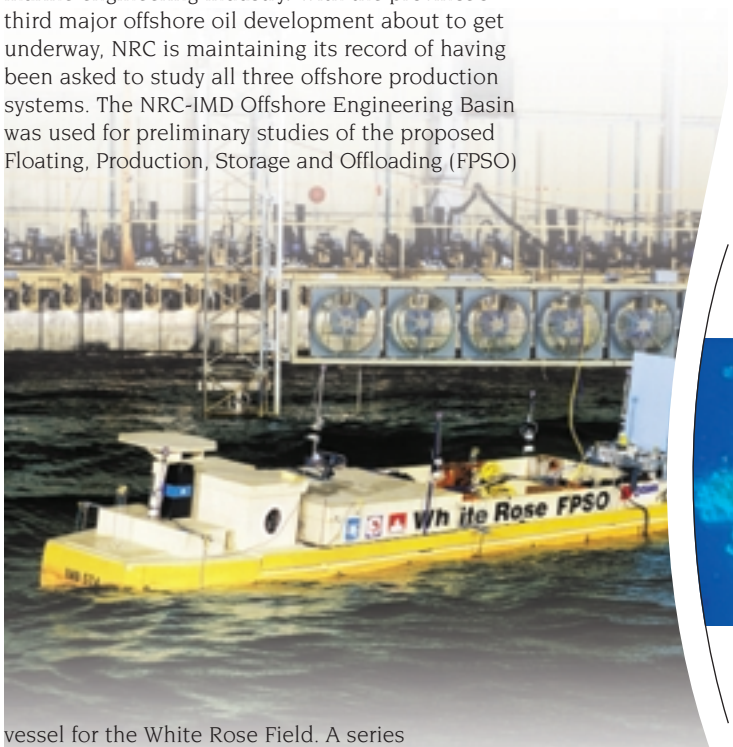
NRC formed its Broadband Visual Communications Research Project (BVC) in 2001 as an outgrowth of its ongoing research into broadband applications for learning. This program involves collaborations with the National Arts Centre (NAC), the Communications Research Centre (CRC), the University of Ottawa, CANARIE, McGill University and the Manhattan School of Music. The program focuses on visual and interactive capabilities unique to broadband with a particular emphasis on the environments and applications that bring people together across distance and time. The program supports three learning communities: advanced violin students working with NAC music director Pinchas Zukerman; high school students engaged in project-based learning in eight broad-band-connected schools across Canada; and high school teachers involved in professional development.

"Science studies what is, technology creates what has never been."

Dr. Theodore von Karman
1881 – 1963

White Rose oil field platform test

Offshore oil field development is important to Newfoundland's economy and the future of its marine engineering industry. With the province's third major offshore oil development about to get underway, NRC is maintaining its record of having been asked to study all three offshore production systems. The NRC-IMD Offshore Engineering Basin was used for preliminary studies of the proposed Floating, Production, Storage and Offloading (FPSO) vessel for the White Rose Field. A series of model tests were conducted involving the producers, Oceanic Consulting, and NRC to measure mooring loads, green water and other factors affecting the FPSO in the field. NRC was the site for extensive testing of the Hibernia Gravity Base Structure that has operated successfully since 1996, the Terra Nova FPSO deployed in 2001, and the Cohasset-Panuke project.



NRC and Dow AgroSciences – battling *E.coli* on a new front

NRC has signed a two-year agreement with Dow AgroSciences Canada aimed at eliminating dangerous *E.coli 0157* outbreaks, such as the Walkerton, Ontario tragedy. The research focuses on including an antibody in cattle feeds, which will lead to the elimination of *E.coli 0157* from cattle digestive systems. The new *E.coli* research agreement follows a collaboration signed in 2000-2001 with Foragen Technologies to commercialize a live vaccine invented by NRC to eliminate *E.coli 0157* in cattle. NRC worked successfully with Dow AgroSciences before embarking on a $10 million strategic alliance with the company for research in canola seed quality, enabling plant biotechnologies, and plant resistance to insects and disease.

After hours – lights, camera, action

Creating economic value takes many forms at NRC – truly innovative, imaginative and occasionally, non-scientific forms. Following on the success of filming scenes for the feature film *Rare Birds* in 2001 at NRC-IMD facilities in Newfoundland, the film industry returned this year with two more productions. The first was *The Shipping News*, a big budget film that brought millions of dollars and hundreds of jobs to the fledgling local film industry. The second was the filming of two docu-dramas about the sinking of the Ocean Ranger and the 1997 Around the World Alone Sailing Race. NRC's world-class facilities were a major factor for producers in deciding to bring the productions to Newfoundland.

Incubators/co-location

Creating value for Canada also involves helping to grow new science and technology-based firms. Incubation not only accelerates the process of starting and growing such firms, but also helps them stay in business. According to a 1997 U.S. study on the impact of incubator investments, 87 percent of firms that were in incubators remained in business after the first three critical years.

Most of NRC's research institutes have industry partnership facilities (IPFs) or other means to incubate new, small, technology-based firms. These IPFs act as magnets that attract innovative firms to NRC. By co-locating with NRC, firms gain direct access to NRC's specialized facilities, the expertise of its researchers, extensive national and international networks, and its technology intelligence and knowledge dissemination resources.

In 2001-2002, 71 firms were incubating or co-located at NRC. New industry partnership facilities are being constructed in Fredericton, Boucherville, Saskatoon, Penticton, Vancouver and Victoria, with new IPFs on the drawing board for Halifax, Winnipeg, and Edmonton. Such facilities will be a part of any new NRC research facility in the future.

One of NRC's newest industry partnership facilities (IPFs), under construction at the NRC Plant Biotechnology Institute in Saskatoon. The facility, slated to open in fall 2002, will contribute to an emerging cluster in Saskatoon on crops for enhanced human health.

A graphic representation of NRC's future IPF at the NRC Institute for Biodiagnostics in Winnipeg. Construction is scheduled to begin in spring 2003, for completion in late 2004. The new facility will promote the development of medical device technologies manufacturing.

NRC spin-off firms 1997-2002

	Total new companies	Cumulative spin-off firms
1997-1998	7	21
1998-1999	10	31
1999-2000	9	40
2000-2001	9	49
2001-2002	3	52

Spin-off and start-up firms

Often the fastest and most effective way to commercialize a new technology or product is to create a new Canadian company. That venture can either be a spin-off firm (formed by NRC employees) or a start-up firm (created by non-NRC principals using NRC technologies). Since 1995-1996, NRC technologies have led to the creation of 52 new companies in Canada.

In 2001-2002, three new companies started up from NRC, with nine more in the spin-off pipeline awaiting formal "graduation." The three new NRC spin-off firms were:

- *Ionalytics Corporation* – Using NRC's high Field Asymmetric Waveform Ion Mobility Spectrometry (FAIMS) technology
- *Capital Laser Inc.* – Using NRC's Laser Micro-machining Technology
- *NavSim Technology Inc.* – Using NavSim™ ship manoeuvring simulation software from NRC.

Ionalytics Corporation – FAIMS moves to market

On November 22, 2001, NRC announced the creation of Ionalytics Corporation, a company spun off from NRC-INMS. Ionalytics has licensed NRC's FAIMS technology, which was developed in collaboration with MDS-Sciex, a manufacturer of mass spectrometry equipment based in Toronto. The new firm will design and manufacture FAIMS chemical analysis systems as accessories for the mass spectrometers that are used in diverse fields. Application areas include biotechnology (proteomics and drug discovery), security (detection of chemical and biological agents), and the monitoring of environmental wastes. The company has already acquired a start-up investment of $2 million from Genesys Capital Partners Inc. of Toronto, a venture capital firm specializing in funding of biotechnology companies.

"MDS Sciex has worked with various institutes of the National Research Council… for the past 20 years and we owe much of our success to that enduring relationship. We look forward to extending our collaborative efforts… to include Ionalytics, and we will certainly support their continued development of the FAIMS technology."

Bill Davidson
V.P. SCIENCE AND TECHNOLOGY
MDS-SCIEX

Capital Laser – laser micro-machining to go commercial

Capital Laser is a spin-off firm from NRC-IMTI in London, Ontario, created to commercialize NRC's IP in laser micro-machining technology. The firm is incubating at NRC's London facility during its start-up phase, a term expected to last for 12 months. The co-location will be crucial to the new firm since NRC's contribution to the company is mainly in the form of trade secrets.

NavSim Technology Inc. – helping ships navigate the world

NavSim Technology Inc. (NSTI) is a spin-off firm taking an integrated navigation system to market. The system includes an advanced and unmatched version of *AutoPilot* that will be useful to ships, both large and small as well as fishing boats. It also includes an electronic chart and display information system, grounding and collision avoidance systems, route planning and dynamic position components. The product will be a compact system designed to integrate available global navigation systems within laptop computers. The company plans to have the first CD available for market this year. NSTI started with six employees.

NRC bucking the trend in new ventures

The probability of success of a new venture, whether a spin-off or start-up firm, is low. According to Statistics Canada, 80 percent of new firms will fail within their first ten years. Of ten new ventures funded by venture capitalists, only one is expected to be a true success; the rest either fail or exhibit only slow growth.

In contrast to this rather bleak picture, NRC spin-offs since 1995-1996 are thriving. Of the 52 created, 49 companies, or nearly 96 percent, have survived and most of these are prospering.

Venture capital funding – over $220 million in five years

The past two years have seen a downturn in both investment and employment in Canada's high-tech sector. According to a recent report by MacDonald and Associates, the number of venture capital deals in Canada dropped 27 percent and the amount committed dropped 15 percent. In contrast, over the same period, the number of venture capital deals with NRC spin-offs has almost doubled, and the amount invested has increased. Even in the last six months, new deals were signed for over $2 million, with follow-on deals of over $50 million.

"Genesys Capital Partners Inc. invests directly in research-oriented biotechnology companies with a focus on genomics and proteomics technologies, late-stage clinical products, speciality pharma and e-health. We were on the lookout for new technology in the NRC laboratories when we came across the FAIMS research team and decided to invest in this promising company."

Damian Lamb
MANAGING DIRECTOR
GENESYS CAPITAL PARTNERS INC.

Some NRC spin-offs to watch

- *IatroQuest* – spun off in 1998 to commercialize technology for the virtually instantaneous detection of chemical and biological toxins, the firm received almost $5 million in venture capital funding in 2001. The company is developing unique, miniaturized sensing and diagnostic systems for defence and peacekeeping, medical diagnostics and environmental monitoring applications

- *SiGe Semiconductor* – this 1997 NRC spin-off firm develops specialized chips for high-speed semiconductors that are being incorporated into devices shipped by a number of leading wireless manufacturers. SiGe raised almost $40 million of additional venture capital in 2000, with almost $8 million in follow-on financing in 2001
- *Metro Photonics* – this spin-off firm landed $62.5 million in a single round of financing to support its push to develop fibre-optic gear for the metropolitan-level network market.
- *NovaDAQ Technologies* – spun off in 2001, this firm has developed a unique digital laser imaging system, a fluorescent imaging technology that uses a specialized dye for imaging techniques in cardiac surgery. The company formed an alliance with Akorn Inc., a pharmaceutical firm, and received initial venture capital funding in 2001. Pre-clinical trials are underway and a submission to the U.S. Food and Drug Administration is being developed.

Increasing innovation capabilities of Canada's SMEs

Canada's nearly two million small and medium-sized enterprises – SMEs – are the key drivers of job and wealth creation in all sectors of the nation's economy. One of NRC's primary objectives in stimulating wealth creation in Canada is to link its diverse networks, programs and infrastructure to SMEs to help them access, develop and exploit new technologies and knowledge essential for their growth and prosperity. NRC's primary vehicle for stimulating the innovation capabilities of SMEs is its Industrial Research Assistance Program (NRC-IRAP). Regarded worldwide as one of the best programs of its kind, NRC-IRAP is a vital component of NRC's innovation strategy and a cornerstone of Canada's innovation system.

This program stimulates wealth creation through technological innovation by providing technology advice, assistance and services to SMEs to help them build their innovation capacity. NRC-IRAP brings together a diverse network of organizations, services and programs to help Canadian SMEs develop and exploit technologies in the competitive, global, knowledge economy. Through expert technical and business advice, financial assistance, access to business information, contacts, and national and international networks, the program provides customized solutions to some 12,400 SMEs annually.

The program's success stems from its track record of customized services and the highly skilled people that deliver those services across Canada. Its 260 Industry Technology Advisors (ITAs) are a unique resource, the focal point of one-on-one relationships with companies that extend for years.

NRC-IRAP builds on this foundation of ITAs with other strengths. It plugs clients into NRC's extensive networks of knowledge, experience and contacts from "around the corner and around the globe." It partners with over 100 Network Member (NM) organizations at the regional level and has more than 1,000 public and private sector innovation service providers within its Canadian Technology Network (CTN) – all providing advice and assistance to SMEs.

NRC-IRAP – 2001-2002 performance highlights

In 2001-2002, NRC-IRAP's total level of activity was $149.65 million. It provided some 12,400 firms with customized information, advice and referral services. The program's total financial contributions to firms were $97.87 million, including $29.71 million in Technology Partnerships Canada funding on behalf of Industry Canada and $3.95 million in Youth Initiatives on behalf of Human Resources Development Canada. The contributions went to 2,841 SMEs for 3,271 innovation capacity building projects.

The program played a proactive role in identifying and facilitating potential SME partnerships, networks and multi-stakeholder interactions at the local, regional, national and international levels.

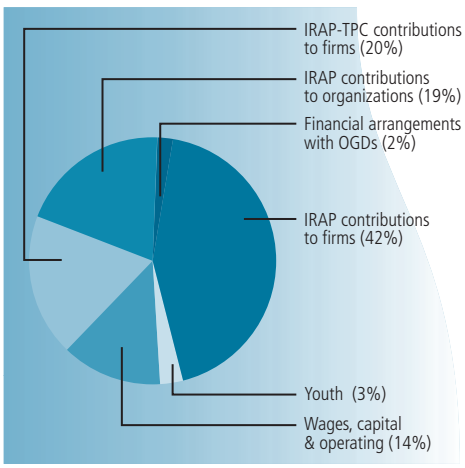
NRC-IRAP maintains a vital and growing network that includes more than 100 of Canada's leading public and private research and technology-based organizations. Organizations collaborate with NRC-IRAP to increase the innovative capability of SMEs through Technology Advisory Services, as well as other agreements for specific collaboration initiatives. These collaborations enhance client value-added services, strengthen national/local infrastructure, extend the program's reach, and bridge gaps in the program's capabilities by creating more innovation services for SMEs.

In 2001-2002, total contributions to NM organizations amounted to $23.52 million. NRC-IRAP also contributed a total of $4.31 million to CTN to address gaps in national, regional and community innovation systems. And, NRC-IRAP worked with local stakeholders across Canada to collectively improve understanding of the community technology cluster concept, reinforce the Government of Canada's innovation agenda, encourage more SMEs and local institutions to participate in cluster activities, and facilitate coordination among community players.

Delta, B.C.-based **Pure Logic Technologies Ltd**. is a consulting firm specializing in sawmill design engineering. In a collaboration brokered by NRC-IRAP, Pure Logic joined forces with the NRC Innovation Centre in Vancouver and the NRC Integrated Manufacturing Technologies Institute to develop *ForeSight* – an AutoCAD-based computer program that allows planners to design, build, and run a virtual sawmill – a first for the sawmill industry.

Cambridge, Ontario-based **Agribiotics Inc.** has moved onto the cutting edge of agricultural biotechnology by acquiring the rights to work with an "inoculant" strain of plant bacteria, originally discovered at the University of Wisconsin-Madison, that promises to improve the prospects of corn farmers around the world. Agribiotics was able to beat out several larger rivals and close a deal with the University in less than two weeks – thanks to the backing of NRC-IRAP and Technology Partnerships Canada.

NRC-IRAP total level of activity in 2001-2002
Total: $149.65 m



NRC-IRAP – new strategic plan on the way

In 2001-2002, NRC-IRAP began work to develop a new strategic plan to provide more benefits to SMEs. The strategy is built on a number of key elements that will strengthen the program further and move in new directions to promote innovation:

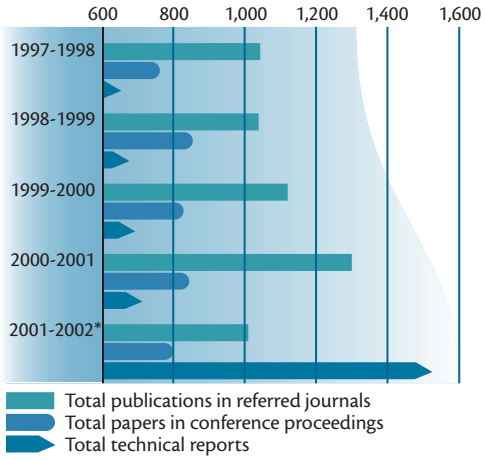
- More assistance, advice and funding for high-risk/high-return R&D at earlier stages – to help small firms grow to medium-size, and medium-size firms grow to large firms
- Increased efforts to create international networks and partnerships – global reach – to help SMEs access foreign technology, alliances and markets via missions, visits, joint ventures, partnerships and collaborative R&D
- Help to nurture new and emerging community-based technology clusters – supporting SME participation, enhancing community infrastructure for clustering, and seeking international opportunities that promote community cluster development
- Building a national competitive technology intelligence (CTI) capacity for NRC-IRAP – to help SMEs anticipate the future and make key technology decisions sooner – keys to their growth and the creation of new jobs
- Greater focus on commercializing publicly funded R&D – encouraging collaboration between research organizations and SMEs, promoting technology exploitation by SMEs, creating receptor capacities and creating tools, programs and forums for best practices, intelligence and information exchanges.

Knowledge for Canada – a vital currency

In today's economy, the creation of new knowledge and its transformation into new products and services are fundamental to economic growth. NRC creates new knowledge directly through its research activities, through publication in peer-reviewed journals, conferences and other key fora, through its participation on committees, and by organizing and attending conferences and workshops.

In 2001-2002, NRC published 1,003 papers in leading peer-reviewed journals, including such prestigious publications as *Science* and *Nature*. It had 800 papers published in conference proceedings and produced 1,527 technical reports. NRC staff held editorships or sat on the editorial boards of some 159 S&T publications. NRC staff also sat on 432 national committees and 589 international committees, organized 151 conferences and workshops, and attended 646 international conferences. NRC staff also held 270 adjunct professorships with universities and colleges across Canada.

NRC publications



* Technical reports have more than doubled primarily due to NRC-INMS having authored substantially more calibration reports, as a result of the International Laboratory Accreditation Cooperation Mutual Recognition Agreement.

NRC's Canada Institute for Scientific and Technical Information – vital knowledge infrastructure for Canada

The importance of NRC-CISTI as Canada's science library, largest scientific publisher and leading scientific, technical and medical (STM) information dissemination resource has assumed increased importance in the knowledge economy. NRC-CISTI maintains, publishes and provides access to the STM information essential to Canada's researchers. It provides access to Canadians through NRC Information Centres (NICs) across Canada as well as virtually via the Internet.

In 2001-2002, NRC-CISTI provided nearly one million documents worldwide, with some 62 percent to Canadians – 20 percent to industry, 50 percent to the academic community, 7 percent to the medical community, and 11 percent to public organizations. NRC Research Press published close to 6,400 peer-reviewed submissions from authors in Canada and around the world.

The program's support of NRC's technology cluster agenda continued in 2001-2002, with initiatives underway to open NICs in Atlantic Canada (New Brunswick and Prince Edward Island), in NINT and at the new NRC-AMTC in Montréal. The program also began operating the Nortel Optical Knowledge Centre in April 2001, for Nortel Networks' Optical Long Haul group in Ottawa. Staffed by an NRC-CISTI information specialist, the centre provides Nortel staff with access to essential information resources. NRC-CISTI is looking at this unique operating arrangement as a model for services to other Canadian companies.

NRC-CISTI is also adopting an integrated management approach for the development and delivery of its knowledge and information products and services. It will implement an innovative e-Business environment to provide access to, and extend the reach of, its information products and services. It is also creating a unique "e-infostructure" which will provide Canada with permanent electronic access to the world's best STM information. In conjunction with NRC-IRAP, it extended its outreach to SMEs and industry associations, and will offer new services such as competitive intelligence, technology roadmapping and technology forecasting information services.

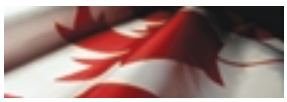
Innovation

Community-based innovation

Building technology clusters across Canada

"Communities are where the elements of a national, globally competitive innovation system come together. They have the potential to accelerate the pace of innovation, attract investment, stimulate job creation and generate wealth. To become magnets for investment and growth, communities need a critical mass of entrepreneurship and innovation capabilities. Communities where innovation thrives typically house individual "clusters" – internationally competitive centres of growth… Canada's communities also have to be part of a globally connected world."

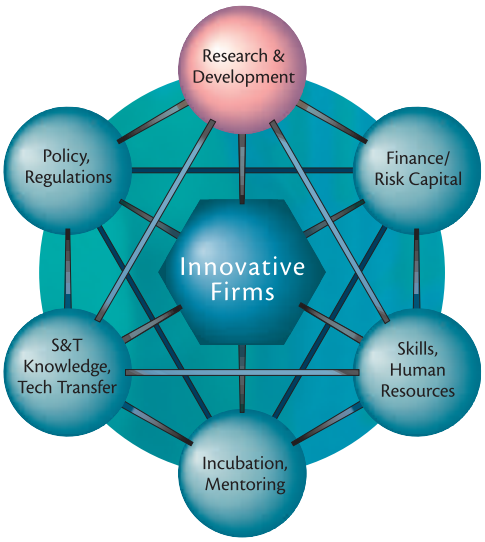
Canada's Innovation Strategy:
Achieving Excellence – Investing in People,
Knowledge and Opportunity



The growing international wave of innovation driven at the local level is based on public and private sector teamwork, partnerships and networks. Canada, given its vast geography, relatively small and dispersed population, and predominance of SMEs, has increasingly taken a collaborative approach to building community innovation over the past decade.

NRC is a nationally accessible, community-based S&T resource for Canadian business. With its world-class R&D, its renowned Industrial Research Assistance Program to provide technology advice and support to SMEs, and its Canada Institute for Scientific and Technical Information as a national information resource, NRC has long played a leading, dynamic role in many Canadian communities. NRC works with communities across the nation to increase their capacity in key technology fields through jointly developed innovation strategies that support the sustained growth of technology clusters.

Building technology clusters: the key components



NRC – community innovation initiatives across Canada

In 2001-2002, NRC continued to develop and expand its local community cluster initiatives in partnership with stakeholders across Canada and focused on achieving four strategic goals:

- Creating a globally competitive research and technology base for cluster development at the community level
- Supporting community leadership, champions and knowledge-based strategies
- Working with stakeholders to leverage funding and new investment in community clusters
- Stimulating the emergence of new firms, jobs, exports and investment growth.

Newfoundland – ocean and marine technologies

To support the new ocean and marine technologies cluster in St. John's, NRC began expansion of its core R&D programs to respond to the community's future requirements, as identified at the community Round Table led by NRC and industry in early 2001. NRC completed plans to construct a dedicated industry partnership facility in 2002 to support young entrepreneurs, start-ups and spin-offs. It also increased NRC-IRAP, CTN and CISTI forces in St. John's to engage and support local SMEs.

In partnership with Industry Canada and a number of public and private sector partners, NRC is leading the Marine and Ocean Technologies Roadmap initiative to identify the future market opportunities and technology requirements of Canada's marine, shipbuilding and energy sectors. The roadmap delivers on one of the government's commitments announced in *A New Policy Framework for the Canadian Shipbuilding and Industrial Marine Industry: Focusing on Opportunities 2001*.

Prince Edward Island – a roadmap to the future

NRC co-led an initiative with the Atlantic Canada Opportunities Agency (ACOA), the province, and university and private sector partners to assess opportunities for P.E.I. to translate its economic strengths in primary resources into a sustainable bioresources technology cluster. The Bioresources Technology Roadmap was completed in March 2002. The exercise considered over 100 opportunity areas and recommended a focus on bioactive compounds from marine and other sources while taking into account regional strengths and a sustainable development context. The steering committee commissioned supplementary reports on receptor capacity in Atlantic Canada and on the bioresource inventory in P.E.I. This exercise worked to bring the Atlantic community together around a common vision for the growth of the bioactives technology cluster. The next steps in the process will be to refine the research opportunity for the cluster, develop a business plan, identify a community champion, and create an Atlantic Canada Bioactives Cluster Network.

To support further growth of innovation capacity in the province, NRC has established an NRC Information Centre and is expanding its NRC-IRAP and CTN presence. Negotiations were underway at the end of the year to lease long-term space in Charlottetown to house NRC's increased activities.

Highlights of community innovation initiatives

- *Ocean and marine technologies* – St. John's – creating new opportunities for this industry sector locally, regionally and nationally
- *Life sciences and marine biosciences* – Halifax – building on community strengths and integrating players in these emerging fields
- *IT/e-Business* – Fredericton, Moncton, Saint John and Sydney – integrating regional strengths to build a world-class IT/e-Business cluster
- *Aerospace manufacturing technologies* – Montréal – assisting the SME community in Canada's largest aerospace cluster
- *Advanced aluminium technologies* – Ville Saguenay – building value-added manufacturing in a region housing 95 percent of Canada's aluminium players
- *Photonics* – Ottawa – supporting the emerging world-class high-tech cluster in photonics and building on Ottawa's vibrant IT cluster
- *Medical devices* – Winnipeg – building a cluster in precision and virtual manufacturing of medical technologies
- *Crops for enhanced human health & nutraceuticals* – Saskatoon – building new dimensions for this world-leading agro-biotechnology cluster
- *Nanotechnologies* – Edmonton – building Canada's R&D capacity, infrastructure and programs
- *Fuel cells* – Vancouver – supporting the development of a world-class cluster in fuel cell and alternative energy technologies.

Nova Scotia – life sciences, marine biosciences and IT

The Greater Halifax region is emerging as one of the "smartest" and fastest growing research centres for life sciences in Canada. Life sciences are one of the province's most dynamic industries, expanding at more than double the national rate.

To support this dynamic sector and help strengthen the region's innovation capacity, NRC has begun to increase its R&D capacity in genomics, proteomics, bioinformatics and advanced imaging, allocating $15 million to NRC-IMB. Work also began on an IPF for the institute to increase technology transfer and commercialization strengths. In partnership with Dalhousie University, the Queen Elizabeth II Health Services Centre, and the Halifax medical community, NRC-IBD and NRC-IRAP completed plans for a strong R&D and business presence at the new brain repair centre in Halifax. NRC's key contributions will be the installation and operation of a functional magnetic resonance imaging system and the establishment of fundamental R&D infrastructure and capability for the centre. As well, the Life Sciences Development Association (LSDA), established in 2000-2001, elected a permanent board and formed new executive and steering committees. The LSDA is vital to the integration, planning, cooperation and governance of the entire life sciences community effort. NRC-IMB co-chairs the LSDA and NRC-IRAP is on the steering committee, contributing to LSDA outreach, networking and communications activities.

In Cape Breton, NRC established the nucleus of an information technology (IT) research group connected to its national IT and R&D strengths. Located at the University College of Cape Breton in Sydney (UCCB), the group will help develop core competencies in software engineering for real-time control and embedded systems for short-range, dynamically reconfigurable wireless networks. NRC and UCCB will establish an IT innovation centre designed to support start-up companies and encourage technology transfer. NRC-IRAP recently initiated an internship program with UCCB that will see up to ten graduates per year join the NRC-IIT research group.

New Brunswick – moving into the e-Business "big leagues"

NRC began construction of its new research institute devoted to information technology and e-Business on the Fredericton campus of the University of New Brunswick. Scheduled to open in the fall of 2002, the new facility will be home to 40 NRC researchers and a similar number of guest workers, visiting scientists and industrial researchers. It will be tied closely to NRC institutes and national facilities across Canada as well as being home to an NRC information centre. Work is underway thanks to an additional $12 million investment by ACOA and the Government of New Brunswick, on satellite facilities in e-Business/IT in Saint John and Moncton, and on a broadband research network to connect all NRC New Brunswick facilities with partners.

NRC and ACOA hosted a two-day forum in Saint John to identify issues and opportunities and to propose a model for development of a collaborative cluster. A steering committee later recommended that a new body – the New Brunswick Knowledge Industry Leadership Network (KILN) – be formed. The governance structure is now under discussion with the community.

NRC-IRAP collaborated with local stakeholders to support SME e-Business projects, establish the Atlantic Ventures Group – an organization designed to attract investment and match sources of capital with growing companies – and support NB-SPIN, a network of IT professionals interested in software process improvement. NB-SPIN offers a forum for the free exchange of software process improvement experiences and concepts, providing SMEs with access to information and services that will improve their competitive performance.

In 2001-2002, NRC began construction of its new research institute devoted to information technology and e-Business on the Fredericton campus of the University of New Brunswick. The new facility is scheduled to open in the fall of 2002.

Building new community innovation infrastructure in Canada

- New industry partnership facilities on the way – 10
- New advanced technology facilities on the way – 6
- New/enlarged institutes/satellite facilities and programs – 11
- New/expanded NRC-IRAP and NRC-CISTI services/presence – 11

Québec – aerospace manufacturing and aluminium technology clusters

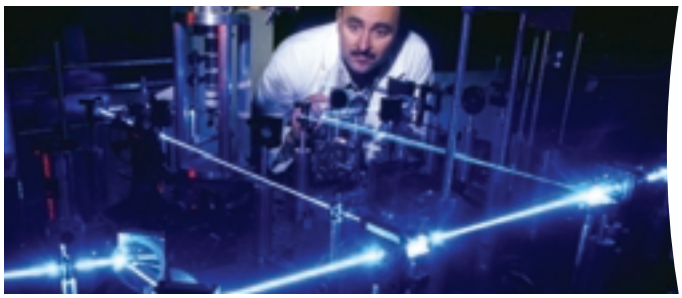
NRC moved forward with its value-added aluminium products industry cluster development effort in Ville Saguenay. Construction began on the NRC Aluminium Technology Centre on the campus of the Université de Québec à Chicoutimi. The centre will provide industry with technical support and expertise needed to develop value-added aluminium-based products and services. It will combine R&D activities, and process simulation and instrumentation efforts targeted to aluminium manufacturing technologies development and to the transformation of aluminium into finished and semi-finished products. The centre will be home to 80 researchers, technicians and technical staff working to support industry, mainly SMEs. In addition, about 20 young scientists will be trained at the centre each year – helping build the highly skilled talent Canada needs in this important sector.

In Montréal, NRC's goal of creating its world-class Aerospace Manufacturing Technology Centre (NRC-AMTC) saw major progress. The facility will provide the region with an integrated approach to aerospace manufacturing technology research, development and application. Located on the campus of the Université de Montréal, it will accommodate up to 100 staff and guest workers investigating advanced metal products, information systems and computational methods, advanced composite products, and functional materials. The research will focus on next-generation manufacturing with particular relevance to SMEs. The centre will respond to the needs expressed by the industry, including challenges in manufacturing and life cycle costs, environmentally compliant materials, processes and systems, strategic intelligence and information management systems, and the training and development of highly skilled people.

Ontario – photonics – light speed technology for Canada

NRC accelerated its plans to establish its NRC Canadian Photonics Fabrication Centre (NRC-CPFC) in Ottawa with the technology cluster funding announcements made in the federal budget in December 2001. The centre will be a unique national resource designed to give the Canadian photonics industry the competitive edge it needs. It will provide a facility to develop and test prototypes of new photonics devices, train highly qualified personnel, and serve as a leading-edge R&D resource and network centre for industry and university researchers. Completing the innovation equation, the centre will help address the shortage of personnel in photonics through remote and on-site training, internships and re-skilling programs.

In addition to tying into NRC-IMS strengths and all of NRC's program, network and knowledge resources, the centre will be closely connected to the business and government communities. NRC and Photonics Research Ontario (PRO) signed a Memorandum of Understanding at NRC's sixth



Ottawa Regional Innovation Forum in May 2001, to promote collaboration in the areas of photonics and biophotonics research. The new centre will focus its initial R&D, design, fabrication and technology transfer activities around new lasers, photonics integrated circuits, detectors and sensors, chips for wavelength division multiplexing and semiconductor optical amplifiers – technology fields with enormous growth potential.

Manitoba – medical devices manufacturing cluster

NRC is expanding its R&D program in medical devices and software, and building a new R&D program to support opportunities for the manufacturing of medical devices in Winnipeg. As part of

this effort, NRC-IBD will strengthen its R&D programs in medical imaging techniques and in manufacturing – design, precision and virtual manufacturing centred on materials, imaging, processes and related technologies. All activities will be connected via the high-bandwidth Ca3.net, locally, regionally and nationally. The goal is to create a national research network for distributed processing.

NRC-IBD will also open a new IPF to promote the development of medical diagnostic technologies manufacturing. The new facility will house spin-offs from NRC and other companies with related manufacturing technologies, providing them with access to business support services, commercialization support and linkages to NRC's R&D, knowledge dissemination and industrial research assistance strengths. The IPF will also house an industrial workshop that will support the manufacture of large, high-tech products, such as magnetic resonance imaging devices. The entire clustering effort will be defined, coordinated and integrated with key players in the community including Manitoba hospitals, universities, local industry and business partners, and federal, provincial and local economic development organizations.

Saskatchewan – crops for enhanced human health

NRC began work on a new research program – Crops for Enhanced Human Health – at NRC-PBI in Saskatoon. The world market for these types of crops is expanding rapidly – projected growth is on the order of 10 -15 percent annually. The potential market for Canadian firms is estimated to be worth $1.5 billion within three years. The initiative will also enable greater participation by rural communities in valued-added activities.

The program focuses on high-quality crops to produce functional foods with enhanced human health properties and naturally derived plant compounds, increasingly called "nutraceuticals." NRC will support the accelerated growth of a competitive, Prairies-based nutraceuticals/functional food industry based on its research, technology development and transfer, and industrial research assistance strengths in the region. A national "nutraceuticals" technology roadmap exercise, launched in December 2001, will help identify promising key technologies and lead to a national-scale action plan for this new field. In addition, this new initiative responds to the priorities of the Canada-Saskatchewan AgriFood Innovation Fund. Plants will also be modified to produce therapeutics and other health products, a process called molecular farming.

The new program and the related development of a new IPF at NRC-PBI are natural fits given NRC's exceptional track record in nurturing the development of the agro-biotechnology cluster in Saskatoon. A number of government, private sector and university players are already actively moving this cluster initiative forward, including Western Economic Diversification Canada, the Universities of Calgary, Manitoba and Saskatchewan, federal and provincial government agriculture ministries, provincial research organizations, agro-manufacturing/processing companies, and the Saskatchewan Nutraceutical Network – to name a few.

The NRC Innovation Centre (NRC-IC) in Vancouver is home to NRC's National Fuel Cells R&D Program. Work is underway here to create a full-fledged NRC institute to lead NRC's fuel cell and fuel cell manufacturing research, technology development and transfer programs.

Alberta – nanotechnology poised to pay off for Canada

Experts are predicting that the economic impact of nanotechnology will be in the range of $100 billion annually within the next decade. Market estimates for "lab-on-a-chip" – just one application of nanotechnology, but one where Canada is already strong – are estimated to be on the order of $10 billion annually.

Through its collaboration with universities and industry locally, nationally and internationally, the National Institute for Nanotechnology (NINT) will work to stimulate the emergence of new nanotechnology-based industries in Alberta and across Canada.

NRC will be the R&D anchor and provide its commercialization strengths to nurture the growth of this cluster. The main features of the new institute include:

- Access to full NRC research, innovation capacity, knowledge and commercialization networks, programs and services by industry, university and government organizations
- A major physical installation and state-of-the-art facilities, shared by the University of Alberta and NRC
- A collaborative R&D program with Canadian and international partners focused on major opportunity areas for Canada

- A national NRC mandate for molecular and nanoscale science and engineering, technology transfer and commercialization.

NINT, to be located on the campus of the University of Alberta, will take approximately three years to construct, but the research program has already begun, with researchers working out of existing NRC institute facilities until temporary space is occupied at the University of Alberta in September 2002.

A community Round Table consultation in Edmonton to engage academia, government and business people in defining the key elements for the cluster development effort is scheduled for early in the 2002-2003 fiscal year. NRC will use the results to refine its research program and work with partners to build a community-based and community-driven action plan.

"Promoting innovation, research and development is a cornerstone of our government's agenda. With the creation of this Institute, Canada will be poised to play a leading role in this exciting new technology – widely considered to rival the impact of the 19th century industrial revolution. This joint investment is another great example of what can be accomplished through our Team Canada approach to making Canada a leader in the new knowledge-based economy."

The Right Honourable Jean Chrétien
PRIME MINISTER OF CANADA

British Columbia – fuel cells lighting the way

The NRC Innovation Centre (NRC-IC) in Vancouver is home to NRC's National Fuel Cells R&D Program. When funding from the December 2001 federal budget doubled the NRC-IC budget, work began to create a full-fledged NRC institute to lead NRC's fuel cell and fuel cell manufacturing research, technology development and transfer programs. NRC will link its strengths with the province's fuel cells leaders, expertise, and networks, and with related fuel cell activities nationally, to promote the growth of an environmentally sound, viable fuel cells industry in the region and across Canada. This is a significant opportunity area for Canada – the estimated value of the fuel cells market by 2010 is $100 billion worldwide. British Columbia, site of the nation's most promising emerging cluster of fuel cell innovators, is well-positioned to lead Canada's effort to capture a significant share of this market.

These developments follow on investments in NRC-IC and in collaborations with government and industry partners to promote fuel cells R&D and commercialization activities. For example, NRC-IC is working to complete the construction of nine new hydrogen-safe fuel cell research laboratories at its Fuel Cell Technology Centre, in partnership with Fuel Cells Canada and Western Economic Diversification Canada, to accommodate growing demand for hydrogen-safe fuel cell laboratory space.

The new laboratories will serve many purposes, such as providing space for R&D testing, product demonstration, and incubator facilities for new companies. The labs will also be used to carry out testing and development of new parts and subsystems developed either by NRC-IC or as a result of NRC collaborations. Existing developers of fuel cell technologies will also have the opportunity to use the labs to demonstrate their technology for commercialization of their products.

In the coming months, NRC will host a community Round Table to help define the agenda and action plans to drive this important local and national innovation initiative.

Clusters

Global reach

At work on the world stage

"Speed wins in the global knowledge society. Advances in virtually all fields are taking place at breakneck speed. Innovative ideas and technologies originate with individuals, research networks, centres of excellence and companies around the world. For Canada to take full advantage of this knowledge, talent and technology in a timely fashion, it is imperative and urgent that Canadian researchers, universities and companies become integral partners in the international effort in S&T."

Report of the Expert Panel on Canada's Role
In International Science and Technology
JUNE 2000

Innovation is a global issue, rooted in each nation's ability to create, exploit and transform new knowledge into the innovative products that can create a competitive edge in global markets.

Canada's participation in international S&T is vital for the nation to gain access to the S&T knowledge and information it needs to succeed in the knowledge economy. This global reach improves the quality of knowledge produced by Canadian researchers. It creates access to the world's best S&T facilities, equipment and talent. It provides vital access to the knowledge produced by researchers in other nations, a necessity for Canada and Canadian businesses. It opens doors for Canadian firms to access the technology opportunities and information they need to remain competitive.

NRC has created international S&T networks of strategic importance for Canada. NRC uses these linkages and networks, not only to transfer S&T information back to Canadian firms, universities and public sector partners, but also to generate new business opportunities for Canadian SMEs.

NRC's international activities are focused on seven key objectives:

- Developing/renewing international S&T alliances of value to Canada
- Enhancing NRC's reputation and credibility for leading-edge R&D around the world
- Securing access to international R&D programs and facilities for Canadian researchers
- Promoting international standards harmonization
- Stimulating foreign direct investment in Canada
- Increasing recognition of its role as an effective integrator and facilitator of international research on behalf of Canada
- Improving its S&T foresight and forecasting for new research and technology domains.

Highlights of NRC's 2001-2002 international work

Throughout 2001-2002, NRC continued to build networks, collaborations and strategic alliances around the world for Canada through hundreds of bilateral organization-to-organization and multi-level agreements, technology and research alliances, as well as over 50 formal collaboration agreements with 22 nations. In 2001-2002, NRC received over 180 incoming delegations and led over 40 formal outgoing missions to other countries, plus numerous other informal international outreach activities. NRC employees sat on 589 international committees and attended 646 international conferences. NRC also organized 105 international conferences and workshops.

New and renewed international ties

NRC worked with international partners to renew a number of agreements and memorandums of understanding (MOUs), continuing access for Canadian scientists to international R&D projects, programs and opportunities.

- Canada and Taiwan renewed their MOU on science and technology cooperation for another 10 years, expanding areas of collaboration to include nanotechnology. The value of the agreement is $4 million. This MOU continues a strong history of collaboration between the NRC and the National

Science Council of Taiwan. Since 1997, there have been 16 co-research projects, 13 workshops and almost a dozen patents as a result of the MOU. This is the largest corporate collaboration for NRC outside of North America

- On the occasion of the visit to Canada of the President of Spain, H.E. José Maria Aznar, NRC signed a letter of intent with the Consejo Superior de Investigaciones Cientificas to foster technological and scientific cooperation between the two nations. The letter identified several cooperation areas to be explored in four scientific workshops: innovation policy and technology transfer, biotechnology, microelectronics/telecommunications and marine research. Two of the workshops were held in 2001-2002, one in each country
- NRC and the British Council renewed their MOU for the Joint Science and Technology Fund that provides financial support for collaborative

research between NRC and British laboratories in strategic areas of mutual interest, including advanced materials, biotechnology and communications technologies. It also supports the exchange of students and staff working in mutual research areas through Researcher Exchange Awards. Seven new cooperative research project awards were approved, worth some $1.4 million. Some $2.5 million has been awarded to date under the MOU

- To celebrate the 30th anniversary of the Canada-Germany S&T Agreement, NRC signed an MOU with Germany's Hermann von Helmholtz Association of National Research Centres. The MOU established a joint fund of $1.5 million per year over the next three years to conduct-leading edge collaborative research projects.

- NRC and the Centre national de la recherche scientifique of France (CNRS) renewed their MOU for an additional five years until 2006. This Agreement promotes research collaboration in fields of science and technology. Since 1998, this agreement has financially supported ten such collaborative projects in the following sectors: biotechnology (3), manufacturing technologies (1), information technologies and telecommunications (2), and molecular sciences (4)

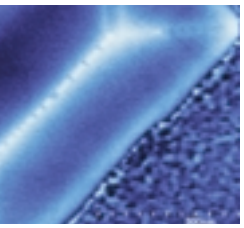
NRC: 2001-2002
Access to international S&T for Canada

- NRC-United Kingdom – seven R&D projects
- NRC-France – 16 R&D and standards development projects
- NRC-European Union framework programs – five FP5 projects
- NRC-European Union member states – over 170 projects
- NRC-European Union – seven ongoing projects, workshops, conferences, and networks – such as the Canadian-European Research Initiative on Nanostructures (CERION)
- NRC-Spain – two workshops
- NRC-Taiwan – 18 R&D projects, missions/visits, workshops and exchanges
- NRC-Singapore – eight R&D projects, training & exchanges
- NRC-Thailand – missions, exchanges/training & R&D
- NRC-Japan – 10 R&D projects
- NRC-People's Republic of China – 10 missions/visits from high-ranking officials, exchanges & several R&D projects
- NRC – access to worldwide astronomy facilities/projects/agreements for Canada's astronomers
- NRC-CISTI, NRC-INMS – dozens of collaborative agreements/MOUs
- NRC-IRAP – missions/visits/competitive intelligence for Canadian SMEs

International R&D collaborations – benefits across the board

International R&D collaborations benefit partner nations through new knowledge, new technologies, new business opportunities and improved quality of life, as some 2001-2002 highlights from NRC's long-term collaboration with Taiwan's National Science Council (NSC) demonstrate:

- The development of copper source reagents for the production of copper containing thin films with applications in micro-electronics and high-temperature superconducting ceramics has resulted in a U.S. patent for the technology and filing for a patent under the Patent Cooperation Treaty
- Development of a method to model and simulate what happens when light aircraft collide with airport lighting towers, which will lead to improved safety through the design and construction of lighting towers that cause minimal damage to aircraft in the event of a collision



- Significant advances for the industrial application of quantum dots through techniques developed to place quantum dots at a variety of pre-determined sites across a semi-conductor substrate. The project also developed a technique for growing quantum antidots – potentially useful for nanoelectronic devices.

Access to the world's knowledge and information

NRC-CISTI has developed a number of resource partnerships providing access for Canadian researchers to the information resources of other major S&T libraries around the world. In 2001-2002, the major agreements included: the British Document Supply Centre, l'Institut de l'information Scientifique et Technique (INST – France), Korea Institute for Science and Technology Information, the Institute of Scientific and Technical Information (China), Sunmedia of Japan, and the Science and Technology Information Centre (Taiwan).

NRC-CISTI also designed the Web site of the Technology Foresight Network (TFN) of the APEC Centre for Technology Foresight, launched in September 2001 in Bangkok, Thailand. The TFN will use this site to provide information to technology foresight professionals in APEC economies and globally, as well as to provide access to a variety of resources that will help build bridges among partners – key tools for innovation and competitiveness in the global economy.

New markets for Canadian Tsuga in Japan

Canadian Tsuga, also known as Hem-Fir in Japan, is one of the strongest commercially available softwood lumber products in the world today. In Canada, Tsuga carries a certified E-120 grade – proof of the wood's superior strength and stiffness. In October 2001, the Japanese Ministry of Land, Infrastructure and Transport confirmed that Canadian Tsuga was fully accepted for post-and-beam house construction under the Japanese Building Standard Law. Japan also assigned design values specifically for Canadian Hem-Fir products – meaning that Canadian exporters can differentiate Canadian hemlock from that of other countries. This is the first time that Japan has accepted a foreign grading for their traditional lumber products. Japan's acceptance of the Canadian E -120 standard came, in no small part, because of the direct involvement and support of NRC-IRC's Canadian Construction Materials Centre for the E-120 certification.

Measurement comparisons stand up to scrutiny

The importance of metrology in international trade has increased greatly over the past decade. International trade agreements now demand demonstrated equivalence between the metrology standards of buyer and seller nations. NRC-IMNS, as Canada's national metrology authority, represents Canada in measurement comparisons with other nations as part of the Mutual Recognition Arrangement of the Comité international des poids et mesures (CIPM).

NRC participated in some 35 such comparisons in 2001-2002, as well as in the comprehensive international review process that takes place following the completion of comparisons. As a result, NRC's calibration and measurement capabilities in acoustics, ultrasound and vibration, photometry and radiometry, and chemical metrology were added to the CIPM database. Canada's standards are now recognized by all of our major trading partners, helping remove technical barriers to international trade and increase exports.

International opportunities for SMEs

In 2001-2002, NRC-IRAP undertook a number of technology missions to Taiwan, Thailand, China, Korea and Hong Kong, including participation in the Team Canada mission to Germany. By the end of the fiscal year, the 53 SMEs involved in the missions had signed 8 MOUs, 7 contracts, and 41 partnership agreements. NRC-IRAP also undertook a series of exploratory missions to Asia, Hungary, Mexico and the United States, and participated in several missions organized by the Department of

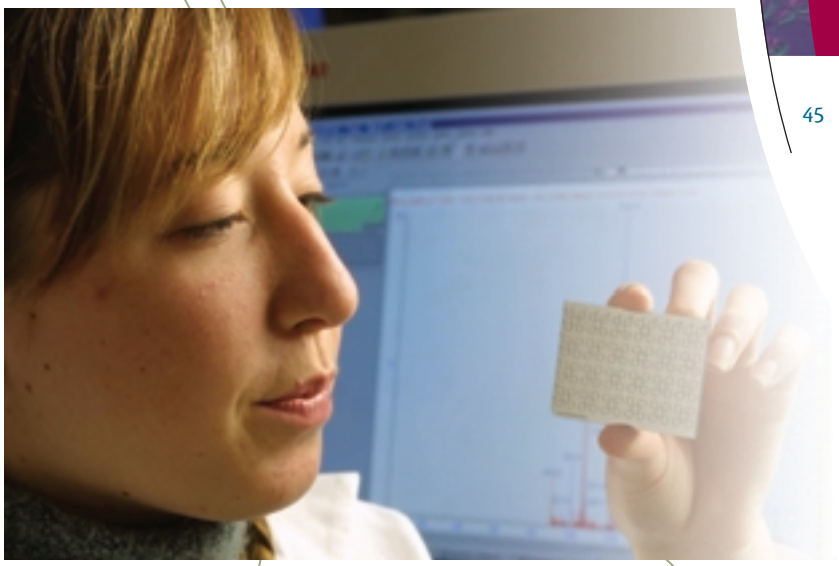
Foreign Affairs (e.g. the composite materials mission to France) as well as individual provincial missions.

In addition to technology missions, NRC signed or extended a number of key international arrangements:

- A new agreement was signed with the China-United Nations Industrial Development Organization to assist technology transfer and technological linkages between Canadian and Chinese SMEs
- NRC-IRAP's support to Intelligent Manufacturing Systems Canada in its work with seven international regions on collaborative R&D was extended, with several collaborative projects under development involving NRC institutes
- The agreement with the Canada-Israel Industrial R&D Foundation was extended to facilitate linkages between Canadian and Israeli SMEs and institutions
- The agreement for exchanges of NRC's Industrial Technology Advisors with the Agence national de valorisation de la recherche of France was extended to investigate best practices and stimulate linkages with SMEs from both nations
- An agreement was signed with Thailand's National Science and Technology Development Agency to develop its Industrial Research Assistance Program, modelled after NRC-IRAP.
- NRC-IRAP also led a mission with 14 Canadian SMEs to the APEC Technomart in Suzhou China to form technology-based joint ventures and seek out new research collaborations. NRC made seven presentations during the Technomart and organized a major exhibit at the technology fair for the event. Firms signed a number of new agreements.

NRC – science lends helping hand

NRC conducts R&D in areas such as marine biosciences and seafood safety, medical diagnostics and devices, agricultural and pharmaceutical biotechnologies, construction codes and materials standards for buildings and infrastructure, aerospace and metrology – all are vital to ensuring public health and safety, not only for Canadians, but for people around the world. In 2001-2002, NRC continued this tradition of "R&D for the public good" through a number of international R&D efforts.



Improving marine toxin and reference standards

NRC-IMB is leading an international team of scientists from Canada, Australia, New Zealand, Taiwan, Singapore, Japan and the United States on a three-year APEC project to develop and validate new analytical methods and produce new marine toxin standards and reference materials. For the millions of people in the Pacific region dependent on seafood for their livelihood, and as their main source of protein, the project will have life-saving impacts.

Puffer fish poisonings solved

Analytical chemists at NRC-IMB successfully identified saxitoxin as the causative agent in near fatal poisonings in the United States associated with eating Atlantic Puffer fish, a species never previously associated with toxicity. Apart from the rapid resolution of the poisoning mystery, this expert research in marine toxins has resulted in increased awareness of a potential new source of seafood poisoning.

Helping identify the victims of the World Trade Center attack

In the aftermath of the September 11 attack on the World Trade Center, health officials in New York City were faced with the unprecedented challenge of identifying the thousands who died when the twin towers collapsed. American firm Gene Codes Corporation, a leading company in the creation of DNA sequencing software and databases, was chosen for the task. Gene Codes Forensics, a wholly owned subsidiary of Gene Codes Corporation, was created for the sole purpose of handling the specific needs of this project.

To help manage the tremendous amount of data generated by the project, Gene Codes recruited the leader of NRC's Canadian Bioinformatics Resource specifically for his world-leading expertise in genetic database management. Using NRC's expertise, new software was created that could rapidly catalogue, search, and compare vast amounts and different types of genetic information, with the ultimate goal of identifying victims. By using different DNA sequencing techniques, a unique DNA signature could be developed for each victim and compared to samples taken from a missing person's personal effects, such as a toothbrush or hairbrush. The software was the first of its kind able to handle such a vast array of information and data with the goal of identifying the victims as quickly as possible.

As the world came to terms with the September 11 tragedy, a team of experts was called upon to investigate and report on the performance of the affected buildings in the vicinity of Ground Zero. Among them was an NRC expert in building performance – the only member from outside the U.S. invited to join the study.

Outstanding people – outstanding achievements

Talent for Canada

"Skills and learning are the foundations of Canada's Innovation Strategy. It is our knowledge and skills that lead to new concepts and original products and services. This strategy is about equipping all Canadians with the tools they need to participate in Canada's workplace… Their knowledge is now the currency of our economy and the factor that will ensure our continued social development."

The Honourable Jane Stewart

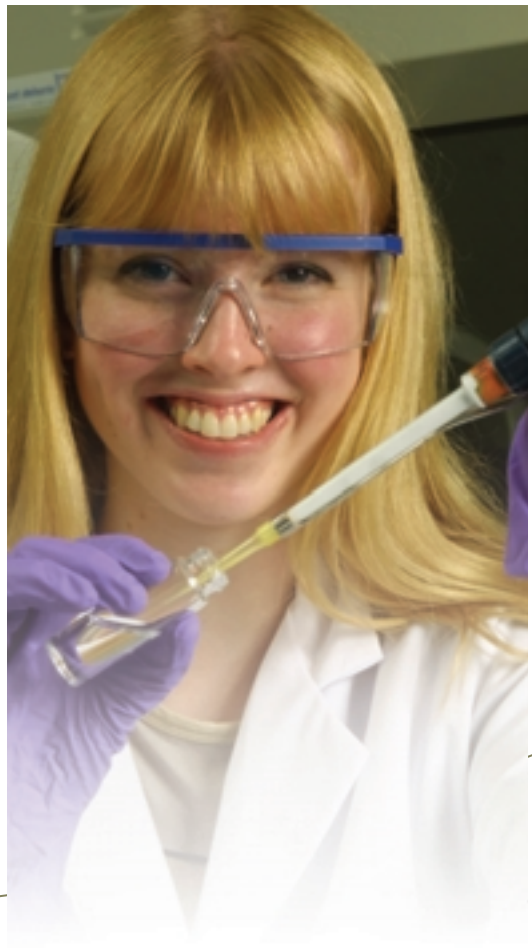
MINISTER, HUMAN RESOURCES DEVELOPMENT CANADA

NRC is committed to helping build the critical mass of skilled, knowledgeable people that are the foundation of Canada's future. NRC's contributions take many forms across the country, from student programs and youth outreach activities to guest worker and expert resource exchanges with other S&T organizations around the world.

Outstanding people – outstanding employer

Great people. Great minds. It's that simple. NRC's success on behalf of Canada lies with the nearly 4,000 dedicated, knowledgeable, creative and talented men and women that give the organization life. Over NRC's 85-year history, its people have earned an international reputation for excellence in leading-edge research and innovation – they have earned the highest regard of peers, colleagues and collaborators in a wide range of science and engineering domains.

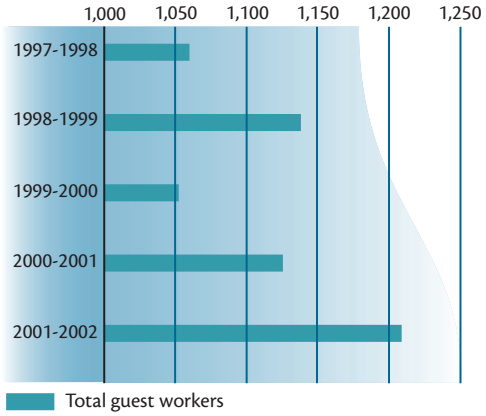
In 2000-2001, NRC launched its Employment Philosophy – its commitment to NRC staff and Canadians to being an outstanding employer of outstanding people – as a cornerstone of Vision 2006. In 2001-2002, NRC undertook a pilot survey across a number of its programs and institutes to define, with staff, the roadmap for living up to the principles of the Philosophy. The findings from this pilot phase will be used to refine the survey and, following its completion in 2002, to put the findings into action.



Guest workers

NRC institutes, technology and innovation centres engaged more than 1,206 guest workers from Canadian and foreign universities, companies and public and private sector organizations. Not only does NRC benefit from the participation of these skilled workers in collaborative projects, their home organizations gain equally from the training provided and the transfer of knowledge and know-how from NRC.

NRC guest workers



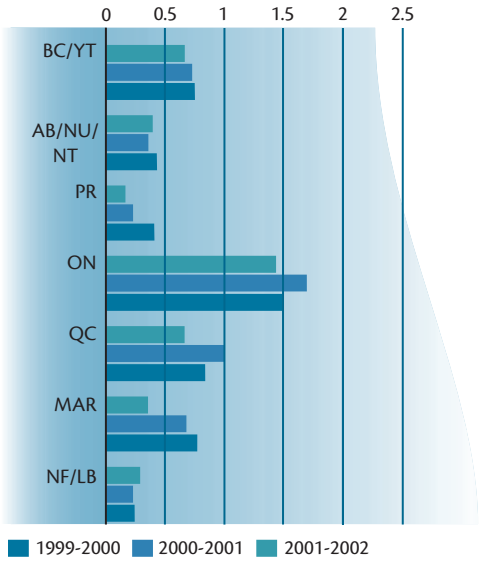
Contributing to Canada's skilled workforce

The demands of the knowledge-based economy create an ever-growing need for a well-educated and skilled workforce in all parts of the economy and the country. NRC helps build this workforce, not only through its own recruitment and training activities, but also through support of programs of other government agencies and universities – in Canada and internationally.

Supporting federal Youth Employment Initiatives

To help SMEs meet their needs for highly qualified personnel, NRC-IRAP manages two youth internship programs on behalf of Human Resources Development Canada. In 2001-2002, a total of 550 graduates were placed in 460 SMEs across Canada. Total contributions to firms amounted to $3.95 million. Of these contributions, more than $3.86 million was invested in the Science and Technology Internships Program supporting 541 recent graduates working in 455 firms. The remaining contributions were invested in the Science Collaborative Research Internships Program to support nine graduates in collaborative projects with SMEs in British Columbia, Manitoba and Ontario.

NRC-IRAP youth employment initiatives
Regional investments from 1999 - 2002
($ millions)

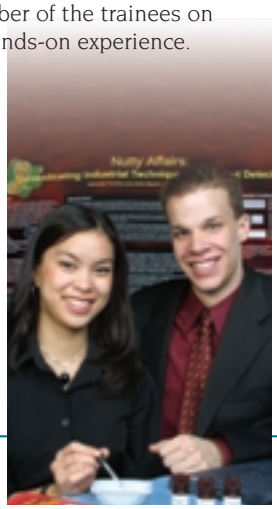


Training to meet Canada's need for a specialized workforce

The creation of new technologies requires a workforce that has the knowledge to properly use them. To give future graduates advanced industry-oriented skills, NRC-IMI has signed an agreement with six educational institutions in three provinces. The agreement will allow NRC to transfer its technology expertise and achievements in a structured environment that will help students build skills and gain relevant practical experience. The university partners include McGill University, École Polytechnique, Université Laval, the University of Windsor, the University of New Brunswick, and Ahuntsic College. The activities will focus on the use of process modelling and simulations software developed at NRC-IMI, within the framework of training programs for engineers and technical officers at the six institutions.

New graduate bio-based curriculum

NRC-BRI is collaborating with Oklahoma State University in the development of a new student internship program that will be part of its "Bio-based Products Graduate Program" scheduled to start in the fall of 2002. The university's research program is focused on developing bio-based technologies for converting agricultural raw materials into various chemical feedstocks. Students will work in multi-disciplinary teams to become familiar with bio-based or bioconversion research involved with these technologies. The U.S. Department of Energy, recognizing the expected energy shortage and the need for alternatives, such as the use of biomass to produce energy, will fund the trainees. NRC-BRI will welcome a number of the trainees on an annual basis to provide hands-on experience.



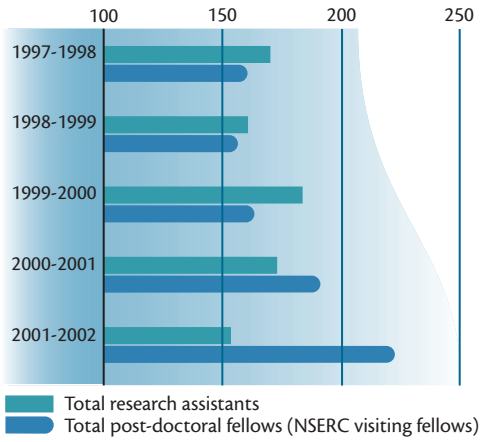
Student and youth outreach

In 2001-2002, NRC student programs provided direct, hands-on training and development work for some 781 graduate, co-op and summer students, and approximately 222 post-doctoral fellows (PDFs). As an ongoing program, NRC and the University of Ottawa also hosted four high school students from Taiwan on six-week summer work assignments. NRC also continued its Women in Engineering and Science (WES) Program to help encourage talented female students to pursue professional careers in engineering and science.

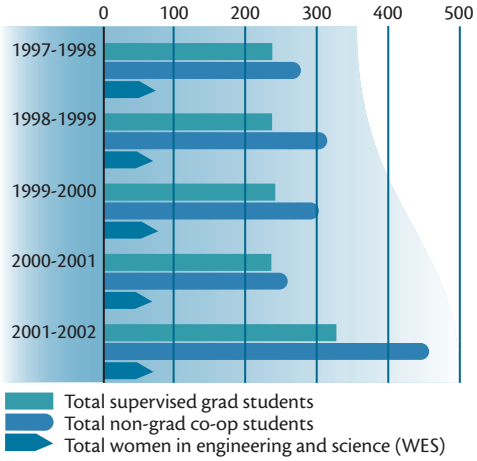
Helping young Canadians reach their potential

A strong science culture is a keystone of Canada's innovation system. Young Canadians, in particular, need to understand and see the benefits of learning science and engineering for their future careers and adult lives. In addition to direct experience, employment and training opportunities, NRC works to interest young Canadians in careers in science and technology through a variety of activities in communities across Canada, including visit programs for schools (and their teachers), science and engineering challenges, and science promotion activities, such as the publication of science resource materials.

PDFs and RAs



NRC student programs



Promoting science, technology, engineering and math

NRC significantly increased its national distribution of science promotion materials to young people in 2001-2002, sending over 114,000 bilingual NRC science resources, including Periodic Table materials and *Canadian Skies* posters, to schools and individuals across Canada. In addition, NRC contributed a direct insert to *SchoolNet* magazine and promoted these resources with teachers, provincial education ministries, resource centres and school boards across Canada. Materials were also made available on the Internet – including SchoolNet and the Ontario Ministry of Education, Science and Technology portal site for teachers and students (OYSTER).

Science challenges and competitions

NRC continued its support for the National Engineering Week and Engineering Challenge for elementary students – an NRC initiative. The Engineering Challenge puts engineers in the classroom with elementary teachers to engage student teams in a problem-solving activity linked to the science curriculum. In 2002, the challenge for grade five students was to design and construct a rubber-band-powered car.

NRC also maintained its support for the Aventis Biotech Challenge offering high school students the opportunity to explore the science of biotechnology, through science projects in molecular genetics, microbiology, biomaterials, environmental biotechnology and other applications. In a similar vein, NRC provided national support to Canadian National Marsville – the cross-Canada space science and astronomy program that offers grades 6-8 students the chance to explore the Mars environment and create life-support systems suited to the red planet.

"Centre of the Universe" opens in Victoria

A special dimension was added to the national astronomy education and science promotion landscape in 2001 when NRC-HIA opened its multi-faceted visitor's centre in Victoria B.C. Called *The Centre of the Universe*, the facility focuses on the celebration of Canadian astronomy and its proximity to NRC's historic Dominion Astronomical Observatory. The centre supports efforts to promote Canadian astronomy and achievements in all regions, in collaboration with other agencies, universities and organizations. Visitors have already come to the new facility from all Canadian provinces, 21 U.S. states, and 27 countries on 6 continents.

Creativity – connecting the arts and sciences

Promoting science and its role in modern life and society was at the core of the Millennium Conferences on Creativity in the Arts and Sciences – a unique collaboration between NRC, The Canada Council for the Arts and the National Arts Centre (NAC). The conferences grew to include many of Canada's leading S&T organizations as well as international partners. The celebration of the connection between the arts and sciences continued in 2001-2002 with the publication of *Renaissance II: Canadian Creativity in the Arts and Sciences – Innovation in the New Millennium*. NRC also signed MOUs with the NAC to explore distance learning using the promise of broadband technologies and with the Canada Council for the Arts for an Artist in Residence (AIRes) Program at NRC. This program will see artists working hand-in-hand in NRC labs with researchers to open new channels of communications and break down barriers between the professions of scientists and artists.

An engineering team from Montréal's École de technologie supérieure conducted underwater tests at NRC's Canadian Hydraulics Centre in Ottawa of their human-powered submarine. The team went on to win with the fastest sub at the 6th International Submarine Races.

STATEMENT OF OPERATIONS BY ORGANIZATION

For the year ending March 31, 2001

(DOLLARS ARE IN THOUSANDS)
FY 2000/2001

Organization	Expenditures [1]	Income
Research Institutes	$357,597	$63,991
Industrial Research Assistance Program[2]	145,299	28,215
Scientific and Technical Information	45,738	24,125
Technology Centres	11,905	14,400
Corporate Branches	94,139 [3]	4,605
Total	$654,678	$134,336

For the year ending March 31, 2002

(DOLLARS ARE IN THOUSANDS)
FY 2001/2002

Organization	Expenditures [1]	Income
Research Institutes	$415,250	$72,927
Industrial Research Assistance Program[2]	152,096	32,585
Scientific and Technical Information	46,292	27,604
Technology Centres	17,207	14,796
Corporate Branches	90,301 [3]	5,374
Total	$721,146	$153,286

(1) Expenditures shown above include both appropriation and income-based expenditures.

(2) Includes amounts received and expended under IRAP/Technology Partnership Canada Pre-Commercialization program (2000-2001, $27.381M; 2001-2002, $31.743M).

(3) Expenditures include construction projects for research institutes managed centrally.

Science

NRC council members

Dr. Wayne Clifton	President, Clifton Associates, Regina, Saskatchewan
Dr. André Gosselin	Associate Professor Centre de recherche en horticulture Université Laval, Ste-Foy, Québec
Dr. Jacques-Yves Guigné	Chief Executive Officer, Guigné International Limited, Paradise, Newfoundland
Mr. David Halliday	Vice president, AMEC Dynamic Structures Limited Port Coquitlam, British Columbia
Mr. Peter Harder	Deputy Minister Industry Canada, Ottawa, Ontario
Dr. Clarke Henry	Manager of Research, Products and Chemicals Division, Imperial Oil, Sarnia, Ontario
Dr. Ross McCurdy	Chief Executive Officer InNOVAcorp, Dartmouth, Nova Scotia
Mrs. Pascale Michaud	Consultant McKinsey & Company, Montréal, Québec
Mr. Gilles Ouimet	President and Director General Pratt & Whitney Canada, Longueuil, Québec
Dr. Louise Proulx	Vice-Principal (Research) McGill University, Montréal, Québec

National Research Council Canada
Governing council & officers
March 31, 2002

Dr. René Racine	Proffesor Emeritus, Physics Department Université de Montréal, Montréal, Québec
Dr. Patricia Shewen	Chair, Department of Pathobiology University of Guelph, Guelph, Ontario
Dr. David F. Strong	Victoria, British Columbia
Ms. Kim Sturgess	President and Chair, Engineered Diamonds Inc. Calgary, Alberta
Dr. Eva A. Turley	Senior Scientist, London Regional Cancer Centre, London, Ontario

NRC Executive officers

Dr. Arthur J. Carty	President (and Chair of Council)
Ms. Patricia Mortimer	A/Secretary General
Dr. Peter A. Hackett	Vice-President, Research
Mr. Jacques Lyrette	Vice-President, Technology and Industry Support

NRC-BRI	NRC Biotechnology Research Institute	Montréal: (514) 496-6100
NRC-CISTI	NRC Canada Institute for Scientific and Technical Information	Canada and U.S.: 1-800-668 1222 outside North America: 613-998-8544
NRC-HIA	NRC Herzberg Institute of Astrophysics	**Victoria**: (250) 363-0001 Penticton: (250) 493-2277
NRC-IAR	NRC Institute for Aerospace Research	Ottawa: (613) 991-5738
NRC-IBD	NRC Institute for Biodiagnostics	**Winnipeg**: (204) 983-7692 Calgary: (403) 221-3221
NRC-IBS	NRC Institute for Biological Sciences	Ottawa: (613) 993-5975
NRC-ICPET	NRC Institute for Chemical Process and Environmental Technology	Ottawa: (613) 993-3692
NRC-IIT	NRC Institute for Information Technology	**Ottawa**: (613) 993-3320 Fredericton: (506) 451-2674 Moncton: (506) 851-3607 Saint John: (506) 636-4775 Sydney: (902) 564-6481
NRC-IMB	NRC Institute for Marine Biosciences	Halifax: (902) 426-8332
NRC-IMD	NRC Institute for Marine Dynamics	St. John's: (709) 772-2479
NRC-IMI	NRC Industrial Materials Institute	Boucherville: (450) 641-5000

NRC institutes /programs

NRC-IMS	NRC Institute for Microstructural Sciences	Ottawa: (613) 993-4583
NRC-IMTI	NRC Integrated Manufacturing Technologies Institute	London: (519) 430-7079
NRC-INMS	NRC Institute for National Measurement Standards	Ottawa: (613) 993-7666
NRC-IRAP	NRC Industrial Research Assistance Program	(across Canada): 1-877-994-4727
NRC-IRC	NRC Institute for Research in Construction	Ottawa: (613) 993-2607
NRC-PBI	NRC Plant Biotechnology Institute	Saskatoon: (306) 975-5571
NRC-SIMS	NRC Steacie Institute for Molecular Sciences	**Ottawa**: (613) 990-0970 Chalk River: 1-888-243-2634
NRC-IC	NRC Innovation Centre	Vancouver: (604) 221-3011
NINT	National Institute for Nanotechnology	Edmonton: (780) 492-8636

NRC Technology Centres

NRC-CHC	NRC Canadian Hydraulics Centre (Ottawa)	(613) 993-9381
NRC-CHC	NRC Thermal Technology Centre (Ottawa)	
NRC-CSTT	NRC Centre for Surface Transportation Technology (Ottawa and Vancouver)	(613)998-9639

For more information visit our Web site at: **www.nrc-cnrc.gc.ca**
or contact NRC at: **1-877-672-2672**

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