Canada's Space Pioneers - The inspiring story of Shirleys Bay's role in launching Canada's early space program.

The Canadian Forces Experimentation Centre (CFEC) at Shirleys Bay may change the way Canada manages its armed forces.

The economic health of Canada's rural and remote communities may depend on the success of Canada's Broadband Initiative. Shirleys Bay is playing a key role.

Feature story on the Canadarm 2, Canada's Premier Robotics Project.

Canadian Forces Experimentation Centre (CFEC), this new agency at Shirleys Bay may change the way Canada manages its armed forces.
Imagine......

In partnership with Shirleys Bay, EMS Technologies has been building the future of space-based communications for the last 50 years.

We'll be there, together, for at least the next 50.

...what we have yet to accomplish.

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PUBLISHER'S NOTE

On Friday November 4th I attended an Open House at Shirleys Bay. I got a glimpse of the six Federal labs and met a handful of the 1200 Scientists and Engineers. With so much to see, it was difficult to get a complete picture of their successes or how these labs work with one another. Hopefully this publication will honour their 50 years of success and demonstrate how they collaborate with industry to serve all Canadians.

Donald Keyes
Congratulations to Shirleys Bay Campus on its 50th anniversary. This is a historical milestone marked by tremendous achievements in Canadian technological innovation.

These achievements include the Alouette 1 satellite, which made Canada the third country in the world to have a satellite in space. They also include the creation of more than 60 Canadian companies, through one of the most successful incubation programs in the country. There is also the Canadarm, which was Canada’s first involvement in manned space flight, and the world’s first direct-to-home satellite TV broadcast of a Stanley Cup game, just to name a few.

Such innovation has been possible because of an absolute commitment, by past and present Campus organizations, to world-class excellence in research and development through strong, collaborative partnerships with federal laboratories, private industry, and academia.

The Shirleys Bay Campus engineers, scientists and researchers are Canadian pioneers. Their work is wide-ranging. From photonics to fibre optics research, from radiation biology to national security, spacecraft testing to electronic warfare support, they are dedicated to making Canada a better place to live and a global leader in innovation.

The Shirleys Bay Campus is a national centre of highly skilled people making remarkable technological advances. Looking ahead, Shirleys Bay Campus organizations will continue to push the frontiers of science and technology, securing Canada’s place as one of the world’s top R&D performers, and advancing our outstanding reputation for driving innovation.

My warmest congratulations to all those who have played a role in the success of the Shirleys Bay Campus, now celebrating its 50th Anniversary. This is indeed a significant success story in the history of federal research and technological innovation in Canada.

The Shirleys Bay Campus has its origins in the Canadian defence research organizations established during World War II; indeed, defence priorities continue to play a large role at Shirleys Bay, with Defence R&D Canada – Ottawa being the lead defence organisation on campus along with two more recent arrivals, the Canadian Forces Electronic Warfare Centre and the Canadian Forces Experimentation Centre.

Over the past 50 years, defence research has yielded the knowledge and technology to support the men and women of our Canadian Forces. We are lucky to have some of the best and most dedicated researchers working for us here at Shirleys Bay.

In the years ahead, Defence R&D Canada (DRDC) will pursue exciting new opportunities as it develops its centres as regional “innovation hubs” with the private sector and universities. These hubs will bring together the best people and technologies and foster dynamic new partnerships. DRDC will continue to improve customer relations, explore new markets, and promote scientific excellence. Most importantly, DRDC will continue to focus on the Canadian Forces and on the needs of its defence clients.

I congratulate DRDC Ottawa and all members of the Shirleys Bay community on 50 years of excellence and on their past and future role in making the Shirleys Bay Campus an outstanding example of the benefits of technological innovation and cooperation within Canada.

John McCallum
Welcome to Shirleys Bay!

It is my pleasure to introduce you to our campus and the outstanding work done here in this 50th Anniversary edition of the Shirleys Bay Review. Through the following pages, you will have the opportunity to meet some of the country’s most talented and respected researchers and scientists. You will see some of our unique lab facilities and find out more about the federal organizations on campus.

For over 50 years, working independently, with other government departments or with private-sector partners, the campus’ federal labs have performed world-class R&D. From building Canada’s first satellite to paving the way for rural and remote broadband for all Canadians, the campus labs have been national and global leaders in technological innovation. Read on to find out how we are contributing to developing leading-edge technologies that advance innovation in Canada and abroad.

Gerry Turcotte
President
Communications Research Centre Canada

Gerry Turcotte left, presents Alouette 1 print to Marc Garneau right

Marc Garneau
President
Canadian Space Agency

Marc Garneau speaking at 50th Anniversary Campus Celebration

I am pleased to offer my congratulations to all those who have contributed to making the Shirleys Bay Campus one of Canada’s premier sites in high-technology research and development. For the past 50 years, the Shirleys Bay Campus has focused a world-class concentration of Canadian scientists — men and women, whose energy, devotion and ingenuity have made Canada a leader in a broad range of technologies. It was in fact at Shirleys Bay that the Canadian Space Program got its start through the design and construction of the Alouette 1 satellite some 40 years ago. Alouette was the beginning of Canada’s significant achievements in space including the ISIS, Hermes, and RADARSAT 1 satellites, as well as the space shuttle Canadarm and the International Space Station’s Mobile Servicing System. The Canadian Space Agency shares the campus through its world-class David Florida Laboratory, which qualifies hardware destined for space. The site is a model for co-operation and partnerships among government departments, universities, research institutes and the private sector.

The Shirleys Bay Campus has earned an international reputation for its world-class research and development, paving the way for an even more promising future.

Marc Garneau
President
Canadian Space Agency

Marc Garneau

Some of the world’s leading technology ideas grew up here

In the past five years, Ottawa was named in a technology report — making it a leader in the world of innovation of the Shirleys Bay Campus. Imagine the possibilities of the next 30 years.

Prakash Bhartia
Director General
DRDC-Ottawa

It is with great pleasure that we in DRDC Ottawa join in the 50th Anniversary celebration of the Shirleys Bay research campus. DRDC Ottawa is proud to be associated with the Shirleys Bay campus. Over the years, we have been part of the collaborative atmosphere and sharing of ideas that exists here.

The defense research agencies of Shirleys Bay have provided technology leadership to the Canadian Forces over the past 50 years. Early on, we produced wartime protective equipment for Canadian and Allied soldiers in World War II and today, our advanced research is helping in the global fight against terrorism and in support of Canadian Forces missions abroad.

DRDC Ottawa’s recent internal reorganization has helped us focus on our special niches, and has helped arrange our teams of talented scientists to allow them to do their jobs most efficiently. This renewed vision will help us become recognized world-wide for creativity and innovation in our chosen niches of information operations, synthetic environments, radar, space systems, radiation biology, among others.

We in DRDC Ottawa join with our campus colleagues to acknowledge the rich heritage in federal research here at Shirleys Bay. We look forward to the challenging road ahead and we will continue making research advances that support the Canadian Forces in their mission to protect Canada, and Canadian interests and values, while contributing to international peace and security.

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The core of Canada’s communications technology expertise resides within a diverse campus, which traces its origins back to World War II.

Covering most aspects of Canada’s telecom, aerospace and military interests, more than 1200 Shirleys Bay engineers and researchers provide Canada with the core expertise it needs to remain competitive in an increasingly technological world.

Standing outside the campus gate it would be easy to conclude that Shirleys Bay is the Federal Government equivalent of an R&D office park. Although the campus houses six separate technology related organizations, funded by three federal government departments… it is in fact a highly integrated capability which plays a large role in maintaining Canada’s place among the leading industrialized nations.

Created from the nucleus of Canada’s WWII R&D efforts, these organizations have evolved together over the past 50 years. They form one of Canada’s most comprehensive independent technology research and development capabilities.

The roots of today’s organizations reach back to pre-World War II, when Canada was tasked by Britain to provide gas masks in anticipation of chemical weapons use in a possible European conflict, and then tasked again by Britain to design and manufacture radar equipment in Canada.

By 1946, operating under the NRC, Canada had created world-class defence research capabilities in the areas of radar, electronics, batteries, gas mask technology, and chemical systems including flame throwers and batteries. In 1947 those NRC labs involved in defense technologies were transferred to operate under the newly created Defence Research Board (DRB). The Defense Research Telecommunications Establishment (DRTE) and the Defence Research Chemical Laboratories (DRCL) shortly after their creation became the inaugural members of the Shirleys Bay campus starting in 1952.

These original organizations went on to diversify and intensify their research into areas that have been important to Canada’s wellbeing. Gas mask technology continued to evolve and improve; flame thrower fuel studies were conducted; nuclear health effect studies were initiated; radio propagation studies were conducted; and of course, the Alouette I was conceived, designed and ultimately constructed during the period preceding its launch in 1962.

Today’s labs reflect much of the same technological focus and culture as the founding organizations. The Alouette I project lead directly to the creation of the CRC as a civilian communications research organization. DRDC-Ottawa continues to pursue communications, electronics and protective sciences research related to our national defense priorities. David Florida Laboratory is Canada’s foremost satellite integration and test facility. Numerous other technology organizations have also proceeded to spin off and flourish within the campus’ rich environment.

So WELCOME to Shirleys Bay Review’s 50th Anniversary Edition. We are proud to share with you the achievements and the spirit of the dedicated people and organizations that have served, and will continue to serve Canada and the world with their immense skill and dedication.

From Gas Masks to RADARSAT2 in 50 Years

The core of Canada’s communications technology expertise resides within a diverse campus, which traces its origins back to World War II.

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From Gas Masks to RADARSAT2 in 50 Years
The WW II Research Labs

PLANTING THE SEEDS OF EXCELLENCE

The culture of excellence that led to the remarkable performance of the Alouette I did not materialize spontaneously in 1958. Excellence and world-class performance were habits of the Shirlleys Bay organizations long before the Alouette I was conceived. As early as 1935, in anticipation of a European war, Canada was tasked by Britain to manufacture gas masks. After a less than successful start, it was determined that in order to manufacture quality gas masks, Canada required more depth in its technical expertise. Dr. E. A. Flood of the National Research Council traveled to Britain to review British research capabilities and brought back with him the knowledge required to establish Canada’s own R&D facilities. Rather than simply meet British standards, Dr. Flood created a team to improve the technology, working within the Chemical Warfare Laboratories on John Street in Ottawa. Their developments extended to the point that Canadian gas masks became recognized as the most advanced in the world.

Similarly, in 1940, Britain again tasked the Canadian Government, this time to manufacture radar equipment in Canada. As part of that initiative, the National Research Council opened the Radio Branch in Leitrim near Ottawa, to manufacture and test experimental radar equipment. This facility was the focal point of Canada’s contribution to the development of radar technology during WW II. By 1945 this branch had developed about 12 types of radar that were put into mass production. Approximately 20 other types were produced in smaller quantities for specific services requirements. These radars set a world standard for performance, playing a key role in establishing the outcome of the war.

By the war’s end in 1945, Canada had created world-class defence research capabilities in numerous technology areas including gas masks; radar design; radio propagation; flamethrowers; and batteries. In 1947 the Department of National Defence (DND) proceeded to form a number of defense oriented research establishments all reporting to the newly created DND agency called the Defence Research Board (DRB).

Three of these organizations, which originally fell under the DRB, were the Defence Chemical Research Laboratory (DKRL), the Defence Research Electronics Laboratory (DREL), and the Radio Propagation Laboratory (RPL). The RPL and DREL were subsequently merged under the Defence Research Telecommunications Lab (DRTL). The DRL and the DRCL being the two organizations that came together as the inaugural members of the new research campus at Shirlleys Bay in 1952.

Photo’s John Street Laboratories, home to Chemical Warfare Laboratory (CWL) Chemist working in John Street Labs.

SHIRLIES BAY: DELIVERY ROOM PARTICIPANT TO THE SPACE AGE

Everyone who participated in the early days of the space race will tell you about the excitement they felt. Defence Research Telecommunications Establishment (DRTL) staff at Shirlleys Bay were in the enviable position of being prepared to contribute in a meaningful way, even as Sputnik 1 was launched. This historical excerpt gives us a feeling for what it might have been like to be part of Shirlleys Bay during those exciting times.

“We had for several months been expecting the launching of the American satellite, but its orbit was to be at low latitudes so that we would not be able to make any use of it. Suddenly, in October 1957, Sputnik was launched. Not only was it passing regularly over Canada, but it carried a radio beacon that was intended to assist in the tracking process. Since the launch was unexpected, there were few, if any laboratories outside the USSR set up for the determination of the satellite orbit at many places in the world. This was important, and the earlier the better because this determination would give new information about the earth’s gravitational field and about its atmosphere.

Because the launch was unexpected, all the radio observatories and laboratories in the Western World were starting even in a light-hearted “race” to see who could first determine and describe the satellite orbit.

I remember hearing the first announcement of the satellite and its radio beacon on the CBC News. Within minutes, Clare Collins had agreed to meet me at the lab and within hours, we had picked up the Sputnik signal and were devising methods to determine the precise location of the satellite each time it approached Ottawa. As they shoved up to work on Monday morning, others, including Colin Hines, were recruited. As word spread of our initial progress, offers of assistance came in from the National Research Council’s Radio and Electrical Engineering Division and from the Department of Transport’s monitoring station. All such offers were gratefully accepted, because we were learning as we went.

Most of us hadn’t thought about orbital motion since undergraduate days, but we relearned what was needed in a few days, or at least what we thought was needed. Later, Nature (and the Russians) trapped us nearly. Sputnik 2 was launched into an orbit for which many of the approximations that we had made for Sputnik 1 proved to be invalid. Fortunately, since we were still doing all our calculations by hand, we realized something was wrong. Some of the other groups who were using computers kept churning out quite ridiculous orbital parameters for some time. But for Sputnik 1, all went smoothly. After three nearly sleepless days and nights of observations and calculations, we had narrowed the possible orbits down to two and here the NRC people were able to give us a single observation that eliminated the ambiguity. We had the orbit and happily sent it off by telegram to the World Data Center in Washington. Later it was confirmed that this was the first valid orbital determination made and reported, at least in the Western Hemisphere and probably one of the first, if not the first, in the Western World.

- Peter Forsyth, Superintendent, Radio Physics Lab, DRTL

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John H. Chapman

serving as Assistant Deputy Minister of Space Technology for the Department of Communications.

A visionary and an excellent communicator, Chapman provided the link between the scientific capabilities at Shirlleys Bay and the government decision-makers that needed his technical understanding and judgment to provide direction to the emerging Canadian space program.

His major accomplishments were to facilitate such programs as the

Track Sputnik

Continued...
Alouette/ISIS scientific satellite program, the Anik communication satellite program including the creation of the Communications Research Centre Canada and Telesat Canada, and the Hermes CTS demonstration satellite.

"Chapman was a natural leader," says Doris Jelly a DRTE physicist who worked for Chapman in the early 1950s. "Even though Chapman was always in a hurry, he had a twinkle in his eye and a spark of fun ... I remember the time we found him demonstrating his version of the twist dance craze in the DRTE machine shop, during the annual Christmas party."

"Chapman, was a very quick and intelligent person, with little time for small talk" says former colleague Dr. LeRoy Nelms, "Chapman would have liked to have become the first head of a Canadian space agency, but unfortunately he didn’t live to see that happen."

Milestones in Chapman’s career included:
- Joining the Radio Propagation Laboratory as a Ph.D. summer student in 1948;
- His successful submission with Dr. Eldon Warren, of the Alouette 1 proposal to NASA in 1958;
- Co-authoring in 1967 of what became Chapman’s Report, or "Upper Atmosphere and Space Programs in Canada", where he recommended the cancellation of ISIS C in favor of the Hermes satellite and pointed the direction of focus for the eventual space program;
- Leading the task force in 1968, which produced a White Paper on 'A Domestic Satellite Communications System for Canada', this was the basis for the establishment of Telesat Canada and the formation of a Canadian Department of Communications in 1969;
- Being the primary force behind Canada’s co-operative program with NASA and the European Space Agency to design, build and demonstrate the Hermes Communications Technology Satellite, which would demonstrate the capability to provide Canadians with direct-to-home television by satellite.

Chapman did not work alone; he was part of an enormously talented technical team. He was, however, personally able to gain the support and confidence of the Canadian Government and their partners to make the investments that led to Canada’s position of leadership in the aerospace and communications technology industries.

"...there was this all-pervading confidence in the ability of the lab collectively to solve new problems, to come up with new approaches to old problems and at the same time to compete technologically with some of the best labs in the world"

-Peter Forsyth, Superintendent, Radio Physics Lab, DRTE

A visionary and an excellent communicator, he provided the link between the scientific capabilities at Shirleys Bay and the government decision-makers that needed his technical understanding and judgment.

By 1957, both the United States and the Soviet Union had announced plans to launch earth-orbiting satellites. It came as a shock to the U.S. and its allies, on October 4, 1957, when the Soviet satellite Sputnik 1 was launched first. The U.S. satellite, Explorer 1, was launched shortly after on January 31, 1958. The Americans, slightly shaken, invited proposals from allied countries to share in joint space programs. Canada was one of the first to respond.

In 1958, John Chapman and Eldon Warren of the DRTE approached the newly formed U.S. organization, NASA, and negotiated an arrangement where, NASA would launch a Canadian satellite intended to study continued...
the ionosphere. The NASA partners were concerned that the DRTE plan was too ambitious since it included the design and construction of the world’s first space-based radar and included advanced “frequency sweeping” as well. NASA proposed to build and launch a simpler fixed frequency version first, with the more complex Canadian version to follow as a second-generation satellite. It would unfold that Canada’s more advanced second-generation satellite would be completed and launched first, despite skepticism within Canada and elsewhere.

Dr. LeRoy Nelms, former DRTE scientist, recalls the Alouette 1 project: “The Alouette 1 was probably the most complicated satellite that had been built up to that time. The person who really pushed Alouette 1 was Eldon Warren. Eldon had great confidence in the abilities of our scientists and knew that we could deliver the complex solution we proposed. Colin Franklin led the electrical team and John Marr led the mechanical team.

Colin may have been the biggest single factor in our success. He used our in-house scanning electron microscope to perform QA on our supplier’s electronic components and decided that commercial transistors were of too low quality for space applications. We ended up paying the manufacturer to set up a dedicated production line in order to produce transistors, which met Colin’s quality standards. This may have been the birth of the space components industry. It was certainly the reason that the Alouette 1 lasted ten years, rather than the industry standard lifetime of several weeks that we had experienced up to then.”

Then, as now, Canada’s defence laboratories carried out R&D for the purpose of keeping the department abreast of current technology and ensuring that Canadian forces were adequately equipped for their role. Much of the research at the DRTE was directed at improving communications via various radio bands. During this pre-satellite era, High Frequency (HF) or short wave radio was the main mode of communication over long distances. HF radio signals reflect off of the Earth’s upper atmosphere, or ionosphere. During the pre-satellite era, this characteristic made HF radio very attractive as one of the few options available for transmitting radio signals beyond the horizon. It was consequently important for DRTE to understand the physics of how the ionosphere behaved and how it could be used to facilitate reliable long distance military communications.

Theoretical and field studies were both carried out. However, both were limited by the availability of ionospheric data. The Alouette 1 spacecraft fulfilled the goal of achieving extensive topside ionospheric data for DRTE’s client department and it fulfilled its goal of establishing Canada’s world-class capability in satellite construction, space borne radar and in space borne signal acquisition and processing.

It was the success of the Alouette program that established for Canada the feasibility of building and operating satellites. This led directly to the Anit communications satellite program; the establishment of Telesat Canada, the civilian agency known as the Communications Research Centre and eventually to the establishment of the David Florida Laboratory and the Canadian Space Agency. All of these facilities can trace their roots back to DRTE’s dream: the Alouette 1, Canada’s first satellite.
Hermes

A DEMONSTRATION SATELLITE THAT OPENED THE DOOR TO NEW SERVICES THAT NOW BENEFIT CANADA AND THE WORLD

Canada’s entry into space with the Alouette satellites was at a time when HF radio was the only means of communication for people in many remote locations. With the Alouette and ISS satellites, scientists learned much about the upper atmosphere, and the engineers learned how to build satellites. In the meantime, engineers in the USA were developing satellite communications. In 1967, John Chapman conducted a study to determine the direction Canadian space research should take. The recommendations, published in a report, ‘Upper Atmosphere and Space Programs in Canada’, were that Canada should solve its communications problems by developing its own satellites. The research should focus on communications satellites and the last scientific satellite, ISS-C, should be cancelled.

Hermes was an experimental satellite built to test a new concept for communications satellites; that is, high power in the satellite and small dishes on earth. Early communications satellites adapted technology already in use for microwave systems (at 6/4 GHz) and hence were limited to transmitting at low power to avoid interfering with the terrestrial systems already in place. As a result very large dish antennas were required on the ground to pick up the weak signals. Hermes transmitted with high power so that TV broadcasts could be received by low-cost earth stations small enough to be used at individual homes. This concept, called a Direct Broadcast Satellite (DBS), was championed by John Chapman as a means of delivering high quality TV transmissions to Canadians outside urban centres.

New technical approaches were required to achieve the goals. Large flexible panels of solar cells generated the high power (1200W) required for the transmitter (panels provided by ESA). The power of earlier satellites was limited by the number of solar cells that could be placed on the surface of the spacecraft. A system to stabilize the satellite body in three axis enabled the solar panels to face the sun at all times and ensured that the narrow transmit beams could be kept accurately pointed towards the earth. Earlier satellites were ‘spinners’. The whole body spun to stabilize the satellite.

The high power transmitter was equipped with a new design traveling wave tube (TWT) that generated 200 watts of power (NASA provided the TWT).

A new, higher frequency band (14.52 GHz) did not interfere with microwave systems on earth and hence earth stations could be used in urban environments. On April 20, 1971, Canadian Department of Communications (DOC) and NASA announced a joint mission to build an experimental satellite - the Communications Technology Satellite (CTS). Communications Research Centre Canada (CRC) would build the satellite and NASA would launch it. CTS was successfully launched on January 17, 1976 from Cape Canaveral. On May 21, 1976, it was officially transferred to DOC. The transition between the spin and three-axis mode of control was complex and constituted a significant mission hazard particularly since this maneuver had not yet been successfully demonstrated for a geosynchronous satellite. The necessary technology for this operation was developed within Canada. The CTS/Hermes satellite occupies an important place in the evolution towards high-power satellites, because it permitted future communications systems to realize the resulting benefits of small, low cost ground stations and incidentally opening the way to a variety of direct broadcasting applications.

The transponder design allowed several types of experiments to be carried out, including:

• TV broadcast to small communities in remote areas;
• Social services including tele-health, tele-education, and teleconferencing;
• Broadcast of radio program material to small earth stations;
• Telephone service including voice, facsimile and data, to and between small transportable earth stations;
• Digital data transmission and exchange;
• Investigation of high-speed satellite data transmission;
• Investigation of time division multiple access (TDMA) techniques.

In 1987, an Emmy was awarded to the Department of Communications and NASA recognizing their joint role in developing the Ku band satellite technology through the Hermes program. Communications Minister Flora MacDonald referred to the Hermes satellite as ‘one of the most important milestones in Canadian space history’ when she presented the award for engineering achievement to the National Museum of Science and Technology. Hermes was the first satellite to operate in remote areas by people with no technical training. In 1976, John Day designed a way to connect telephones via Hermes. After the success of Hermes, Telesat Canada acquired the world’s first hybrid satellite, Anik B, to provide service in both 14.52 GHz and 6.8 GHz bands. Telesat has continued to provide service in both bands. Field trials of social services initiated with Hermes were continued with Anik B. Several of these trials were continued as operational services. These included education networks in Ontario (TVo), BC (Knowledge Network), Alberta and Saskatchewan.

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1979: Canadian and Peruvian officials in the garden of a Canadian diplomat in Lima, Peru watch a Stanley Cup playoff game thanks to Hermes. This was the first demonstration of the feasibility of direct-to-home broadcasting. The Earth station is on display at the National Museum of Science and Technology, Ottawa.
Bert Blevis, former Director General, Space Technology and Applications at the Communications Research Centre Canada (CRC) and one-time Assistant Deputy Minister, Research and Space Program at the Department of Communications (DOC) lived and worked through some of Shirley Bay’s most exciting times.

Blevis is pictured above holding the Emmy that was awarded jointly to NASA and CRC for the advancement in broadcasting technology achieved through the Hermes program. Bert was in New York in 1987 to accept the Emmy on behalf of the team at CRC that worked on the program. He played a key role, first as the Director responsible for the Hermes communications program, and then as the Director General of CRC accountable for all of its space programs. He was also a major player in the negotiations, which established the international standards for the use of satellites for broadcasting.

Starting in 1956 at Shirleys Bay with the Defence Research Board, he was there to witness the beginnings of Canada’s space program. He went on to play a senior role in satellite communications research and in several international negotiations that reinforced Canada’s position as a respected member of the international science and technology community.

Dr. Blevis points out that, “Technical achievements such as the Alouette/ISIS program, the ANIK/C condo., Hermes and SARSAT are remarkable and important in themselves. However, just as important are the power and influence that they provide to a relatively small country like Canada during international negotiations. CRC’s pre-eminence research and technical expertise is an essential element in supporting Canada’s national and international regulatory responsibilities.”

Dr. Blevis represented Canada in 1977 on a delegation to the International Telecommunications Union (ITU)’s World Administrative Radiocommunication Conference on Satellite Broadcasting in Geneva, where he was appointed Chairman of the Planning Committee for the Americas. He explained that “because of Hermes, Canada was one of the few countries at the time with actual experience and technical expertise in direct satellite broadcasting. This put us into a very powerful position in putting forth our interests at the international telecommunications Union (ITU).”

The ITU, a specialized agency of the United Nations, is the international body that regulates telecommunications standards and the use of radio frequencies by member countries. It was very important for Canada to influence decisions at the ITU in order that Canadian standards and special needs be accommodated in the resulting agreements. The ITU now divides the world into three regions, each of which adopted slightly different plans for the introduction of satellite broadcasting. It would have made a great deal more sense to agree on a uniform plan throughout the world, but getting such widespread agreement among a diversity of political and commercial interests is almost impossible.

Blevis also led Canada’s negotiating team for international agreements relating to SARSAT and its then Soviet counterpart COSPAS, the enormously successful Search and Rescue Satellite system that Canada conceived, along with the U.S., and helped design and implement in partnership with the U.S., France and the Soviet Union. As a result, Canadian industry was able to capture major contracts to build the satellite on-board transponders and user ground terminals.

Multilateral international agreements implemented through international agencies and standardization organizations such as the ITU continue to be critical to Canada’s competitiveness. It is by maintaining our scientific and technical expertise, as we continue to do within Shirleys Bay that we are able to participate in the negotiation effectively and successfully and thereby bring economic benefits to Canada.”
Mobile Satellite Communications

WHY SHIPS AND PLANES ARE NEVER OUT OF TOUCH

Anyone who travels by plane or ship will appreciate the benefits of INMARSAT, the worldwide satellite network that allows mobile aircraft and ships to communicate with the world regardless of where they are located.

The Communications Research Centre Canada (CRC) has played a major role in developing the concepts, protocols and technologies that led to today’s INMARSAT air service. Several Canadian companies have used their relationship with CRC to find ongoing business opportunities related to the INMARSAT service.

CRC’s role in mobile aeronautical communications began in the 1970s. Jack Rigley, CRC’s Vice-President, Satellite Communications and Radio Propagation recalls that “In the early 70s CRC was involved in AEROSAT, an International Program to launch an aeronautical satellite. We were doing the research on antenna design in conjunction with DND. Through this program CMC Electronics developed a linear array antenna operating at L-Band. This antenna has flown for many years on a government executive jet.”

Although the AEROSAT program was abandoned in the late 1970s, CRC’s involvement with the concept was revitalized in the 1980s by a program to develop technology that would allow aircraft to communicate through the established INMARSAT marine communications service. Specialized antennas, protocols, ground stations and airborne communications technologies all had to be developed. The communications signal design developed by CRC with the International Civil Aviation Organization ICAO were ultimately adopted for use by INMARSAT itself. Bruce Bailey of CMC Electronics credits CRC with providing valuable technical support in their successful effort to develop antenna technology compatible with INMARSAT. Bailey reports that “CMC now has a major share of the world market for aeronautical INMARSAT antennas. These highly complex directional antennas meet rigorous performance standards set by INMARSAT and ICAO for reliability and coverage.”

CRC’s activities with INMARSAT have generated business opportunities for their sister organization the David Florida Laboratory. DFL has been designated by INMARSAT as the one agency certified to do performance testing of communication equipment that uses CRC INMARSAT communications signal design.

Other companies which have benefited from the CRC mobile satellite initiative include EMS Technologies, which has commercialized the modulation encoding technology used on board the aircraft; and Square Peg Communications, which has commercialized the test equipment used to ensure ground station compatibility and performance compliance with aeronautical terminals.

Effective communication demands a clear, simple message.
A Focus on Dual Use Strategy Allows Canadians to Benefit Twice from their Investment in Defence Technology

Defence R&D Canada (DRDC) - Ottawa supports Shirleys Bay defence-related initiatives working closely with other Shirleys Bay agencies that lend their expertise to Canada’s Department of National Defence. Areas of DRDC expertise and activity include:

- Electronic Warfare
- Surface Radar
- Aerospace Radar
- Space Technology
- Defence Communications
- Information Operations
- Radiation Technology
- Radiation Biology
- Navigation

DRDC-Ottawa’s mandate is to emphasize dual use technologies leading to civilian and military demands for their products and services. This is achieved in part by working in close cooperation with other Shirleys Bay organizations, which support defence related projects.

- The Communications Research Centre addresses the exploitation and adaptation of civilian standards and technologies for military use;
- Canadian Forces Experimentation Centre utilizes modeling and simulation tools to provide decision makers with recommendations concerning future defence technologies and strategies.
- Canadian Forces Electronic Warfare Centre supports DND operational forces electronic warfare initiative drawing on DRDC expertise in support of their operational programs and initiatives.

Canada has one of the world’s longest coastlines, representing enormous challenges to those agencies responsible for surveillance against illegal imports, immigration and threats to our fish stocks and national security. Airborne surveillance using Canada’s fleet of Aurora Aircraft is effective but expensive. Operating costs of the Aurora are reported to be in the order of tens of thousands of dollars per hour.

A team of DRDC Scientists led by Drs. Hing Chan and Harold Wilson work on a project at Shirleys Bay, that is aimed at reducing these costs and improving Canada’s effectiveness in monitoring maritime traffic along our coastline. The fundamental problem with using radar to monitor offshore maritime traffic is that common radar signals, like beams of light travel in a straight line. Consequently, targets below the horizon are not detectable using ground-based radars. The DRDC radar takes advantage of a particular propagation characteristic of electromagnetic signals, called surface wave, to operate in a frequency regime where the radar signal actually follows the earth’s curvature. As a result, surface vessels and low-altitude aircraft below the radar horizon can now be detected using this shore-based radar. Canada will soon have the ability to put in place a very cost-effective wide-area coastal surveillance radar network based on this technology. This coastal surveillance radar network can monitor the 200 nautical mile Economic Exclusion Zone (EEZ) continually.

DRDC’s commercial partner in this project, Raytheon Canada, is investing cooperatively with DRDC and has the rights to sell the technology worldwide. Dr. Chan says, “There is excellent commercial potential in this technology. Competing technologies such as sky wave radar and aircraft surveillance are much more expensive, lacking some of the potential advantages that we offer”. DRDC continues developing this technology. Areas of study include the reduction of interfering noise caused by radar reflecting off of the ionosphere and the use of data fusion with other sensors to increase the information that can be gained from the data.
dirty bombs - defending our cities against a new kind of threat

Dean Haslip works with a group of defence scientists studying the effects of a potential threat that the world has yet to encounter. Dirty bombs or Radiological Dispersal Devices, RDD's as they are called, are unlike conventional bombs that are designed to destroy buildings and people through the explosion. RDD's are weapons of terror that rely on the radioactive contamination that they disperse.

DRDC's main interest in RDD's is to assist DND preparations for the eventuality of Canadian Forces facing this kind of threat during peacekeeping or other activities. Knowledge of RDD's and how to respond to them could be equally important for civil defence as RDD's are a potential terrorist weapon.

Haslip observed that, "With the end of the Cold War, the threat of nuclear war is much lower, or at least much different. However, the possibility that Canadian Forces could be attacked by Radiological Dispersal Devices or Dirty Bombs is one of the new possibilities that we've been considering. The radioactive source could be a medical source, an industrial source, or spent radioactive fuel. It could be dispersed explosively or otherwise. The attackers would be trying to contaminate people and equipment. It turns out that the same kinds of threats can be used against a civilian population. The civilian population wouldn't be as prepared. It could be an economic weapon as well. Buildings could become unusable or need to be demolished. Radiological contamination is quite difficult to extract. Decontamination is very expensive and time consuming, and may not even be able to meet the standards that are specified by organizations such as the Canadian Nuclear Safety Commission."

"We use computer codes to predict how the radioactivity spreads and to determine the ramifications for people in the affected area. Due to the increased threat of terrorism this past year we are using the codes more often in predicting the consequence of radioactive dispersal to civilian personnel and infrastructure."

Other work that Haslip's group does is applicable to consequence management. They develop new techniques for radiation detection, evaluate techniques for decontamination, and perform field measurements and sample analysis in support of deployed forces. They have also been contributing to the civil defence effort by supporting presentations made by Canada's Office for Critical Infrastructure Protection and Emergency Preparedness OCIPET in delivering radiological terrorism awareness sessions to groups of civil first responders including firemen, police and emergency medical staff.

"With the end of the Cold War, the threat of nuclear war is much lower, or at least much different."
FINDING SMART WAYS TO TRANSFORM OUR MILITARY: CFEC IS PART OF A BROAD DEFENCE INITIATIVE

There is a new establishment being created within the Shirley Bay campus called the "Canadian Forces Experimentation Centre" or CFEC. Initiated in late 2001 with only 12 people, the establishment staff should grow to 50 and will be housed in a new $4M building by the end of 2004. We had the good fortune to speak with the commanding officer Col. Mark Aruja. Aruja explained that the official mission statement for the new centre was "To lead the exploration of emerging concepts to determine the capabilities required by DNDD and the Canadian Forces of the future". Aruja went on to describe some examples of how this could be done, and the kinds of projects in which they are already involved. "One of the key capabilities which the department has mandated us to develop is a modeling and simulation-based capability to explore ideas from their initial conception, experiment with the good ideas in a rigorous experimentation environment, and then transition those ideas into the Canadian Forces for operational use. We are fundamentally in the business of challenging the way we currently do business with new ideas. Private business has dramatically changed their cycle time from concept to market, it makes sense that we examine ways to do the same. After all, in the Cold War, we knew who our adversary was, and who our allies were. Not so any more: we have to have the capability to deal with uncertain adversaries in concert with ad hoc coalitions. Currently we spend years getting a requirement approved, and then turn to industry to deliver a capability, which fifteen years later is fielded to the force. We then repeat that cycle with a mid-life upgrade. What is a mid-life of a weapon system when the life of digital processing technology is measured in months? The B-52 is still in front-line combat with the US Forces after 40 years, yet desktop computers are disposed of after four years, is there something to be learned from this?" Building models that, irrespective of where they may reside, are able to interact with other models to depict a particular environment will allow us to examine an idea in a digital environment. Industry is engaged early on to provide their ideas, which can be evaluated in that synthetic environment and when proven and accepted, linked to the tools industry and used to actually produce the product. That synthetic environment is then used to allow for continuous improvement, perhaps finding a new use not previously conceived for that system, or even early disposal of unmanned systems are a particular application for these new tools. We have already conducted live-fly trials of a number of unmanned aerial vehicles to gain insights from which to baseline our simulation efforts. At specific points we will again conduct live fly experiments of increasing complexity to validate if what we are seeing in the simulations is in fact true. Unmanned systems are a means for us to ask many questions. For example, when does a piece of equipment become disposable? If software is disposable, notwithstanding the investment, why not hardware? Can we change the software in an unmanned system at the same time as the hardware becomes available to support new capability... like every year, as opposed to the 15 years I mentioned earlier? Sending TV images from unmanned systems uses up a lot of bandwidth, and is expensive. Can we use artificial intelligence to allow us to look for certain things, and only send the information, which is of use? What level of autonomy should we expect to achieve with artificial intelligence. At what level, can an autonomous "vehicle" interact with other unmanned systems? Would these become self-organizing systems, and if so, how might they behave? Would that behaviour be acceptable? Can we apply alternative fuel technologies to unmanned systems as a quick means to reduce the demand on moving fuels and batteries to deployed operations around the globe? How should manned and unmanned systems interact to achieve an effect with maximum synergy? We do our work not in isolation, but in collaboration with many organizations and people both here in Canada and internationally. The Canadian Forces, when deployed overseas will inevitably work with other countries, so we must take interoperability into consideration from the outset. We are working closely with our allies to look at joint operations, and are doing so with distributed simulations across a new network dedicated to experimentation. Concept development and experimentation require a synthetic environment, which stimulates thinking, promotes asking the unquestionable, and accepts the notion that learning from failure is a good thing. We have a mix of scientists who make sure we are bringing the right science to the problem, we have analysts who ensure that we apply sound methodologies and rigor to the work we do, and we have military officers who make sure that the questions we are asking are relevant and that we think through how we are going to move a good idea which stands the test of experimentation into the hands of those who can capitalize on that good idea."

Colonel Aruja explains the use of unmanned aerial vehicles UAV's.
In 1997, Telstar-401—a communications satellite in geostationary orbit—failed. It now drifts uncontrolled 35,000 km above North America, threatening collision with at least 22 active satellites that provide critical communications capabilities to Canada and the US.

The risk of collision between two objects in orbit around the earth is real. In 1996, a discarded rocket booster impacted the stabilization boom of a French satellite, causing it to tumble uncontrolled until ground controllers were able to upload new stabilization software to the satellite. They were lucky—a few more meters to the side and the satellite would have been destroyed.

It does not take something big to damage a satellite. In a recent incident, a flock of paint impacted the space shuttle windshield leaving a 4 mm crater. The paint chip was probably a fleck of paint impacted the space shuttle when it struck. The shuttle is built to withstand this sort of impact and the satellite would have been destroyed.

Brad Wallace is a Defence R&D Canada (DRDC) scientist. Brad Wallace, shown with one of three optical telescopes that he is using to track space debris,

Brad Wallace explained further, “One of our goals” says Dr. Wallace, “is to demonstrate our ability to collect useful data as a starting point from which to begin work with the Americans as a part of their larger surveillance system.”

Dr. Wallace explained further, “The U.S. Department of Defence currently operates the Space Surveillance Network (SSN). Their goal is to keep track of all orbiting objects larger than 10-30 cm. Where possible, the SSN attempts to identify the object, and in the case of operating satellites, their capabilities. Current estimates are that there are about 9000 orbiting objects of this size. The Department of National Defence is currently in the process of procuring a space surveillance satellite called Sapphire. This will link with the U.S. Space Surveillance System and significantly enhance Canada’s role as a partner in this critical mission. The work we are doing at DRDC is providing the foundation for the inclusion of both our network and Sapphire into the SSN.”

Brad Wallace is a Defence R&D Canada (DRDC) scientist working on Canada’s contribution to international surveillance efforts designed to turn space into a safer place. His team is currently deploying a network of three remotely controlled ground telescopes that will monitor some of the earth’s larger orbiting objects. The telescopes are to be located across Canada but they will transmit their imagery to Shirleys Bay for data collection and analysis.

“One of our goals” says Dr. Wallace, “is to demonstrate our ability to collect useful data as a starting point from which to begin work with the Americans as a part of their larger surveillance system.”

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One of Shirleys Bay’s important roles is to understand and help manage the technologies that allow Canadians to communicate with one another and the world.

Shirleys Bay expertise is central to Canada’s capabilities in the following areas: the creation of a stable regulatory environment; the negotiation of advantageous international agreements; and in the adaptation of commercial technologies to meet the unique and special needs posed by our country’s expansive geography.

Multiple agencies within the campus contribute to these capabilities.

Communications Research Centre (CRC) is Canada’s centre of excellence for communications R&D and an independent source of advice for public policy purposes.

Defence Research and Development Canada (DRDC)-Ottawa is Canada’s centre of excellence in exploiting the spectrum for defence purposes, this includes both radar and communications technologies.

Certification and Engineering Bureau (CEB) is the provider of equipment certification services for the telecommunications industry.

National Capital Institute of Telecommunications (NCIT) funds pre-competitive research in the areas of telecom and IT innovation.

The CRC Innovation Centre assists young Canadian communication oriented companies to develop their potential through on-site technology incubation and priority access to Shirleys Bay expertise and organizations.

The communications capabilities in all of these organizations have evolved primarily from the Defence Telecommunications Research Establishment (DRT), one of the campus’s two pioneering agencies. It is with pride that they carry on the Shirleys Bay tradition of innovation and technological excellence.

There was a time in Canada when being left off of the Central Pacific Railroad or the Trans-Canada Highway meant slow death to a small community. That same phenomenon may be happening again today, as high speed Internet becomes an essential component of commercial activity and personal communications. Our smaller, more remote communities are not currently receiving the level of Internet services that they need to prosper.

Gérald Chouinard, CRC program manager for Rural and Remote Broadband Access, is in charge of CRC’s efforts to make sure that this problem is addressed.

Telidon prepared us to recognize and utilize the value of the Internet as soon as it emerged” ... Thom Whalen

His job is to orchestrate the work in various R&D projects at CRC towards developing technologies and systems in support of Canada’s broadband access challenge.

Working with one foot in technology development and the other in the policy/regulatory arena is nothing new for Shirleys Bay program managers. “Broadband Access has really become an international issue”, says Chouinard, “It is almost a race between countries to see who can get the best access the soonest.” The U.S., like Canada, sees broadband access as a means to improving the quality of life of their citizens. It brings with it health through telemedicine, knowledge through online schooling and information exchange, improved business to business commerce, and facilitates business to individual commerce.

CRC is trying to develop technologies that would make it easier and cheaper to get high speed Internet to the home in rural and remote communities.

The broadband initiative is intended to bring the quality of Internet access in rural and remote Canada to the same level as in urban Canada.

“In my opinion, CRC needs to focus on the last mile solution and bring it in at the lowest possible cost.” says Chouinard. “ Here at CRC we currently have...”

Communications
Canada’s Broadband Initiative
Continued from page 31.

Our smaller, more remote communities are not currently receiving the level of Internet services that they need to prosper. 14 separate R&D initiatives underway, each selected for its potential to help achieve the broadband equal access goal.”

“Finding a technology solution to this problem will allow Canada to avoid seeking solutions through difficult regulatory and cross-subsidization means,” says Chouinard. “Once this technology is transferred to Canadian industry, it will provide an opportunity for companies to take part in the broadband implementation in Canada and also export equipment to larger developing countries like Brazil and India who have similar access problems.”

Communication infrastructure programs are a complex combination of market awareness, technology, regulation and international standards negotiations. The broadband program is no different.

CRC has the needed expertise in areas such as RF transmission both, terrestrial and satellite; modulation and channel coding for high speed or large bandwidth systems; broadband communication protocols; audio compression; video compression; and network interfaces to name a few. CRC also possesses the skills and experience needed to ensure that its solutions will be communicated effectively to government and international regulatory bodies as well as successfully transferred to Canadian industry.

If there is one lesson to be learned from the history of the Shires Bay Campus, it is that success breeds success. Canada’s technology successes of World War II led to Alouette 1, which in turn, led to the campus’s current leading-edge projects. It is clear that having access to specialized expertise and contact with a culture of excellence leads to further success.

With a mandate to help build a strong Canadian economy, Communications Research Centre Canada (CRC) started operating its Innovation Centre in 1994. The Centre is designed to incubate start-up technology companies, as well as the new R&D initiatives of more established businesses.

The CRC Innovation Centre consists of about 20,000 square feet of office and lab space spread over six buildings on the Shires Bay Campus. The Centre’s goal is to match qualified business start-ups with CRC research mentors willing to sponsor these companies by sharing their expertise.

In order to qualify, a candidate company must have a business plan and a technology idea that parallels CRC’s R&D interests. There must also be a capacity at CRC in the form of available office space and a researcher willing to act as a technology advisor.

CRC also offers access to its top-notch support services, including marketing information and contacts; a scientific library; meeting rooms; an in-house graphic arts facility; and a unique machine shop/prototype development facility tooling specifically to develop one-off electronics and communications products.

Office space and services are offered at market rates, and companies are willing to pay, since comparable services are not often available anywhere else. The prestige that comes with being located at CRC and having access to valuable networking opportunities are also strong selling points.

Innovation Centre Manager Marie Lussier is the President of the Canadian Association of Business Incubators and a strong proponent of the incubator concept. She is very proud of the more than 30 companies that have come through the CRC Innovation Centre – including names such as SkyWave Mobile Communications, Square Peg Communications and Spotwave Wireless, to name a few.

Lussier says the CRC incubator is tailored to create a synergy between the private and public sectors in Canada.

“Companies benefit from CRC expertise, and access to world-class test beds and technologies,” she says. “And CRC benefits from sharing knowledge and technology with the private sector.”

Lussier adds that CRC’s experience, coupled with that of other business incubators, shows that incubators create jobs and contribute to an innovative economy.

“They lead to higher business success rates and facilitate strategic alliances between start-ups and larger public and private organizations in Canada and abroad,” says Lussier. The National Business Incubator Association in the U.S. estimates that there are about 4,000 incubators worldwide, with about 1,000 in the U.S. and 150 in Canada.

For more information about the CRC Innovation Centre, please visit www.crc.ca.

For your convenience we encourage you to visit our website at www.iskurkey.com.
The world of wireless technology moves at a blinding pace. New products and services are announced almost daily, and any one of these may impact the future direction of a communications project or the strategic direction of a government initiative. You could say that it is a research topic unto itself: to study the current state of wireless technologies, along with the impact of their combined effect when they are used to create solutions for problems in business, education or government.

In fact that is what the CRC WISELAB has been created to do.

Their mandate is to study comprehensive solutions to specific problems. Luc Boucher, the WISELAB’s manager explains, “We’re looking at whole systems and how they can be used, not just at one specific technical aspect. Our group needs to understand how each individual component can be applied, together with other technologies, to create whole solutions.”

“A key skill we have in the WISELAB is the ability to learn quickly, in order to respond rapidly to the requests of our clients”, says Mr. Boucher. “We must acquire knowledge quickly in order to understand the required field in a very short time so that we can come up with the answers very quickly. The fact that we are collocated at Shirley’s Bay with all of their technology specialists is a very important part of our ability to get our job done.”

As with other labs, infrastructure and facilities is key. By providing a versatile testing environment, the CRC WISELAB can support advanced development and evaluation of terrestrial wireless technologies for industries, governments and universities. The infrastructure in place includes broadband wireless links, wide area networks access, personal area networks, and multimedia platforms. Some of the facilities that the lab maintains for test services include:

• 802.11a/b/g WLANs, Mesh networks and Bluetooth
• Broadband point-to-point and point-to-multipoint links
• LMCS, MMCS, and Free space optics links
• OFDM simulator
• CDMA 1xRTT, GPRS and IS-95 access
• Handheld Wireless tablets, Pocket PC, Palm
• WAP, SMS, MMS, BREW, J2ME, etc.

Mr. Boucher says, “We’re overwhelmed with requests for our services from inside and outside CRC. We’re looking forward to building a larger team of partners, to include industry and universities, to help us better address Canada’s wireless broadband requirements.”
The Canadian public owns a valuable resource that they cannot see, hear, smell or touch, but is worth billions of dollars to our economy. That resource is the electromagnetic spectrum.

The uses for the spectrum are ubiquitous: radio and television transmissions, cell phones, ham radio, police radar and radios, wireless Internet, remote garage door openers, and the list goes on and on.

Data transfer over radio link is well understood and very useful, but before we can launch any new service we first must allocate a frequency band where this service can operate effectively and without undue interference from or to other services.

That being said, all frequencies were not created equal. David Rogers, program manager at CRC's Radio Propagation Laboratory explains: "As new services come online there is a shortage of spectrum, particularly at lower frequencies. One of the reasons that lower frequencies are attractive is that the technology is relatively inexpensive. For example, cellular telephones operate at fairly low frequencies and the equipment used is fairly inexpensive.

However, there is not enough room in that part of the spectrum for all of the new applications that are coming online. Broadband access, for instance, is just one application that may require service providers to move to higher frequencies, to take advantage of the greater bandwidths allocated in higher bands.

In this higher frequency portion of the spectrum, propagation characteristics are less well characterized. It is our responsibility to try to understand the physics of any transmission using this part of the spectrum, including power requirements; the effects of precipitation; signal blockage and scatter from buildings and other structures, and the potential for interference problems with other services. Many millions of dollars may be at stake when launching new services. Our expertise reduces the risks of poor performance and interference with existing services before these investments are made.

New concepts are constantly being brought forward, and they have to be evaluated. For instance, we are currently looking at MIMO, or multiple-input, multiple-output systems. This is a new concept for which the achievable performance is currently unknown. So we could not make a frequency allocation and demand a certain capacity utilization from a service provider, if we don't know if it can be met.

One other reason that CRC propagation expertise is so important to Canada is that we are such a large and somewhat sparsely populated country. We need to provide reliable communications to remote areas and to the military in the far north, for example. Canada's climate and environments are extremely diverse and this makes a difference to communication performance and the effects must be understood. Provision of service in a mountainous area can be very difficult due to blockage and diffraction by the hills and so on and so forth. If you want to provide reliable services in areas where there can be huge variation in local conditions, you need to be very sophisticated in your understanding of propagation issues."

A Fish Eye view of Communication Research Centre Canada's main building illustrates one technique for the measurement of local signal blockage.
Radarsat 1 being lowered into the David Florida Lab test chamber

**Canada's First Science Satellite in 30 Years**

Today, the goal of SCISAT 1 is to help us better understand the ozone layer above the earth so that we can be more effective in our efforts to protect our environment.

Marc Garneau, president of the Canadian Space Agency, which owns and operates the David Florida Lab, says that “We will help not to correct the problems with the environment but to better understand them.”

SCISAT 1 is scheduled to be air-launched on a Pegasus XL rocket by NASA in early 2003. The satellite will study global ozone depletion. The onboard experiment is called Atmospheric Chemistry Experiment (ACE).

Bristol Aerospace Limited has been selected by the Canadian Space Agency to build the all-Canadian science satellite, SCISAT 1. Bristol has begun work on the satellite at the David Florida Laboratory (DFL), which holds the international reputation as a unique pre-launch satellite test facility.

The DFL, located in Shirleys Bay, is managed by the Communications Research Centre (CRC). CRC collaborates with satellite service providers and users by developing and demonstrating applications such as telemedicine and tele-education.

The DFL also works closely with Defence R&D Canada (DRDC) - Ottawa in the areas of: radar data exploitation; ground station technology; data fusion; antenna research and space based mission simulations; and

CRC manages the implementation of the major portion of the satellite communications component of the Canadian Space Plan. It serves as the contract and technical authority on multimillion-dollar industrial development contracts. CRC also collaborates with satellite service providers and users by developing and demonstrating applications such as telemedicine and tele-education.

Together, DFL, CRC, and DRDC-Ottawa offer one of the world’s most comprehensive satellite development and testing capabilities.

**Experience, Determination and Synergy Make Shirleys Bay a Key Partner in Canadian and International Space Programs**

In 1962 Shirleys Bay agency, Defence Research and Telecommunications Establishment (DRTE) distinguished itself and Canada by successfully completing Alouette 1 making Canada the third country in space.

The success of the Alouette program led, in 1969, to the creation of Telesat Canada and the conversion of the DRTE into a civilian organization called the Communications Research Centre (CRC). The CRC’s role, in part, was to provide technical support and supervision to Telesat Canada for the deployment and management of Canada’s Anik series of commercial telecommunications satellites.

This challenge was followed by a joint program with NASA to build and launch the Hermes satellite, the world’s first ‘direct to home’ television broadcast satellite. This was the project that initiated the creation of Shirleys Bay’s David Florida Laboratory to manage the integration and testing phases of the Hermes satellite construction.

Today we know that:

- The Alouette program went on to be designated as one of the 10 most outstanding achievements in the first 100 years of engineering in Canada;
- The CRC (with NASA) were awarded an Emmy for their joint role in developing the Ku-band satellite technology through the Hermes program; and
- The David Florida Laboratory has evolved into Canada’s national facility for spacecraft assembly, integration and test.
The major scientific goal of the Atmospheric Chemistry Experiment (ACE) mission is to measure and understand the chemical processes that control the distribution of ozone in the Earth’s atmosphere, especially at high altitudes. The data that will be recorded as SCISAT 1 orbits the Earth will help Canadian scientists and policy-makers assess existing environmental policy, and develop protective measures for improving the health of our atmosphere and preventing further ozone depletion. The ACE mission is designed to last for at least two years. Advances in our understanding of the mechanisms responsible for ozone losses will tell us whether an ozone “hole,” such as the one found in Antarctica, is likely to occur above Canada in the future. More importantly, continued research, such as that which will be carried out on the ACE mission, will also help us identify how the ozone layer can be restored and preserved, thus protecting the health and well-being of all Canadians.

The Anik F2

When Telesat’s Anik F2 satellite soars skyward in 2005, the Communications Research Centre (CRC) will toast the satellite’s ascent with good cause. Working on behalf of the Canadian Space Agency, CRC is overseeing the development of advanced made-in-Canada technology that will debut on Anik F2. In addition to carrying traditional C-band and Ku-band payloads, Anik F2 will be the first North American satellite to incorporate an advanced, spot beam Ka-band payload. This feature will enable Telesat to provide high-speed broadband services to customers throughout Canada and the continental U.S. Thanks to the CRC and the Canadian Space Agency, Anik F2 will fully capitalize on its Ka-band capabilities. The satellite will carry two Canadian-built Ka-band innovations, one from EMS Technologies and another from COM DEV International.

EMS Technologies is developing an experimental onboard processor that will enable two remote earth stations to communicate directly with each other using Anik F2’s Ka-band spot beams. The other Canadian technology to fly on Anik F2 comes from COM DEV International. This company is building a system to funnel traffic from various remote sites to a given Ka-band gateway. Dubbed BeamLINK, this multi-functioning satellite will add great value to Anik F2’s commercial payload.

"Putting these two Ka-band systems on Anik F2 will allow Telesat, the manufacturer, and the satellite industry to assess the equipment’s in-flight performance," says Ken Gordon, Director, Broadband Technology Development with Telesat. "By coordinating the projects, CRC is playing an important role in the development of Canadian satellite technology. Ka-band offers Telesat some important advantages. First, it allows the company to cover the serving area using some 45 spot beams that concentrate satellite power on relatively small zones. This concentration enables customers to use compact, low-cost satellite terminals, and it equips Telesat to offer bandwidth-hungry applications such as videoconferencing and high-speed Internet access. Second, Telesat can reuse a given Ka-band frequency five or six times—a characteristic that keeps transmission prices low. This efficiency occurs because a beam serving, say, the British Columbia lower mainland won’t interfere with one of the same frequency serving, say, the Winnipeg area. The ACE has been instrumental not only in coordinating the two Canadian technology projects, but also in developing the types of advanced broadband applications that Anik F2 will support. Telesat and CRC have worked together closely for several years to bring medical, educational, judicial, Internet, and other services to remote Canadian communities via satellite.

"CRC has been outstanding," says Mr. Gordon. "They’re extremely responsive and professional—an ideal partner in every sense. They do an excellent job helping remote communities use satellite to get access to advanced broadband applications. Who knows what satellite advances await down the road? Anik A3 redesigns would have marveled at Anik F2’s power, size, and capabilities. Wherever the satellite industry is headed, however, one can be sure that CRC and Telesat will be at the forefront, helping Canadians and others around the world to communicate evermore efficiently and cost effectively."

If you were lost in the wilderness, on foot, in a downed aircraft, or stranded at sea, you would want to know that someone was looking for you. You would also want to know that they would be able to find you within hours rather than days. Fortunately, there is a free service which will allow you to call for help using a radio beacon valued at less than $1,000. Once turned on, the beacon will transmit your distress signal to a monitoring station via satellite. The service known as Cospas-Sarsat has been credited with saving more than 14,000 people since its creation 20 years ago.

Jim King, Director, Major Satellite Communications Programs at CRC took a few minutes to explain what the system is and the role that CRC played and still plays in its development. "Cospas-Sarsat is an international, humanitarian search and rescue system. It consists of three main components: satellites to detect and locate emergency beacons carried by ships, aircraft, or individuals; the emergency beacons themselves; and a network of ground stations that detect the emergency signals.

When an emergency beacon is activated, the signal is relayed via a satellite to the nearest available ground station where it triggers a search and rescue action on the part of the responsible agency. Cospas-Sarsat is now a well established international service with many participating countries. Today all Canadian Cospas-Sarsat ground stations and the Canadian mission control centre are operated by CRC. However, like so many communication technology innovations, CRC has played a role in both its conception and its ongoing development.

Some of the earliest experiments were done at Shetleys Bay in the mid 1970s. CRC first carried out a proof of concept experiment. They modified an existing distress beacon to work at a frequency that allowed it to transmit through an amateur radio satellite. By doing a series of calculations CRC showed that a dedicated search and rescue satellite system could operate effectively using the beacons that were then in use for the existing aircraft based search-and-rescue service. The original SARSAT program started as an experiment between Canada, USA and France, and soon Russia joined and developed and launched its own COSPAS satellites, which were compatible with ours, so it became a four-country program. Today, some 35 countries share in the operation of the system and the administrative costs, and many provide their own ground stations.

The initial Cospas-Sarsat system, used what is called LEOSAR or Low Earth Orbit SAR. These satellites monitor a continent wide swath during each polar orbit they make around the earth. One satellite provides coverage for the entire earth in 12 hours. By using the constellation of four or more satellites that we have today, there is usually no more than a two-hour window without at least some coverage. By the mid 1980s the international team began launching what we call GEOSAR satellites. “GEO” standing for GEostationary. This has given us constant coverage in the areas that the system reaches. Since GEOSAR doesn’t cover the polar regions and it can miss beacons hidden behind a mountain, or behind the superstructure of a ship, we still need LEOSAR as part of the complete solution. Today CRC and the international Cospas-Sarsat team are looking at new areas of development including: MEOSAR, or Medium Earth Orbit SAR is a system where repeater payloads would be placed on board GPS and other multipurpose satellites, with 25 to 30 satellites in a constellation there would be almost constant coverage. AND the satellites would not suffer from shadow effects to the extent that GEOSAR does, since they would be in constant motion. CRC is also looking at improved detection and verification using signal processing techniques to distinguish and filter out interfering signals that are not originated by distress beacons."
CANADA RESUMES THE LEAD IN REMOTE SENSING SATELLITES

RADARSAT 2

RADARSAT 2, Canada's next-generation Earth observation satellite will soon undergo integration and testing at the Canadian Space Agency's David Florida Laboratory.

RADARSAT 1, developed by the Canadian Space Agency (CSA), became Canada's first commercial Synthetic Aperture Radar (SAR) satellite, positioning Canada as a world leader in the business of Earth observation. Launched November 4, 1995, the satellite has spawned a follow-on program to provide data continuity for thousands of RADARSAT 1 data users around the world. RADARSAT 2 will soon undergo integration and testing at the David Florida Laboratory at Shireys Bay, like its predecessor did in the 90s.

One of the hallmarks of Synthetic Aperture Radar is its capacity to use microwaves to penetrate cloud cover, making the surface of the earth accessible at all times, regardless of weather conditions. This is a particularly valuable characteristic for users who require images on a regularly scheduled basis, or acquired at times that coincide with specific events. Radar is particularly good at monitoring oil spills, floods, and ice flows.

Another useful characteristic of images produced by radar is that they contain phase information from the microwave energy reflected off the earth. This opens the door to many unique applications including measuring minute changes in land elevation due to earthquakes or oil field depletion, and the characterization of different materials or terrain based on the polarization shifts of reflected radiation.

Building on the success of RADARSAT 1, the Canadian Space Agency received the mandate to develop a follow-on program in co-operation with the private sector. The RADARSAT 2 program originates from this mandate and ensures the continuity of the original RADARSAT program and supports the evolution of the Earth observation industry in Canada.

RADARSAT 2 is a unique collaboration between the Canadian Space Agency and MacDonald, Dettwiler and Associates Ltd. (MDA). Under a financial and management agreement, MDA will own and operate the satellite, while the CSA will recover its investment through the supply of images to Canadian government departments.

The spacecraft is scheduled for launch in 2004 and is designed with an operational life of seven years. The RADARSAT 2  program features some key technology upgrades and enhancements that will bring additional value to the international data user community. RADARSAT 2 will image the earth's surface at spatial resolutions between 3 and 100 metres, with nominal swath widths ranging from 10 to 500 kilometres.

RADARSAT 2 will be the first commercial radar satellite to offer multi-polarization, a capability that aids in identifying a wide variety of surface features and targets in agriculture and disaster management for example. All imaging modes will be available to both the left and right side of the satellite track. These capabilities will make RADARSAT 2 the most advanced commercial radar satellite ever launched.

The flexibility of RADARSAT 2 beam modes and its 24-hour data acquisition capabilities position the satellite as a major information source for commercial applications and remote sensing science, helping scientists and researchers better, understand, monitor and protect the earth and its environment.

First and foremost, RADARSAT 2 is being developed to address the needs of the commercial market, but the mission is also providing Defence Research and Development Canada (DRDC) Ottawa with an opportunity to carry out a defence-related proof-of-concept experiment. Dr. Chuck Livingston heads a team of nine defence researchers that will use RADARSAT 2 data to detect and track moving vehicles on the earth's surface. The Ground Moving Target Indication (GMTI) demonstration project involves the development of a specialized defence payload on the satellite that will collect and process data central to this application. The information will be transmitted back to earth using secure encryption techniques.

The GMTI project has obvious defence applications; Dr. Livingston explained however that it could ultimately have important civilian applications as well. "By using the GMTI technique, we expect to be able to detect moving vehicles on the surface of the earth. Airborne radar results have been very positive and our analysis indicates that we could expect similar results using RADARSAT 2."

He also adds: "Our detection cell size on the surface of the earth is 6 metres, however GMTI is usually able to detect targets smaller than the radar cell size. The ability to monitor and analyze traffic patterns from space could be an interesting civilian application of the demonstration project."

Our wave of success started here. Yours could too.
THE DAVID FLORIDA LABORATORY PARTICIPATES IN CANADA’S PREMIER ROBOTICS DEVELOPMENT PROJECT
The Canadarm2 is shown here as one part of a three-part, Mobile Base System (MBS) at the David Florida Laboratory. Canadarm2 (SSRMS - part 1) is mounted on the Mobile Base (MBS - part 2) which moves along a set of rails that extend the entire length of the space station. By 2004 a specialized manipulator system (SPDM - part 3) will be inserted at the end of the Canadarm 2 and will provide the space station operator with a powerful tool for carrying out detailed extravehicular tasks without leaving the station.

The original Canadarm went into space for the first time more than 20 years ago. It has since flown on nearly 70 space shuttle missions. Designed and built by Spacelab Robotics, now MacDonald Dettwiler Space and Advanced Robotics Ltd (MD Robotics), the first Canadarm cost about $100 million. It was Canada’s contribution to the U.S. Space Shuttle Program. NASA has since ordered four additional units, at a cost of about $460 million.

Canadarm 2, now a significant addition to the International Space Station (ISS) which includes the Canadarm 2, represents Canada’s contribution to the International Space Station. The Canadian Mobile Servicing System and Canadarm 2, are an essential component of the International Space Station. The system has three parts:
- Canadarm 2, the Space Station Remote Manipulator System (SSRMS) - delivered to the ISS in 2001;
- the Mobile Base System (MBS) - a work platform which will move on rails along the length of the space station - delivered to the ISS in 2002; and
- Special Purpose Dexterous Manipulator (SPDM) - a 'robotic astronaut' which has two arms of its own - scheduled for delivery in 2004.

The MSS gives astronauts the ability to move equipment and supplies around the space station. It provides the only way to manipulate objects outside of the space station without having a human actually leave the relative safety of the space station.

THE SPECIAL PURPOSE DEXTEROUS MANIPULATOR OR SPDM
Gary Searle is an MD Robotics Program Project Manager who has just completed two years working at the David Florida Laboratory, testing the components of the MSS which will make up the Special Purpose Dexterous Manipulator or SPDM. We asked Gary why he thought the Canadarm 2 system was important for Canadarm 2.

He responded, ‘Projects like the Canadarm 2 bring Canadians into the forefront of technology, where we become pioneers rather than followers. The capability that MD Robotics has developed by building the Canadarm systems for the Canadian Space Agency has made us world leaders in our particular field of robotics. We have no real competition. Organizations from all over the world, including the U.S. and Japan are coming to us with their requirements.”

The project that Gary Searle worked on actually was the Special Purpose Dexterous Manipulator or SPDM. This is a system that will allow the Canadarm 2 to do more intricate work than it can currently do using its end effector, or mechanical hand. The current end effector is suitable grasping a large object such as a satellite or a component to be added to the ISS.

The SPDM which will be added in 2004, is designed, as you would expect from its name, to carry out tasks that require more dexterity. Using two arms, each having its own much smaller more specialized end-effector, called an Orbital Fluid Change-out Mechanism or OFCM. The OFCM is specifically designed to grasp the small attachment devices used to secure equipment and electronic boxes to the outside of the space station. These attachment devices are in turn referred to as micro fixtures.

Taken as a whole, the two armed SPDM with its specialised end effectors, can be thought of as the space station's robotic external maintenance technician. Fully controllable from within the station, astronauts will be able to service most aspects of the outside of the station without being exposed to the hazards of a space walk.

THE ROLE OF THE DAVID FLORIDA LABORATORY IN THE SPD DEVELOPMENT
Space is a totally different environment from earth.”, explains Gary. “We encounter atomic Oxygen, no breathable air, extreme temperatures that fluctuate, vacuum conditions and high vibration conditions on launch. Every system is affected differently by these conditions and every system must be designed and tested in ways that take these conditions into account.”

Gary Searle talked about his experience at the DFL where the SPDM components were tested. “Any components that had brakes were tested under thermal vacuum. Space brakes are designed to work in vacuum to operate. We put our systems into the DFL thermal vacuum chamber in order to test them. We would run the motors and then hit the brakes. The cycle would be repeated several times under hot conditions and then during cold, to run in the brakes. It takes about 2 weeks to perform a complete set of tests, a week for thermal vacuum testing, a day and half to do the vibration testing and then all the ambient testing that has to be done in between.”

THE IMPORTANCE OF CONTINUITY
We asked Gary about what it took to be successful in the space robotics industry. Gary’s immediate response was, ‘Continuity’. Many of the engineers at MD Robotics and at the David Florida Lab that helped build the original Canadarm have now retired. However, they personally trained people like Gary who are in turn training a new generation of engineers who will pick up the skills needed, and the lessons learned, to address the even more demanding requirements that will come in the future. “Passing on the torch is critical because this is something you can’t learn in a book,” says Gary.

Gary is very satisfied with his career at MD Robotics, he explained, “Having the opportunity to work on this type of hardware is rare. We are able to attract the best and the brightest out of university and train them to carry on. Furthermore our products are unique in the world. Nobody else does what we do. We’ve gained the respect by NASA and other countries for those very reasons.”

NEW HORIZONS
Gary Searle is now the program manager of what is called the “neuroArm”. Using much of the same technology that went into the Canadarm, MD Robotics is building a robot arm which will be used to carry out brain surgery while the patient is placed in an MRI. Working on a smaller scale than the SPDM the neuroArm requires similar levels of precision, safety and user control as those required in space. Features which will make the neuroArm unique include:

Haptic control
The neuroArm will have a variety of surgical instruments attached, such as forceps and specialized instruments used to hold, cut and cauterize tissue. The instruments MD Robotics is developing for the arm will be almost identical in appearance to normal instruments, except for how they are held. When the operator, a surgeon, uses these instruments to touch a piece of tissue they will ‘feel’ the force that the tool is applying to the tissue through the hand controllers.

This kind of sensory feed back to the operator is called ‘Haptic control’. The surgeon will sit at a work station located outside the operating room where the patient is located. It will be the robot that does the surgery. “Haptic control” is a capability unique to neuroArm in the field of surgical robots, as none of the other commercially available surgical systems offer this feature.

Optical Force Sensor
MD Robotics has developed an optical force sensor in order to achieve ‘Haptic control’, force is usually measured using ordinary electrical, mechanical sensors, and then electrical signals are transmitted to the feedback devices within the hand controller. However common electrical sensors cannot operate correctly within the MRI environment. To solve this problem MD Robotics has invented and patented a purely optical force sensor that communicates the force load on it by way of reflected light from a fiber optic probe. No electrical signals or components are required.

Canadarm Software
The technologies needed for the development of the neuroArm are very similar to those used in the Canadarm 2, except that the scales are much smaller. The neuroArm needs to get around in tighter areas,
but the fineness of motion is the same. If you imagine your own shoulder moving a quarter of an inch, your arm will have moved almost a foot. The accuracy in the Canadarm has to be very precise at the shoulder in order to get the accuracy needed at the end of the arm.

The neuroArm requires 1mm resolution of movement in order to be able to suture small arteries. The mechanical parts have to be very accurate as well. MD Robotics will need to machine some components to within two one thousandths of an inch, much the same tolerances as those required in the Canadarm 2. What is really critical in both of these applications is the software that enables the arms to move. A good portion of the software being used in the neuroArm came from the Canadarm projects. In space the safety systems have to be as perfect as they do in brain surgery. You can’t risk having the arm start jerking in space when the lives of personnel or the safety of valuable equipment is at stake.

Applications of Canadarm technology do not stop at neuro-surgery. MD Robotics manufactures mining robots, vision systems that detect ice and chemicals from a distance. MD Robotics has even sold dinosaur robots to Universal Studios. These animated Triceratops won a gold award at the recent Design Engineering Awards. According to the award announcement, “While not a manufacturing system, the entry is used as commercial equipment by Universal Studios Islands of Adventure. The complex programming and smooth motion control systems make for a stunningly real illusion to customers who are never more than six feet away from the exhibit-sometimes even touching it. The dinosaur has a range of realistic behaviour-dilating pupils, coordinated muscles and tongue movement among them-a striking simulation of a live animal.”

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