IEEE Canada Life Member Milestone Tour August 25 to September 3, 2013

Welcome to the IEEE Canada 2013 Life Member Milestone Tour
Within this booklet you will find more detailed information about the sites you will be visiting on this tour as well as some general information about the tour itself. In the package you will also find several copies of the IEEE Canadian Review which is a magazine all IEEE Canada members receive usually 3 times per year. These issues deal with some of the milestones you will be visiting. I hope you have an amazing tour!

Cathie Lowell, Administrator, IEEE Canada

On behalf of the IEEE Canada leadership team, it is a pleasure to welcome you to this inaugural Canadian Life Member Milestone Tour. The organizing committee has gone to great lengths to plan a memorable event and to ensure the tour includes not just the technical details of these engineering feats but also some of the personal history that took place behind the scenes.

We live in a great and prosperous country and this is partly due to the calibre of our members. In the past, you have likely heard me speak about how IEEE Canada members contribute more to the overall IEEE areas of interest than our relative size implies. The IEEE milestone program is one good example that illustrates my point. While IEEE Canada membership is approximately 4% of the total IEEE membership, we hold 10% of the IEEE milestones (14 out of 137 as of the time of writing). As IEEE life members, you have played an important part in making this happen and I thank you for it.

The reality that is often overlooked is human ingenuity and drive to overcome the challenges of the day is what allowed people to perform these feats – the work did not happen on its own or overnight. As such, I strongly encourage all participants to make the most of this opportunity and to take the time to connect, collaborate, and communicate with fellow tour members and to learn their stories.

In closing, I wish you an enjoyable, memorable, and dynamic time on the tour and look forward to hearing about the stories that follow.

Keith B. Brown, Ph.D., P.Eng., SMIEEE
2012-13 President, IEEE Canada
2012-13 Director/Delegate (Region 7), IEEE Inc.

Itinerary			
Date	**Time (approx)**	**Details**	**Location, Room Name**
25-Aug		Arrive and settle into the Delta Toronto Airport West	
26-Aug	7 – 9 am	Breakfast	Delta Toronto Airport West Hotel - Chardonnay Restaurant
	9 am – 12 pm	Depart for Paris – Host: Bert DeKat	
	12 – 2:30 pm	Depart for Decew Falls Power Plant – Host: David Hepburn	
	2:30 – 4:00	Tour Niagara Falls – on own	
	6:00 pm	Dinner hosted by Toronto Life Members – Speaker : Karl Martin	Delta Toronto Airport West Hotel – Alderwood Room
27-Aug	7 - 9 am	Breakfast	Delta Toronto Airport West Hotel - Chardonnay Restaurant
	9 – 11 am	Depart for the C. H. Best Institute – Host: Patrick Finnigan	
	11 am	Depart for Peterborough. Lunch at canoe museum - Hosts – Sean Dunne, Luc Matteau	Canadian Canoe Museum, Tour key sites in Peterborough
	3 pm	Depart for Ottawa	
	6 pm	Dinner	Delta Ottawa City Centre – Capitale Room
28-Aug	7- 9 am	Breakfast	Delta Ottawa City Centre – Lift Lounge
	9 am	Depart for tours of Carleton U, U of Ottawa, and Algonquin College – Host - Jane t Davis	
	11 am	Back to hotel for free time in Ottawa	
	6 pm	Dinner at Delta Ottawa Hotel	Delta Ottawa City Centre – Capitale Room
29-Aug	7 - 9 am	Breakfast	Delta Ottawa City Centre – Lift Lounge
	9 am	Depart for Montreal	

Aug 29	12:00 pm	Lunch	Delta Centre-ville – St-Paul
	1:30 pm	Depart for Hydro Québec, 75 Boul René Lévesque. – Host: Lorne Keyes and Arthur Yelon	
	2:00 pm	Depart for HQ -IREQ (Varennes)	
	6:00 pm	Dinner at hotel with Life Member Presentation	Delta Centre-ville – St-Paul
30-Aug	7 - 9 am	Breakfast	Delta Centre-ville – St-Paul
	9 am	Depart for Fredericton, NB	
	7 pm	Dinner at the Delta Fredericton	Delta Fredericton - Governors Ballroom
31-Aug	7 - 9 am	Breakfast	Delta Fredericton – Governors Ballroom
	9:00 am	Depart for Baddeck, NS. Lunch on own at Bell Museum	
	6:00 pm	Arrive at Syndey Mines – Host: Dirk Werle	
	7 :30 pm	Dinner at hotel in Sydney, NS	Cambridge Suites Hotel – see signs at hotel for room location
01-Sep	8 am	Breakfast	Cambridge Suites Hotel
	9 am	Depart for Marine Ferry Dock	
	11:45 am	Depart on ferry for Newfoundland	Lunch on ferry on own
		Dinner in Gander, NFLD	Comfort Inn
02-Sep	8 am	Breakfast at Comfort Inn, Gander	
	9 am	Depart for Heart's Content Cable Station – Host: Lori Hogan	
	1:30 pm	Depart for Signal Hill – Host: Lori Hogan	
	3:00 pm	Free time to see St. Johns	
	5:30 pm	Dinner	Delta St. John's – Salon E (ML West Tower)
03-Sep	At leisure	Breakfast	Delta St. John's – Quinns Restaurant

Milestone #1 - First Distant Speech Transmission in Canada, 1876 –
Contact: Bert de Kat (519) 647-3075
Paris, Ontario, Canada, Dedicated 4 May 2008 - IEEE Hamilton Section

On 10 August 1876, Alexander Graham Bell demonstrated on this site that the human voice could be transmitted electrically over distance. While family members spoke into a transmitter in Brantford, 13 km away, Bell was able to hear them at a receiver located here. This test convinced Bell that his invention could be used for communication between towns and could compete successfully with the telegraph.

The plaque is publicly viewable at 91 Grand River N, Paris, Ontario

On the night of 10 August 1876, Alexander Graham Bell transmitted human voices by means of electrified wires from Brantford, Ontario, Canada, to Paris, Ontario, Canada, a distance of 13 km, firmly establishing the electric speaking telephone as an effective method of communication. Musical notes, the human voice, and songs spoken and sung were plainly audible at the other end. This was a one-way communication; sounds from Brantford were audible to Bell in Paris. This was the climax of several "distance tests" Bell had conducted in Ontario.

Bell made use of the telegraph wires of the Dominion Telegraph Company between its office in Brantford and its office in Paris. Because the battery power available at Brantford was to low for Bell's membrane telephones, the Dominion Telegraph Company provided power from Hamilton and Toronto, Ontario. Bell connected his membrane telephone and triple mouthpiece to the wires at the Brantford office, then, at the Paris office, he connected his iron box receiver. Through bubbling and crackling sounds, Bell could hear the voices from Brantford. By using high resistance electro-magnetic coils at each end of the line, the sounds were transmitted and received so distinctly that Bell could recognize the voices of the speakers.

Milestone #2 - DeCew Falls Hydro-Electric Plant, 1898 – Contact: David Hepburn (905) 353-6866
DeCew Falls, Ontario, Dedicated 2 May 2004 - IEEE Hamilton Section

The plaque can be viewed at the DeCew Falls Generating Plant No. 1, 6.4 km south of St. Catharines, Ontario: 15 Lockhart Drive, St. Catharines, Ontario.

The DeCew Falls Hydro-Electric Development was a pioneering project in the generation and transmission of electrical energy at higher voltages and at greater distances in Canada. On 25 August 1898 this station transmitted power at 22,500 Volts, 66 2/3 Hz, two-phase, a distance of 56 km to Hamilton, Ontario. Using the higher voltage permitted efficient transmission over that distance.

DeCew Falls No. 1 Plant

The first plant at DeCew Falls, two miles from St. Catharines, was built by the Cataract Power Company to supply power to Hamilton, a distance of 35 miles. It draws water from Lake Erie through the Welland Canal, with a storage reservoir in Lake Gibson. Seven steel penstocks are supported on the hillside by concrete piers. The direct-connected, turbo-generator units are mounted horizontally on a gravel foundation. The tail-water is carried downstream in Twelve Mile Creek to Lake Ontario at Port Dalhousie. The head is 260 feet. This plant began operation with two 1,500-hp units on 26 August 1898; two 3,000-hp units were added in 1900; the plant was completed in 1912 with a total output of 44,600 KVA at 66 2/3 cycles. It supplied power to Hamilton several years before Niagara power reached Toronto. In 1930 it was bought by Ontario Hydro and converted to 60 cycles. This is the oldest Niagara plant still operating.

The Cataract Power Company of Hamilton Limited (the predecessor to the Dominion Power and Transmission Company) was organized in 1896. The idea for the company came from John Patterson (one of the "Five Johns" to found the Cataract Power Company) who was developing the Hamilton Radial Electric Railway at the time. He wanted to supply his railway with water-generated electric power and selected DeCew falls as the place to do this. The water originated mostly from the Welland Canal and was used to supply St. Catharines. Before the project could commence, the waterworks commission of St. Catharines had to be consulted.

Though they were initially supportive, in the end they refused to provide the necessary facilities. Subsequently, engineers were called on to devise a way to divert the water from the Welland Canal to a more suitable site. They recommended building a waterway to the escarpment bordering the canal channel. In 1897 the Cataract Power Company got a lease for water from the Welland Canal at Allanburg. A canal was constructed from Allanburg to an area near the falls which had recently been converted into an 800-acre storage dam.

This in turn led to the power house at the head of the falls. Known as the "Power Glen" plant, it transmitted electricity along 34 miles of wire to the city of Hamilton.

At the time long-distance transmission of electric power was still being developed. Lord Kelvin, an English authority on electricity, stated that electric power could not be transmitted further than 12 miles economically. With the development of new types of equipment however, in 1898 electric power was successfully delivered almost three times that distance at a voltage of 22,500 volts (more than double any previously used voltage). Following the establishment of this local source of electric power, many of the radial railways switched from steam to electricity.

Though the "Power Glen" had one penstock operating two units with a capacity of 9,000 horse power at the outset, this would expand in the following years to seven units with a capacity of 52,000 horse power, making it one of the most economical installations in North America. This allowed the company to provide attractive prices and make enough profit to acquire the radial electric railways centered in Hamilton as well as the power services of Hamilton and Brantford (among others). The first of these was the Hamilton Electric Light and Power Company, which had closed its steam plant and had begun purchasing power from the Cataract Power Company.

In 1899, the Hamilton Electric Light and Power Company was taken over by the Cataract Power Company, which subsequently changed its name to the Hamilton Electric Light and Cataract Power Company Limited. In 1900, the newly named company bought both the Hamilton Street Railway and the Hamilton Radial Electric Railway. A further name change occurred in 1903. The company was incorporated as the Hamilton Cataract Power, Light and Traction Company Limited. This name would not last because in 1907 the company was organized for the last time as the Dominion Power and Transmission Company (D.P.&T.). This all-encompassing name reflected the company's large list of subsidiaries (of which there were 12).

As the company expanded smaller hydraulic plants were built in Brantford and St. Catharines and steam plants were built in Brantford and Hamilton. The Hamilton steam plant, constructed in 1917, was the largest of the four new plants with a capacity of 23,000 horse power.

Even though Dominion Power and Transmission (DP&T) was expanding it still encountered difficulties. D.P.&T. had encouraged the belief that they were operating in the best interests of Hamilton and that they were more akin to a public service organization than a business. However, the 1906 strike of one of its subsidiaries, the H.S.R., dispelled this perception as the public's resentment towards H.S.R. management was transferred to D.P.&T. Many people thought that D.P.&T. emphasized its industrial customers over its municipal ones. When the publicly-owned Hydro-Electric Power Commission was formed in 1906, many were ready to see D.P.&T.'s monopoly defeated. Although a by-law submitted to ratepayers to enable the City of Hamilton to enter into a contract with the Commission passed, D.P.&T. still had support on City Council and was able to have its contract renewed for five years. However, when asked for tenders, the Commission estimated costs for such things as arc lamps and sewage pumping at significantly lower prices than what D.P.&T. had been charging. D.P.&T. lowered their prices accordingly and made an offer to supply any municipality with service at rates ten percent lower than those of the Commission. Nevertheless, when D.P.&T.'s contract ran out in 1911 a new by-law was passed allowing the City of Hamilton to get its power from the Commission. Additionally, the city would own its own distribution system: a hydro-electric plant costing $505,160. The system was adopted in 1912 and put into operation in 1913. Even though D.P.&T. had lost its monopoly, it still retained almost all of its business and industrial customers (which had always been its primary focus).

Since its inception, D.P.&T. was greatly interested in interurban railways and their expansion, however, this area of business would prove to be unprofitable as time wore on. With the death of John Patterson (D.P.&T.'s biggest promoter of radials) in 1913 came the increasing realization that electric railways had a poor potential for profit in the face of automobiles. The last new interurban cars were purchased that year and no further improvements were made to the lines from then on. D.P.&T. still wanted a piece of the transportation pie however, and began by purchasing 10 buses in 1926. By 1929 the company was replacing its radial lines with bus lines, buying up competing bus lines and increasing its fleet of buses to ninety-two.

In 1930 the D.P.&T. company was taken over by the Hydro-Electric Power Commission of Ontario (better known as Ontario Hydro). Ontario Hydro promptly sold the entire bus system to Highway King Coach Lines on the condition that the bus lines would be protected against interurban competition. This was the final motivation for the complete abandonment of the radials, and with them, the last traces of the Dominion Power and Transmission Company passed away.

HISTORICAL NOTE:

DeCew Falls derives its name from John DeCou (the name was variously spelled by his relatives and descendants and latterly as DeCew), one of the pioneer settlers in the district. Born of English stock in Vermont in 1766, he came to Upper Canada as a young United Empire Loyalist in the years following the American Revolution. He married Catherine, daughter of Frederick Docksteter of Butler's Rangers in 1798 and they had 11 children. In 1788, he secured a number of lots adjacent to the falls on the Beaver Dam Creek. He built several mills near the falls and laid the foundation for what became the flourishing settlement.

DeCou served as a captain of the militia in the War of 1812. He was taken prisoner during the capture of Niagara and Fort George on May 27, 1813. During the same year; the tide of battle turned against the British who were forced to retreat to Burlington Heights, Hamilton, leaving only a small force at the John DeCou stone house under Lieutenant James Firzgibbon.

On June 23 that year, in the Village of Queenston, Laura Secord, wife of James Secord, heard American soldiers, billeted in her home, discussing plans to overpower Fitzgibbon's party. She took counsel with her husband, who was ill at the time, and they decided that she should make the perilous 32 km (20 mile) journey on foot to warn Fitzgibbon.

Unaware that she was embarking on such a famous trek, she stole quietly away from the house, reaching St. David's by sunrise on the following morning where she was joined by a niece, Elizabeth Secord. To avoid American patrols, the two women followed an old Indian trail from St. David's to Shipman's Corners (now the intersection of St. Paul and Ontario Streets in St. Catharines).

From this point the Canadian heroine hurried on alone to the DeCou House. Acting on her warning, Fitzgibbon and his men, with their Indian allies, captured the entire American force, with its Commanding Officer; Lieut. Col. Charles C. Boerstler, by bold strategy. That action, now known as "The Fight in the Beech Woods," was an important turning point in the war. Thus did Laura Secord and the stone house of John DeCou take their places in the bright pages of history.

DeCou escaped in 1814, participating in the Battle of Lundy's Lane. After the war, he restored and developed this property, and the area became known as the Hamlet of Decew Town (now DeCew Falls). He advocated and became a director of the First Welland Canal. When the route was changed leaving the mills without water power, he became an opponent of the scheme. He sold his house in 1834. He died in

1855 at DeCewsville in Haldimand County, the second community of which he was the founder.

The DeCew stone house was occupied by David Griffiths and his descendants until 1942 when it, with the surrounding property, was acquired by the Hydro-Electric Power Commission of Ontario for the extension of the DeCew Falls generating station.

In 1950, while unoccupied, it was destroyed by fire. In view of its intimate association with Canadian history, steps were taken to preserve the remains of the house.

A flagstone floor was built and the existing Queenston limestone walls, 66 cm (26 in) thick, were left intact to the height of the ground floor window sills. Grounds around the house were landscaped and new stone piers were erected at the two driveway entrances.

A large bronze plaque, recording the interesting history of the old house, was set into a cairn-like structure, forming part of the back wall of the venerable structure.

On October 13,1953, the property was officially declared an historic site by the Hon. Leslie M. Frost, Prime Minister of Ontario. Participating in the ceremony along with Premier Frost was former Hydro-Electric Power Commission of Ontario Chairman Robert H. Saunders who said the preservation of the DeCou House by the Commission was in keeping with its policy of restoring and maintaining historic landmarks situated on the properties, as a tribute to the pioneers who laid the foundations of the nation.

Cataract Power Company of Hamilton - In 1886, the transmission of electricity over long distances for commercial purposes was still in much of an experimental stage. After numerous surveys and the examination into the physical feasibility of using DeCew Falls, a scheme was developed for the generation of electrical energy. As a result of this scheme John Patterson, the Hon. J.M. Gibson, John Moodie, James Dixon and J.W. Sutherland procured a charter dated July 9, 1896 and formed the Cataract Power Company of Hamilton Ltd. for the purposes of developing this power and transmitting it 56 km (35 miles) to the city of Hamilton.

On securing the water lease, the company then entered into a contract with the Royal Electric Company of Montreal, dated December 8,1897. This company undertook the electrical engineering and designed the plant.

During the early years, the station was sometimes referred to as the "Power Glen station" because of its close proximity to that area.

MISCELLANEOUS:
It is interesting to note that ND1 originally generated power at 66 2/3 Hz prior to any standardization of frequency.

The Rankine Generating Station – Niagara Falls

The Rankine Generating Station is downstream from the older Toronto Power Generating Station. The Canadian Niagara Power Company was formed in 1892 and began generating electricity in 1905. The Rankine station produced 25 Hz power.
When it was built, it was the most advanced hydroelectric station in the world.

60 Hz eventually became the North American standard. In 2009, Canadian Niagara's water rights ended and the Rankine plant was given to the Niagara Parks Commission.

Nikola Tesla Monument within Queen Victoria Park, Niagara Falls

Nikola Tesla designed the first hydroelectric power plant at Niagara Falls, New York which started producing electrical power in 1895. This was the beginning of the electrification of the United States and the rest of the world. Today, Tesla's AC electricity is lighting and powering the globe. Nikola Tesla is the genius who lit the world.

Now, the inventor of alternating current has a permanent tribute overlooking the Horseshoe Falls at Niagara Falls, Canadian side.

As a boy, Tesla saw a picture of Niagara Falls and told his uncle in Lika, Croatia, that he wanted to put a wheel under the falls to harness the power of the moving water.

This great monument of Nikola Tesla at Niagara Falls is one of greatest recognition of Nikola Tesla's work. Tesla designed the first hydro-electric power plant at Niagara Falls and with George Westinghouse started the electrification of the world. This monument is built in one of the most beautiful and most important place in the world.

Milestone #3 - First External Cardiac Pacemaker, 1950 – Contact: Patrick Finnigan – (416) 434-9353
Toronto, Canada, Dedicated September 2009- IEEE Toronto Section

In 1950, in Room 64 of the Bantling Institute of the University of Toronto, Drs. Wilfred Bigelow and John Callaghan successfully paced the heart of a dog using an external electronic pacemaker-defibrillator having implanted electrodes. The device was developed by Dr. John Hopps at the National Research Council of Canada. This pioneering work led to the use of cardiac pacemakers in humans and helped establish the importance of electronic devices in medicine.

The plaque may be viewed at the front entrance of the C. H. Best Institute, 112 College Street, Toronto, Ontario, Canada.

According to a medical study published by Barber and Madden, up until 1945, the only successful operative cases of cardiac standstill had been treated with cardiac massage and intraventricular injection of adrenaline (33% of 143 such cases survived). Callaghan and Bigelow also report on the work of Hyman (1932) who used a cranked generator and needle inserted into the right auricular wall of guinea pigs to restart their stopped hearts. Also of note is that Sweet restarted to human hearts during operation by applying electrical current to the sino-auricular nodal region. Mark Lidwell from Australia reported at the Third Congress of the Australian Medical Society in 1929 the successful use of electrical stimulation with alternating current in 1928 to restart the heart of a child born in cardiac arrest.

Jack A. Hopps developed a simplified circuit and a portable model Pacemaker-Defibrilator which was used to continously stimulate stopped hearts to beat at a pre-set rate, or to induce spontaneous heart beating after which the heart continued to beat normally. These beats were induced in dogs and rabbits through an inter-cardiac catheter electrode, rather than other approaches (e.g. needle electrodes) tried previously. This device was built in limited numbers commercially by Smith and Stone co., Ltd, Georgetown, Ontario, Canada.

Subsequent work by Zoll in 1951 (the PM-65 pacemaker) led to successful clinical use. In 1955, a patient with cardiac arrest was treated and had his heart pulse restored in Montreal using a Zoll device built by Electrodyne Company, Norwood, Massachusetts, U.S.A. In 1956, Aubrey Leatham and Geoffrey Davies developed an external stimulator with which to resuscitate patients with heart block.

The 1950 Toronto pacemaker demonstrated the engineering feasibility of using an external electronic cardiac pacemaker to force regular cardiac pacing, or induce spontaneous re-establishment cardiac pacing using an intercardiac electrode. This device was produced commercially.

The results were widely publicized and further developed by noted surgeons such as Dr. Walter Lillehei at the University of Minnesota and others. Dr. Lillehei worked closely with Earl E. Bakken and Palmer Hermundslie at Medtronic to develop the first wearable tranistorized pacemaker as well as advances in implanted electrodes, achievements which are commemorated in the IEEE Milestone for the wearable pacemaker.

Canadian Canoe Museum – Peterborough, Ontario – Contacts: Sean Dunne - 705 742-2881, Luc Matteau - 705 743-7712

Canoe Museum is a unique national heritage centre that explores the canoe's enduring significance to the peoples of Canada, through an exceptional collection of canoes, kayaks and paddled watercraft. We're an engaging, family-friendly museum with more than 100 canoes and kayaks on display. Visitors will enjoy interactive, hands-on galleries, a scavenger hunt, model canoe building and puppet theatre for children. Through inclusive, memorable and engaging exhibits and programs we share the art, culture, heritage and spirit of paddled watercraft with our communities.

Founded on a collection of the late Professor Kirk Wipper, and established in Peterborough, Ontario, in 1997, the museum's holdings now number more than 600 canoes, kayaks and paddled watercraft. Together they span the country from coast to coast to coast and represent many of the major watercraft traditions of Canada.

The museum's artifacts range from the great dugouts of the First Nations of the Pacific Northwest to the singular bark canoes of the Beothuk of Newfoundland; from the skin-on-frame kayaks of northern peoples from Baffin Island in the east to the Mackenzie River Delta in the northwest to the all-wood and canvas-covered craft manufactured by companies with names like Herald, Peterborough, Chestnut, Lakefield and Canadian. Over the years paddled watercraft from as far away as Paraguay and the Amazon have helped the Museum expand its reach and scope to include International examples

Peterborough Lift Locks

The Peterborough Lift Lock is a boat lift located on the Trent Canal in the city of Peterborough, Ontario, Canada, and is Lock 21 on the Trent-Severn Waterway. The dual lifts are the highest hydraulic boat lifts in the world, with a lift of 19.8 m (65 ft). This was a considerable accomplishment at the time when conventional locks usually only had a 2 m (7 ft) rise. It is not the highest boat lift of any type in the world today: the lift at Strépy-Thieu in Belgium has a greater capacity (1,350 tonnes) and height difference (73.15 m). In the 1980s, a visitors' centre was built beside the lock. It offers interactive simulations of going over the lift lock in a boat, and also historical exhibits detailing the construction of the lift lock.

The Peterborough Lift Lock was designated a National Historic Site of Canada in 1979, and was named an Historic Mechanical Engineering Landmark by the American Society of Mechanical Engineers in 1987.

The lift lock was designed by Richard Birdsall Rogers, a superintendent of the Trent Canal (part of the Trent-Severn Waterway). In 1896, he travelled to France, Belgium and England to see existing examples in operation.

Part of the reason that the lift lock was built was political. At the time a federal election was taking place and in order to shore up local support the project was fast tracked. In 1896 construction was approved and contractors signed on prior to any real working drawings being ready. The government still fell, and Richard Rogers, who was concerned about his links to the former administration, only released portions of the working drawings bit by bit. It worked, allowing him to remain on the job as the main designer.

The final project included many engineering firsts. It was the first lock to be built out of concrete, and at the time was the largest structure ever built in the world with unreinforced concrete.

Construction was by Corry and Laverdure of Peterborough, which excavated the site and built the concrete towers and lock, and Dominion Bridge Company of Montreal, which completed the metal work including rams, presses and large caissons, and was finished in 1904. The lift lock officially opened to the public to a crowd of thousands on 9 July 1904, and remains in full use today.

The lock has two identical ship caissons (like bathtubs) in which vessels ascend and descend. Both caissons are enclosed at each end by pivoting gates, and there are pivoting gates at the upper and lower reaches of the canal at the junctions with the caissons. The gates on the caissons fit into slots on the gates on the reaches, so that they open in unison.

Each caisson sits on a ram, the shafts for which are sunk into the ground, are filled with water, and are connected with a pipe that has a crossover control valve. The caissons are guided up and down on either side by rails affixed to concrete towers. The caissons with water (1040 m^3 or 228,093 imperial gallons) weigh 1,700 tons (1,542 tonnes) and are 140 ft (42.7 m) long, 33 ft (10 m) wide and 7 ft (2.1 m) deep.

No external power is needed: the lift lock functions by gravity alone using the counterweight principle. One caisson always ascends and the other always descends during each locking cycle. When one caisson reaches the top position, it stops 30 cm (12 inches) below the water level of the upper reach, and the control valve is closed; Siemens ultrasonic sensors are used to help determine the 30 cm differential. The upper reach and top caisson gates open, and water flows into the top caisson until the level equalizes. The weight of the extra 30 cm of water is 144 tons (130.6 tonnes), making the total weight of the upper caisson 1,844 tons (1,672.6 tonnes). Any vessels that just ascended in the top caisson exit into the upper reach, and any new vessels making a transit of the lock then enter the bottom or top caisson from the lower or upper reach respectively. Once the vessels are secured, all gates are closed and the crossover valve in the connecting pipe between the ram shafts is opened. Since the upper caisson weighs more than the lower caisson (1,844 vs 1,700 tons), it pushes down on its ram, forcing out water from its shaft via the connecting pipe into the shaft of the bottom caisson. The force pushes up on the bottom caisson's ram, raising the caisson up to the top position. When the gate of the newly descended top caisson and lower reach gates open at the bottom, the extra 30 cm of water flows out and equalizes with the water level in the lower reach of the canal, and any descended vessels exit, allowing the cycle to start over again.

Milestone #4 - Alouette-ISIS Satellite Program, 1962 – Unfortunately at this time tours of this facility are prohibited. You will be visiting Algonquin College, the University of Ottawa, and Carleton University research facilities instead.
Ottawa, Ontario, Canada, Dedicated May 1993 - IEEE Ottawa Section

Driven by the need to understand the characteristics of radio communication in Canada's North, Canadian researchers focused on the exploration of the earth's upper atmosphere, the ionosphere. Canada's satellite program commenced with the launch of Alouette-I on September 29, 1962. Alouette-II followed in 1965, ISIS-I in 1969, ISIS-II in 1971. The Alouette/ISIS tracking antenna serves as a reminder of Canada's contribution to this international effort in space science.

The plaque can be viewed at the Shirley's Bay Research Centre, Nepean, Ottawa, in Ontario, Canada.

Alouette I, the first Canadian-built satellite, was launched into orbit on 29 September 1962, marking Canada's first foray into space. The satellite was used to study the ionosphere from the top down to learn its effect on radio transmissions. Subsequently, Alouette II was launched in 1965, ISIS (International Satellite for Ionosphere Studies) in 1969 and ISIS II in

1971. By 1990, more than 1,000 papers and reports had been published from information received from the Alouette/ISIS Program. The Alouette/ISIS antenna, which received information from the satellites, is located at Shirley's Bay Research Centre and is preserved as a reminder of Canada's contribution to the international space science effort.

Alouette/ISIS was initiated in 1958 by Dr. John H. Chapman, IEEE Fellow '64 (1921-1979), director of the Defence Research Telecommunications Agency. Over time, three government agencies -- Communications Research Centre, Defence Research Establishment Ottawa, and Canadian Space Agency -- took over the program, which concluded in 1984.

Milestone #5 - First 735 kV AC Transmission System, 1965 – Contacts: Lorne Keyes (514) 488-2883, Arthur Yelon (514) 932-5759
Quebec, Canada, Dedicated November 2005 - IEEE Quebec Section

Hydro-Quebec's 735,000 volt electric power transmission system was the first in the world to be designed, built and operated at an alternating-current voltage above 700 kV. This development extended the limits of long-distance transmission of electrical energy. On 29 November 1965 the first 735 kV line was inaugurated. Power was transmitted from the Manicouagan-Outardes hydro-electric generating complex to Montreal, a distance of 600 km.

The plaque can be viewed at the headquarters of Hydro-Quebec 75 Boulevard René-Lévesque Ouest, Montréal, QC; and at the Manicouagan 2 Hydroelectric Generating station, on the south end of the Manicouagan Reservoir on highway 38.

The large undertaking of building a 735 kV line was tackled by Jean-Jacques Archembault and the Quebec Hydro. In recognition of this great feat, the IEEE awarded Archembault the 1972 IEEE Habirshaw Award for pioneering the line. The line transported electrical power from the hydraulic centers of the Manicouagan River, in the North East of Quebec, to the load centers in the south of Quebec. It had important economic ramifications as well. The lines allowed the transmission of power from remote hydroelectric plants to load centers at a relatively low cost, thereby giving customers some of the lowest rates in the world. Due to the vast amount of materials required, including but not limited to insulators, spacers-dampers, and towers, it had an impact on national and international manufacturers.

Alexander Graham Bell National Historic Site

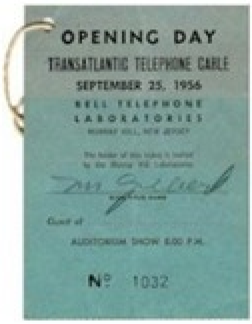
Alexander Graham Bell National Historic Site of Canada is a member of Parks Canada's family of special places and spaces that commemorate our natural and cultural heritage.

Here you can explore the amazing worlds of a lifetime that has touched all of us. You're in for a pleasant surprise because the telephone was only the beginning of Alexander Graham Bell's life-long pursuit of knowledge and invention. Discover how air and water captured Dr. Bell's imagination and how ideas led him to transmit sound on light and create a treadle powered sound recording device, man-carrying kites, airplanes and a record setting-hydrofoil boat. Find out how he bridged the world between sound and silence, participate in experiment, kite-making and kite-flying programs, enjoy hands-on activities designed especially for children and take in a presentation in Mr. Bell Theatre.

Plan to spend a minimum of two hours in this accessible facility where interactive displays, films, artifacts, models and a beautiful historic photo collection provide an entertaining and informative experience for everyone. Ask about our children's area.

Be sure to visit the Museum Store and the Tetra Café. Website: http://www.parcscanada.gc.ca

Milestone #6 - The First Submarine Transatlantic Telephone Cable System (TAT-1), 1956 – Contact: Dirk Werle - 902 477-2266
Clarenville, Newfoundland, Canada; Sydney Mines, Nova Scotia, Canada, and Oban, Scotland, Dedicated 24 September 2006 - IEEE Newfoundland & Labrador Section, IEEE Canadian Atlantic Section, and IEEE UKRI Section



Global telephone communications using submarine cables began on 25 September 1956, when the first transatlantic undersea telephone system, TAT-1, went into service. This site is the eastern terminal of the transatlantic cable that stretched west to Clarenville, Newfoundland. TAT-1 was a great technological achievement providing unparalleled reliability with fragile components in hostile environments. It was made possible through the efforts of engineers at AT&T Bell Laboratories and British Post Office. The system operated until 1978.

The plaques can be viewed in three locations: at 52 Cormack Dr., Clarenville, Newfoundland, Canada; at the Cape Breton Fossil Centre in Sydney Mines on Cape Breton Island, Canada; and in Gallanach Bay, in Oban, Scotland.

The first transatlantic telephone cable, TAT-1, inaugurated the modern era of global communications. Many of the basic concepts and processes developed for achieving highly reliable submarine infrastructure have not changed significantly from those used in TAT-1. Before TAT-1, voice was carried across the Atlantic on unreliable and expensive radio channels. Text messaging was carried on submarine telegraph cables (the technology of the previous 90 years) which were reliable, but slow and expensive.

Cooperation between North America and the United Kingdom to build an electrical bridge across the Atlantic had gone back over a century. After a period of failure and learning, the Great Eastern, the world's largest ship, laid in 1866 the first permanent transatlantic link under the leadership of Cyrus Field, and telegraph communication began. However, the communication capacity of the first transatlantic cable was very limited while the demand for rapid communication continued to increase.

Telegraph systems developed steadily over the years. Advances in materials and techniques, such as inductive loading, led to gradual increases in performance to the point that, in 1919 a study of deep-water submarine telephones began. In 1928 this work culminated in a proposal for a repeaterless cable bearing a single voice channel. Two considerations, however, killed the project: radio circuits were continuously improving, and the cost estimate was $15 million, a prohibitive price tag after the economic collapse that began in 1929.

A commercial radiotelegraph service, which began in 1908, had greatly contributed to transatlantic communication. Transatlantic long-wave and short-wave services had been established in 1927 and 1928, respectively. The first commercial voice link across the Atlantic, which was launched in 1927 with a single radio telephone circuit, shed new light on the desirability of a transatlantic telephone cable. While radio circuits provided a voice service, the vagaries of sunspot and seasonal and daily variations were never overcome entirely. Moreover, radio did not guarantee its users privacy and security. Recognition of the technical limitations of radio for transatlantic telephony led to studies of the feasibility of a North Atlantic submarine telephone cable.

In the mid-1930's electronic technology had advanced to the point where a submarine cable system with repeaters, electrical devices that would boost voice signals after they had reached the fading point along a circuit, became feasible. Since the repeaters had to have sufficiently long lives to operate with small likelihood of failure over a period of time, they were subject to rigid reliability requirements. Most fragile, however, were the vacuum tubes, which were the only means of amplification. Development of these tubes was begun in 1933, and they were continually tested for a period of eighteen years.

The North American side utilized the flexible repeater technology in the 1950 Havana-Key West cable, which adopted an earlier version of the TAT-1 repeater. British Post Office had developed a single repeater system and used it for shallow-water links in the 1940’s.

In 1953 the agreement for the first transatlantic telephone cable was signed. TAT-1 was a joint effort of AT&T Bell Laboratories, the British Post Office Engineering Department, and the Canadian Overseas Telecommunication Corporation. The design of the TAT-1 repeater provided a unique solution to the historic challenge of placing a telephone cable two and a half miles beneath the surface of the North Atlantic. The repeater was flexible thus allowing it to be wound over a cable standard drum. It was eight feet long and had a diameter of 2.875 inches tapering down to the cable width of 1.625 inches over twenty feet.

The main Atlantic link, designed by the Bell System, called for two cables (one in each direction of transmission), which embodied one-way flexible repeaters at 37-mile intervals. H.M.T.S. Monarch, then the world’s largest cable ship, laid the two cables in the summers of 1955 and 1956, respectively. The links were from Clarenville, Newfoundland to Oban, Scotland. Each cable had fifty-one repeaters in a cable stretching over approximately 1950 nautical miles. The repeater provided 65 dB of gain and 144 kHz bandwidth around 164 kHz. Amplification in each repeater was made possible by means of three vacuum tubes, whose design, testing and manufacture set new standards of reliability. The vacuum tubes of the original TAT-1 never failed in twenty-two years of continuous service from 1956 to 1978. TAT-1 also included an overland portion and an underwater link. The Canadian provided an overland line-of-sight radio system from Nova Scotia to Montreal and to a point in Maine where the Bell System took over. Under the shallow waters of the Cabot Straits, British-pioneered two-way rigid repeaters allowed transmission from Newfoundland to the mainland through Sydney Mines, Nova Scotia over a single cable. TAT-1 initial service provided twenty-nine telephone circuits between London and New York, six circuits between London and Montreal and a single circuit split among the three destinations for telegraph and other narrow band applications.

Over the last fifty years since TAT-1 went into service, the capacity of telephone cables has grown explosively from initial thirty-six voice-band channels to modern broadband optical fiber systems. Today, single cables can support eight fiber pairs and carry in excess of eight terabits of capacity across the Atlantic and the Pacific Oceans, which is approximately four million times the number of voice circuits carried on TAT-1.

With communications traffic traveling at the speed of light on undersea cable, optical or electrical, the time difference encountered between end points across the ocean or across a city does not disturb communications being barely noticable hence, there is little difference between a voice call to another continent and one within one's own city. The transmission capabilities of undersea optical fiber are crucial for linking computers of different continents. Whether surfing the internet, making a reservation or calling a friend in another country on another continent, all these services are made possible due to the unique technologies deployed in modern global submarine cable systems, whose progenitor was TAT-1. Other resources; www.atlantic-cable.com www.telegeography.com

Milestone #7 - Landing of the Transatlantic Cable, 1866 – Contact: Lori Hogan (709) 368-4150
Heart's Content, Newfoundland, Canada, Dedicated 15 June 1985 -
IEEE Newfoundland-Labrador Section

A permanent electrical communications link between the old world and the new was initiated at this site with the landing of a transatlantic cable on July 27, 1866. This achievement altered for all time personal, commercial, and political relations between peoples on the two sides of the ocean. Five more cables between Heart's Content and Valentia, Ireland were completed between 1866 and 1894. This station continued in operation until 1965.

The plaque can be viewed at the Heart's Content Cable Station, Provincial Historic Site in Heart's Content, Newfoundland.

On Friday, 13 July 1866, the Great Eastern, by far the largest ship afloat, left Valentia, Ireland , (corresponding IEEE Milestone) with 2730 nautical miles of cable in her hold. Fourteen days later 1852 miles of this cable lay at the bottom of the ocean, the ship was at anchor in Trinity Bay, Newfoundland, and the old and new worlds were in permanent telegraphic communication.

The quest to establish a transatlantic telegraphic link took twelve years and five attempts at laying the cable, demanding the confidence and expertise of countless financiers, electrical engineers, scientists, and sailors. Cyrus Field, who had made enough money in the paper trade to allow him to retire at age thirty-five, decided to back the laying of the transatlantic cable in 1854. He talked to Matthew Maury, a leading oceanographer, to find out if laying a telegraph cable on the ocean floor between Newfoundland and Ireland was possible, and then to Samuel Morse to ask if, once in place, such a cable would work. After being assured that the project was indeed feasible, Field was ready to seek financial backers.

Four of New York's richest men --- Chandler White, Peter Cooper, Marshall Roberts, and Moses Taylor --- joined Cyrus and Dudley Field to found the New York, Newfoundland, and London Telegraph Co. Their first step was to lay submarine cables between Cape Ray, Newfoundland, and Cape Breton Island, Nova Scotia, and then between Cape Breton Island and the Nova Scotia mainland. Through a combination of submarine cables and overland lines, St. John's, Newfoundland, and New York City were connected in 1855.

Field and nine associates then formed the American Telegraph Co., which soon ranked As one of the top six telegraph companies in North America. By mutual agreement, these companies established regional operating boundaries, and Newfoundland, New Brunswick, and the United States' eastern seaboard became American's territory. A clear path of communication from Canada to Florida now existed for the messages which would come over the proposed transatlantic cable.

The next several months were spent in establishing still another company, the Atlantic Telegraph Co., choosing the cable design, manufacturing the cable, finding backers, and securing agreements of support of the project from both the British and American governments. Then, on 5 August 1857, the American steam frigate Niagara and the Royal Navy's steamer Agamemnon left Valentia Bay, Ireland, each with half-an- ocean's length of cable in her hold. After laying about four hundred miles of cable, however, the line snapped and could not be recovered from the ocean floor.

During the next ten months, improvements were made to the machinery for paying out the cable, a better insulating compound was developed, William Thomson (later Lord Kelvin) invented his mirror galvanometer, which was used for improved detection of the signals coming over the cable, and still more capital was raised. The cable, which had been stored on the docks at Plymouth, England, was reloaded onto the Niagara and the Agamemnon, and the ships left Valentia Bay on 10 June 1858. This time, only one hundred and sixty miles of the cable had been laid when it broke. Field pushed to try again immediately. The two ships met in mid-ocean on 29 July, spliced the cable, and steamed off in opposite directions, laying the cable as they went. Both reached their respective ports in Newfoundland and Ireland on 5 August 1858; transatlantic communication by telegraph was a reality. The glory was short-lived, however. The cable was dead by 18 September.

This was the worst set back in the troubled story of the transatlantic cable. It was nearly impossible for Field to find backers for another attempt. The British government was reluctant to increase its support of the project. And the political situation in the US in 1859 gave little priority to Field's venture.

To investigate the special problems of submarine cables, a commission was set up under the British Board of Trade. Between 1859 and 1860, the commission, which included such notables in the field of telegraphy as Charles Wheatstone and Latimer Clark, carried out experiments on the construction, insulating, testing, and laying of cables. The final opinion of the commission was that... a well-insulated cable, properly protected, of suitable specific gravity, made with care, and tested under water throughout its progress with the best known apparatus, and paid into the ocean with the most improved machinery, possesses every prospect of not only being successfully laid in the first instance, but may reasonably be relied upon to continue for many years in an efficient state for the transmission of signals.

But, even with this official vote of confidence, Field was unable to interest the British government, which felt that support of the cable project might imply an alliance with the industrial North of the war-torn United States. Finally, an encouraging break came in 1862 --- Glass, Elliott and Co. offered to make and lay the new cable and to put up $125,000 as well, in return for reimbursement of materials and labor costs, plus an additional 20% of the cost of the line. With this promise of support, Field then turned to the private sector in both Britain and the US to raise the necessary capital. Although this canvassing was quite lucrative, by the beginning of 1864 more than half of the needed funding still had to be raised. It seemed that all of the government and private sources had been tapped to their limits.

Then, a catalyst appeared in the form of Thomas Brassey, a railroad entrepreneur and London financier. After talking with Field, Brassey agreed to be one of ten to supply the remaining funds. Brassey's endorsement was enough to bring John Pender, a Manchester industrialist, into the group of ten. Pender took things a step further, though, by heading the merger of Glass, Elliott and Co. and Gutta Percha Co. to form Telegraph Construction and Maintenance (TC&M). Not only did TC&M handle all aspects of the cable's construction, but the company also subscribed the remaining necessary capital. All Field needed now was a ship to lay the cable.

Isambard Kingdom Brunel's Great Eastern had captured the popular imagination. She was by far the largest ship afloat, measuring 693 feet in length and 120 feet in width. She could carry a load of 18,000 tons in her double hull and her coal bunkers could hold enough fuel to take her from England to Australia and back. From the beginning, though, the Great Eastern had been a major money loser. So, when she was put up for auction in January 1864, Daniel Gooch, with the financial help of Field and Brassey, bought the Great Eastern for $125,000 (she had cost $5 million to build) and put her at the disposal of the cable laying expedition.

On 23 July 1865, the Great Eastern began laying out the new cable, which had been manufactured according to much stricter technical specifications. But, once again, the cable accidentally snapped and was lost --- this time only 600 miles out from the Newfoundland coast. This trip proved, however, that the improved methods of making and laying the cable were sound, and few people doubted that the next attempt would succeed.

So, again, capital had to be raised. The newly-formed Anglo-American Telegraph Co., TC&M, and a few British capitalists answered the call. A new cable was constructed, the Great Eastern was again called into service, and, on 13 July 1866, the cable laying began. Two weeks later, the cable was landed and began operating at Heart's Content, Newfoundland. The Great Eastern then returned to the spot where the 1865 cable had been lost, retrieved it from the ocean bottom, spliced it, and paid out the remaining 600 miles back to Newfoundland. By 8 September 1866, not one but two telegraph lines were sending messages across the Atlantic.

Milestone #8 - Reception of Transatlantic Radio signals, 1901 –
Contact: Lori Hogan (709) 368-4150
Signal Hill, Newfoundland, Canada, Dedicated 4 October 1985 - IEEE Newfoundland-Labrador Section

At Signal Hill on December 12, 1901, Guglielmo Marconi and his assistant, George Kemp, confirmed the reception of the first transatlantic radio signals. With a telephone receiver and a wire antenna kept aloft by a kite, they heard Morse code for the letter "S" transmitted from Poldhu, Cornwall. Their experiments showed that radio signals extended far beyond the horizon, giving radio a new global dimension for communication in the twentieth century.

The plaque can be viewed in Signal Hill National Park, St. John's, Newfoundland, Canada.

On 12 December 1901, Guglielmo Marconi and his assistant, George Kemp, heard the faint clicks of Morse code for the letter "s" transmitted without wires across the Atlantic Ocean. This achievement, the first reception of transatlantic radio signals, led to considerable advances in both science and technology. It demonstrated that radio transmission was not bounded by the horizon, thus prompting Arthur Kennelly and Oliver Heaviside to suggest, shortly thereafter, the existence of a layer of ionized air in the upper atmosphere (the Kennelly-Heaviside layer, now called the ionosphere). Marconi's experiment also gave the new technology of "wireless telegraphy" a global dimension that eventually made radio one of the major forms of communication in the twentieth century.

In 1901, Marconi built a powerful wireless station at Poldhu, Cornwall, (corresponding IEEE Milestone) in preparation for a transatlantic test. The spark-gap transmitter fed a mammoth antenna array -- four hundred wires suspended from 20 masts, each 200 feet tall, placed in a circle. A similar station was set up on the American side of the Atlantic at South Wellfleet, Cape Cod.

Then a series of disasters struck. On 17 September a ferocious gale hit the Poldhu station, destroying the elaborate antenna system. A temporary one was put in its place a week later, but tests showed that it was too inefficient to reach the Cape Cod station. Consequently, before leaving England for North America, Marconi decided to set up his equipment at St. John's, Newfoundland, which was much closer to Poldhu. The decision proved academic in any case, because on 26 November, the day before Marconi's scheduled departure, the Cape Cod antenna blew down in a hurricane.

Landing at St. John's on 6 December, Marconi and his assistants set up their experimental apparatus on a table in the Signal Hill barracks near the harbor. Meanwhile, an improved antenna: had been installed at the Poldhu station, whose operators had instructions to send Morse code for the letter "s" from 3 to 7 pm (GMT) starting on 11 December. Marconi tested the winds on the 10th by sending aloft a kite trailing a wire antenna, but the kite broke loose. At the prearranged time on the 11th, Marconi and his assistants sent up a balloon, but heard nothing from their receiver. They next dispensed with the tuned receiver and tried a more sensitive detector, but the balloon broke loose. On the 12th, a strong gale still blew and carried away the first kite they sent up. The second kite, which trailed 500 feet of antenna wire, stayed up long enough for Marconi and Kemp to hear the transatlantic signals through a telephone earpiece connected to the receiver.

Marconi's diary for that date has the simple entry, "Sigs. at 12:30, 1:10 and 2:20. 11 more signals were confirmed on the next day, Friday the 13th, but none on Saturday. On Monday the 16th, Marconi released the news to the press and then began packing for a new location because the Anglo-American Telegraph Company threatened legal action for violating its communication monopoly in Newfoundland.

Marconi's announcement met with enthusiastic acclaim, but also with some skepticism. After all, the only witness was George Kemp, hardly an impartial observer, and the signals were too weak to operate an automatic recorder. Two months later, though, Marconi received transatlantic signals of sufficient strength from Poldhu to operate a Morse inker in the presence of witnesses. (Although later knowledge of radio-wave propagation indicates that the Signal Hill reception occurred under inopportune conditions, recent historians have suggested that Marconi picked up a high-frequency harmonic on his un-tuned receiver.) In January 1902, between the time of the Signal Hill reception and the later verification, the American Institute of Electrical Engineers held their annual dinner meeting in honor of Marconi. In attendance were such electrical engineering notables as Alexander Graham Bell, Charles Proteus Steinmetz, and Michael Pupin. Thomas Edison, who sent his regrets, called Marconi "the young man who had the monumental audacity to attempt, and succeed in, jumping an electrical wave clear across the Atlantic Ocean."

Other Milestones in Canada

Nelson River HVDC Transmission System, 1972

Winnipeg, Manitoba, Canada, Dedicated 3 June 2005 **-** IEEE Winnipeg Section

On 17 June 1972, the Nelson River High Voltage Direct Current (HVDC) transmission system began delivery of electric power. It used the highest operating voltage to deliver the largest amount of power from a remote site to a city. The bipolar scheme gave superior line reliability and the innovative use of the controls added significantly to the overall system capabilities. Finally, the scheme used the largest mercury arc valves ever developed for such an application.

The two plaques may be viewed at either Manitoba Hydro's Radisson and Henday Station (Nelson River),Manitoba, Canada, or at Manitoba Hydro's Dorsey Station, Rosser, Manitoba, about 26km northwest of Winnipeg, Canada.

The Province of Manitoba is situated in the center of Canada, immediately north of the Midwest United States. The Nelson River, located in the province, was up until the early 1960s an untapped resource for hydroelectric power. To provide electricity to the growing demand of the province, the government decided to tap into this abundant resource. Approximately 4,000 MW of generating capacity was developed, 3,600 MW of which was hydro. Most of the hydro generation is located in the northern portion of the province. Quite remote from the load center in the south, Manitoba's two largest generating plants, Kettle Rapids and Long Spruce, with a combined capacity of 2200 MW, are located in the north.

More than 550 miles of transmission lines from the Kettle Generating Station to Winnipeg were constructed. Power is generated in alternating current (ac) and converted to direct current (dc) for economical reasons. Direct current was chosen because it loses less power and is more stable. Also, dc lines are 2/3 less expensive than ac lines.

To support the dc transmission line, over 3,900 guyed towers and 96 self supporting towers had to be constructed. One of the challenges of establishing this transmission line was the varied terrain and the presence of permafrost, which existed in some areas at 30ºF to 32º F (-1ºC to 0ºC), making the foundation subject to a reduction in soil strength and settling of up to 3 feet (1 meter).

The output of these plants (Kettle and Long Spruce) is then transmitted from Radisson and Henday Converter Stations (ac to dc), via the Nelson River dc line, more than 600 miles (965 km) southward to Dorsey Station, located near Winnipeg. Initial DC service was established in 1972 and expanded to match generation additions, bringing the present total transmission capability to 2, 500 MW.

The significance of this low-voltage line lies in the fact that for the first time two HVDC bipoles were paralleled and deparalleled using high voltage high-speed switches, the system being unique in the sense that Bipole 1 uses mercury arc valves while Bipole 2 comprises second generation thyristor valves.

A bipolar transmission line is defined as having two conductors consisting of one positive pole and one negative pole, which normally operate at equal current. The term bipole refers to the conversion equipment in the converter stations at both ends of Manitoba Hydro's HVDC transmission lines.

The other major advantage of the HVDC system is very low electric rates, one of the lowest in North America.

Pinawa Hydroelectric Power Project, 1906

Nelson River, Canada, Dedicated 6 June 2008 **-** IEEE Winnipeg Section

On 9 June 1906 the Winnipeg Electric Railway Co. transmitted electric power from the Pinawa generating station on the Winnipeg River to the city of Winnipeg at 60,000 volts. It was the first year-round hydroelectric plant in Manitoba and one of the first to be developed in such a cold climate anywhere in the world.

The legacy of Manitoba Hydro's predecessor company, Winnipeg Electric Railway Co., was the ability to prove that rivers in Manitoba could be developed to supply low cost electricity for streetcars and emerging domestic and commercial markets. The proof was in the successful development of Pinawa in 1906. This brought about competition from the emerging municipal utility, City of Winnipeg Hydro, which later developed the second hydroelectric plant on the Winnipeg River, Pointe du Bois in 1911. The two utilities battled to keep rates lower than anywhere else in North America. In 2002, Manitoba Hydro purchased the smaller Winnipeg Hydro and electricity rates are still the lowest in North America.

Although the plant itself is conventional by the standards of the 1900s, the ability to provide solutions to construction problems in the primitive wilderness surrounding the Winnipeg River were unique at that time. In addition, the operational problems of a plant faced with frazil ice formation at the onset of each winter had to be considered and dealt with. These were met with success.

The Pinawa plant with an ultimate rating of 22 MW was the first in a series of 13 plants on the Winnipeg, Nelson, and Saskatchewan Rivers in Manitoba for a total capacity of 5000 MW. The most recent plant, Limestone with a rating of 1340 MW, was completed in 1992. There is also an undeveloped hydro potential of some 5000 MW for the future.

The Milestone plaque may be viewed at the Manitoba Electrical Museum and Education Centre, 680 Harrow St, Winnipeg, MB R3M, Canada
http://www.hydro.mb.ca/corporate/history/electrical_museum.shtml

Eel River High Voltage Direct Current Converter Station, 1972
Eel River, Northern New Brunswick, Canada, Dedicated 24 February 2011 **-** IEEE New Brunswick Section

Operating since 1972, Eel River, New Brunswick is home to the world's first commercial solid state High Voltage Direct Current converter station. This 320 MW interconnection facility, built by Canadian General Electric and NB Power, incorporates high current silicon solid state thyristors to convert alternating current from Hydro Quebec to direct current and back to alternating, allowing asynchronous, stable power transfers to serve NB Power's customers.

The plaque may be viewed in the main lobby of the Eel River Dalhousie Generating Station in North Shannonvale, New Brunswick, where it can be viewed by employees and visitors.

This converter station was historically significant because it was the first that was designed and built from solid state high voltage, high current thyristors. Previously the medium was a plasma in a glass envelope using mercury vapor. These had more losses and were prone to re-strikes during transient fault events. Additionally, the mercury is considered a dangerous pollutant. Nelson River HVDC had used thyristors in a portion of the bridge to mitigate re-strikes but these were retrofits. The knowledge gained there served as a proving ground to give confidence for a full scale project at Eel River.

With this project, the march of solid state systems to higher current and voltage ratings was advanced another major step. In fact, the Eel River Station performance was such that the station ran at 10% overload for the first 15 years without difficulty. The project allowed surplus Hydro Quebec energy to flow into New Brunswick which is synchronized with the Eastern Interconnection, without the risk of loss of transmission if disturbances happened in either New Brunswick or Hydro Quebec.

Indeed Eel River served to govern and stabilize both systems with its External Control System, a benefit to either system in case of disturbances. This economically advantageous energy imported to the benefit of New Brunswick customers, allowed more expensive NB Power generation to be exported to New England where energy costs were higher, an economic advantage to the parties on both side of the US border.

The electronic external control system enhancing governing and stability as a response to weighted system frequency and weighted system acceleration was a new feature which allowed both Hydro Quebec and NB Power to use the other system as a crutch during power system disturbances in either system. This feature has had a major beneficial impact on dynamic system performance. This is where a difference in frequency modulates the power transfer in a manner to assist the deficient system being governed back to safety. In the event of a difference in acceleration, the system slowing down is assisted by the other system while mitigating any power swings as quickly as possible to regain stability.

The triggering for the thyristors was achieved by using fibre optics to communicate the isolated trigger pulse to the thyristors at various voltage levels. This was an early application of another new technology, now ubiquitous.

First Television Broadcast in Western Canada, 1953
North Vancouver, BC, Canada, Dedicated 6 November 2010 **-** IEEE Vancouver Section

On 16 December 1953, the first television broadcast in Western Canada was transmitted from this site by the Canadian Broadcasting Corporation's CBUT Channel 2. The engineering experience gained here was instrumental in the subsequent establishment of the more than one thousand public and private television broadcasting sites that serve Western Canada today.

Plaque is viewable on a wall near the main gate of the CBC Broadcasting Site on Mount Seymour just below the Mount Seymour Ski Area.

The CBUT broadcasting site on Mount Seymour (North Vancouver, British Columbia) was both the first television broadcasting site in Western Canada and the first high elevation/mountain top broadcasting site in Canada. The opening broadcast featured special launch ceremonies at 6 pm and was followed by a CBC newscast at 7 pm. (Western Canada refers to the four provinces west of the Great Lakes: British Columbia, Alberta, Saskatchewan and Manitoba. It is physically separated from Central Canada (Ontario and Quebec) by the Great Lakes and the relatively inhospitable Canadian Shield.)

At the time of the first broadcast, the establishment of a television station in Vancouver was seen as an important contribution to Canadian sovereignty and cultural identity. The first broadcast and associated ceremonies were major events. At the same time, CBUT provided an important training ground for and contributed to the principles and practices that guided the engineers who went on to deploy the over 1000 public and private broadcasting sites that serve Western Canada today.

Although VHF transmitting sites had already been established in Western Canada for FM broadcasting, these sites were generally located atop tall buildings in urban areas, e.g., VE9FG (later CBU-FM), a 1-kW FM broadcast station that became operational on 21 November 1947 and which was located at the Hotel Vancouver in downtown Vancouver.

The three television broadcasting sites that had been established in Canada previously (in Montreal, Toronto and Ottawa) were also installed at relatively low elevations. For the CBC managers of the day, establishing the network's fourth television transmitter so far West and at a high elevation and a remote location was a bold and significant decision.

The relatively complicated topography of the Lower Mainland of British Columbia required that considerable care be taken to choose a broadcasting site that would provide the best coverage. Predicting and evaluating the coverage of a VHF broadcast transmitter in mountainous terrain is much different from the corresponding task for the MF broadcast transmitters that had been installed at various low-level locations throughout the Lower Mainland during the 1930's and 1940's.

The quality of the initial site selection and engineering is underscored by the longevity of the CBC Broadcasting Site on Mount Seymour and the large number of other television and FM broadcast transmitters that are installed in the same general area today.

First Radio Astronomical Observations Using VLBI, 1967

Kaleden, British Columbia, Canada, Dedicated 25 September 2010 - IEEE Vancouver Section

On the morning of 17 April 1967, radio astronomers used this radiotelescope at DRAO and a second one at the Algonquin Radio Observatory located 3074 km away to make the first successful radio astronomical observations using Very Long Baseline Interferometry. Today, VLBI networks span the globe, extend into space and continue to make significant contributions to both radio astronomy and geodesy.

The plaque is at the base of DRAO's 26-m radiotelescope. Constructed in 1959, it is currently used for a variety of astronomical projects. The address of the Observatory is 717 White Lake Road, Kaleden, B.C., Canada V0H 1K0. The geodetic coordinates of the radiotelescope are +49° 19' 15.18", -119° 37' 13.31".

The 26-m radiotelescope at the Dominion Radio Astrophysical Observatory. (c) National Research Council of Canada

The DRAO 26-m radiotelescope was completed in 1959 and the Algonquin 43-m radiotelescope in Ontario was completed in 1966. As a result, Canada had two major radiotelescope installations in 1967. Although the Algonquin radiotelescope ceased radio astronomy operations in 1988, DRAO is still very active today.

Discussions of the feasibility of interferometry spanning the continent, i.e., Very Long Baseline Interferometry or VLBI, began in 1960, and technical developments continued at various sites around the world until success was achieved in Canada in 1967. From its Canadian beginnings, VLBI has become an important technique for both radio astronomy and geodesy. It has been the central theme of over 3,500 papers in the scientific literature over the ten-year period 1999 to 2008, and the flow continues unabated.

The significance of VLBI was recognized almost immediately. In 1971, the American Academy of Arts and Sciences awarded the Rumford Prize to the members of three pioneering VLBI research groups, including the team from Canada that made the historic first observations and teams from: (1) MIT and (2) NRAO (National Radio Astronomy Observatory) and Cornell University that conducted important follow on work.On On

In the late 1970s the community of Canadian VLBI scientists proposed the next step: deployment of an array of large radio telescopes across the entire breadth of Canada which they referred to as the Canadian Long Baseline Array. Using VLBI techniques, the array would function as one giant imaging telescope. The project fell victim to a barren funding climate for science in Canada in the 1980s but the concept was used by US scientists to build the Very Long Baseline Array (VLBA) across that country. The VLBA has been a scientific success story since its completion in 1993.

Canadian researchers pursued VLBI research with the DRAO 26-m radiotelescope until 1988. In 1990 DRAO scientists and engineers became involved with the first extension of VLBI techniques into Earth orbit. The DRAO team designed and built a forefront correlator, a special-purpose digital processor that combined signals from a Japanese space telescope, VSOP, with ground based radiotelescopes around the world. VSOP was launched in 1997 and operated with superb effectiveness until 2003. In the process, it achieved many world firsts.

VLBI provides better angular resolution than any optical telescope and can reveal details within some of the most distant objects detectable. Astronomers use VLBI to provide crucial tests of General Relativity, to demonstrate definitively the existence of black holes in galaxy cores, to test the fundamentals of high energy physics, and to look back to the early Universe.

VLBI techniques also permits the position of objects on Earth and in the solar system to be measured with millimetre accuracy with respect to the ICRF (International Celestial Reference Frame) defined by distant quasars. On 13 August 2009, the XXVII IAU (International Astronomical Union) General Assembly adopted the second-generation ICRF2 as the fundamental celestial reference frame as of 1 January 2010. A complete description of ICRF2 is available in IERS (International Earth Rotation and Reference System Service) Technical Note 35. VLBI techniques are now routinely used: (1) to provide the basis for all terrestrial precision surveying, including the Global Positioning System, (2) to precisely track spacecraft on voyages to the planets, and (3) to make important measurements of the movement of crustal plates and to help predict earthquakes.

Short-baseline interferometry had been used in radio astronomy for high-resolution imaging since the 1940's. Cables or (sometimes) radio links were used to connect two or more radio antennas to signal processing equipment. The distance or baseline between pairs of antennas in such interferometers was initially small but gradually It became larger over time.

It soon became clear that important astrophysical questions could be answered only by building interferometers with baselines greater than any cable or radio link could span.

The principal technical challenge of the first VLBI observations was to establish two independent receiver systems with individual clocks and recording devices that were sufficiently stable to maintain coherence over periods of many minutes and sufficiently sensitive to detect the very weak radio astronomical signals.

Scientists from across Canada worked together and applied great ingenuity to achieve a difficult goal within a limited budget. For example, the first VLBI observations were collected using surplus video recorders that had been purchased from the Canadian Broadcasting Corporation.

First 500 MeV Proton Beam from the TRIUMF Cyclotron, 1974

Vancouver, British Columbia, Canada, Dedicated 16 December 2010 - IEEE Vancouver Section

At 3:30 pm on 15 December 1974, the first 500 MeV proton beam was extracted from the TRIUMF cyclotron. Since then, TRIUMF has used proton beams from its cyclotron (and secondary beams of pions, muons, neutrons and radioactive ions produced in its experimental halls) to conduct pioneering studies that have advanced nuclear physics, particle physics, molecular and materials science, and nuclear medicine.

The Milestone plaque can be viewed on a wall outside the cyclotron main control room at TRIUMF Meson Facility, 4004 Wesbrook Mall, Vancouver, BC V6T 2A3, Canada. (The first successful beam extraction was manually controlled from the main console in that room.)

TRIUMF is Canada’s national laboratory for particle and nuclear physics. It is owned and operated as a joint venture by a consortium of Canadian universities. Its operations are supported by the Government of Canada through a contribution from the National Research Council Canada while capital funds for buildings are provided by the Government of British Columbia. TRIUMF's mission is:

- To make discoveries that address the most compelling questions in particle physics, nuclear physics, nuclear medicine, and materials science;
- To act as Canada’s steward for the advancement of particle accelerators and detection technologies; and
- To transfer knowledge, train highly skilled personnel, and

commercialize research for the economic, social, environmental, and health benefit of all Canadians.

More information concerning the TRIUMF Laboratory can be found at http://www.triumf.ca

The heart of the TRIUMF Laboratory is the 500 MeV cyclotron that was conceived, designed, constructed and commissioned between 1965 and 1974. The events leading up to extraction of the first 500 MeV proton beam from the cyclotron are described in: J.R. Richardson, E.W. Blackmore, G. Dutto, C.J. Kost, G.H. MacKenzie, and M.K. Craddock, "Production of simultaneous, variable energy beams from the TRIUMF cyclotron," *IEEE Transactions on Nuclear Science,* vol. NS-22, no. 3, pp. 1402-7, Jun. 1975, and in a retrospective that was prepared for the twenty-fifth anniversary of the event: M.K. Craddock, "The First Beam - A Whirlwind Visual History - and Prehistory," *Annual General Meeting of the TRIUMF Users' Group,* 13 December 1999.

Compared to the first and second generation of cyclotrons that provided much lower beam energies and intensities, the physical size of the 500 MeV cyclotron is truly impressive. The main magnet is 18 metres in diameter and weighs 4000 tons. The 23 MHz main RF amplifier delivers almost 1 million watts of power in order to develop 200 kV across the accelerating gap.

December 1999: The Silver Anniversary celebration of the first extraction of a full energy proton beam from the TRIUMF cyclotron. Pictured are TRIUMF Directors from left, Dr. Jack Sample, Dr. Alan Astbury, and Dr. Erich Vogt.

The sheer scale of the design and construction effort required TRIUMF staff and contractors to develop revolutionary computer-assisted design, modelling, measurement and tuning technologies in an era dominated by mainframes and minicomputers. Some of these codes, e.g., ACCSIM, a synchrotron beam simulation code, and PHYSICA, a data analysis and plotting code, continue to be widely used, both within TRIUMF and at other laboratories.

Because of its size, TRIUMF was one of the first particle accelerators to employ a software-based supervisory control and data acquisition (SCADA) system rather than direct linkage of cyclotron and beamline components to a hardware-based control panel.

By providing intermediate energy proton beams (i.e., beam energies greater than 100 MeV but less than 1 GeV) that are two orders of magnitude more intense than were previously available, the TRIUMF cyclotron (and its two sister meson factories in the United States and

Switzerland) have revolutionized nuclear physics, particle physics, molecular and materials science, and nuclear medicine.

The quality of the initial design and engineering and the significance of the result are underscored by the longevity of the TRIUMF cyclotron. Thirty-five years after the first 500 MeV proton beam was extracted, the cyclotron is still the main engine of TRIUMF’s world-leading research program which currently includes meson physics, nuclear physics, nuclear astrophysics, nuclear medicine and irradiation services for industry.

In the 1980s, TRIUMF proposed to use the 500 MeV cyclotron to inject proton beams into a complex of storage rings and synchrotrons (often referred to as the KAON Factory) that would raise the proton beam energy to 30 GeV and yield the most intense high energy proton beams in the world - about 100 times the particle flux of existing machines. Details are described in many publications, including:

M.K. Craddock, "The TRIUMF Kaon Factory" in Proc. 1991 IEEE Particle Accelerator Conference, 6-9 May 1991, pp. 57 - 61. KAON is both the name of the high energy K-mesons that the accelerator complex would have made and an acronym that refers to the entire suite of particles that would have been produced, including K-mesons, Anti-protons, Other hadrons and Neutrinos.

Although the KAON project was unable to secure the international investment required to proceed to full construction and was eventually shelved in the mid-1990s, the intense development effort prepared the TRIUMF Laboratory to take on other ambitious projects in the 1990s and 2000s. Foremost among these is ISAC (Isotope Separation and Acceleration), a facility in which a proton beam from the 500 MeV cyclotron is used to produce beams of exotic isotopes which are further accelerated using linear accelerators. The facility allows researchers to study the properties and structure of these exotic isotopes.

TRIUMF is contributing the skills and knowledge that it has developed during the past forty years to other labs. It has provided accelerator and beam-line components to facilities such as the Hadron-Electron Ring Accelerator (HERA) at DESY in Hamburg, the Alternating Gradient Synchrotron (AGS) at the Brookhaven National Laboratory in Long Island, New York and the Large Hadron Collider (LHC) at CERN. It has also provided detectors and other equipment used in the ATLAS detector employed by the Large Hadron Collider (LHC) at CERN and the T2K (Tokai-to-Kamioka) neutrino oscillation experiment in Japan.

TRIUMF, in partnership with MDS Nordion, uses proton beams from the main cyclotron and four smaller cyclotrons to produce radioisotopes for use in medical imaging and diagnostics. The recent decision to fund Advanced Applied Physics Solutions (AAPS) under the Canadian Centres of Excellence in Commercialization and Research program paves the way to further application of TRIUMF-based discoveries and methods in ways that directly benefit society.

Distinguishing features or characteristics of this work

TRIUMF is the world's largest cyclotron, and one of only five intermediate-energy high-intensity accelerators in the world. The TRIUMF design team was among the first to adopt the use of H^- ions to simplify beam extraction and the use of an AVF (azimuthally varying field) main magnet to permit both isochronous acceleration and proper focusing of the H^- ions even as they reach relativistic velocities. They also pioneered the simultaneous extraction of multiple (up to 4) beams at independently variable energies (70-520 MeV). (H^- ion beams can be easily extracted from the cyclotron by passing them through a stripping foil that removes the two electrons from each ion. If the foil is correctly positioned, the resulting proton beam simply curves in the opposite direction, out of the cyclotron's beam port and into the beamline. The fragility of H^- ions limits the magnetic field strength that can be used, accounting for the large size of the cyclotron.)

Unlike the world's other four intermediate-energy high-intensity accelerators (the two other meson factories located at the Paul Scherrer Institut near Zurich and the Los Alamos National Laboratory in New Mexico, the SNS linear accelerator located near Oak Ridge, TN and the ISIS synchrotron located in Oxfordshire, UK, respectively), the TRIUMF cyclotron can deliver multiple variable-energy and full-energy proton beams simultaneously with a 100% macroscopic duty cycle.

The high intensity of the beam allows the cyclotron to serve as the driver for multiple experiments within the course of a week. The TRIUMF cyclotron's ability to provide steady, intense and reliable energy beams in a flexible manner has also allowed the facility to become a world leader in providing beams of exotic isotopes using the "isotope separation online" technique.

Further information on IEEE Milestones worldwide can be found at:
http://www.ieeeghn.org/wiki/index.php/Milestones:List_of_IEEE_Milestones

Further information on the history of IEEE Canada and its' Sections can be found at: http://www.ieee.ca/history/index.htm

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On these next few pages please feel free to write down your thoughts and impressions on the sites you have visited. These pages may be removed from the book and collected in St. John's, or you can simply email me your thoughts when you get home. Thank you. Cathie Lowell c.lowell@ieee.org

Milestone #1 - First Distant Speech Transmission in Canada, 1876

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Milestone #2 - DeCew Falls Hydro-Electric Plant, 1898

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Milestone #5 - First 735 kV AC Transmission System, 1965

Milestone # 6 - First Submarine Transatlantic Telephone Cable System

Milestone #7 - Landing of the Transatlantic Cable, 1866

Milestone #3 - First External Cardiac Pacemaker, 1950

Peterborough Sites

The University of Ottawa, Carleton University

Milestone #8 - Reception of Transatlantic Radio signals, 1901

Overall Impressions of Tour