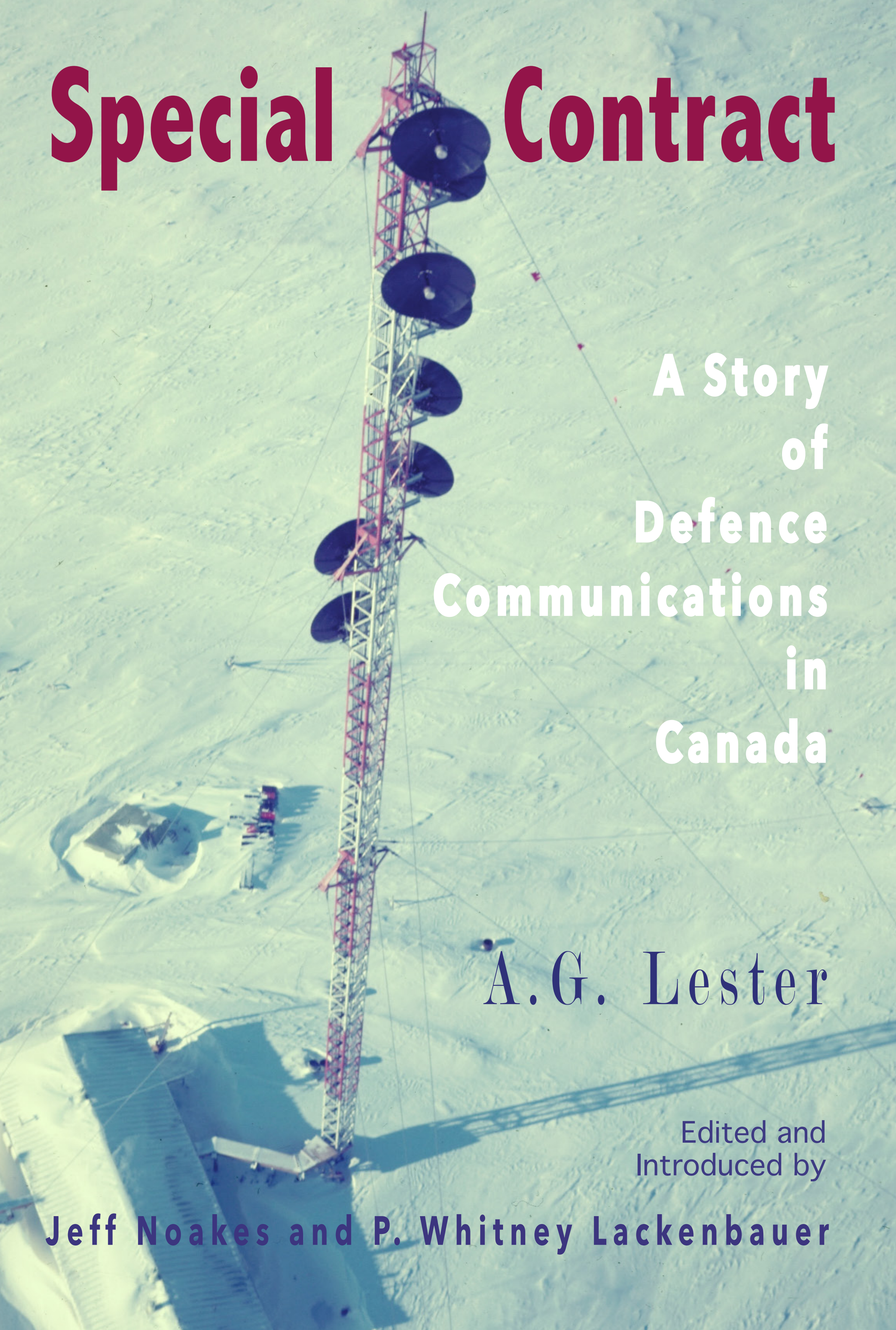

Special Contract

A Story of Defence Communications in Canada

A.G. Lester

Edited and Introduced by

Jeff Noakes and P. Whitney Lackenbauer

Mulroney Institute
St. Francis Xavier University
5005 Chapel Square
Antigonish, Nova Scotia, Canada
B2G 2W5

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Cover image: Detection Site, Microwave Tower, Mid-Canada Line at RCAF Station Great Whale River, 8 February 1958, Department of National Defence PC-2294, Photographer F/O Sankey

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As part of the Mid-Canada system, 102 sites were established - eight major air stations, 90 doppler and 4 tropo-scatter installations, over a distance of 2,800 miles. Something over 200,000 tons of material were transported to and distributed along the 55th parallel of latitude. This involved transport of every sort: rail, sea, major aircraft, including 12 Cansos of the total of 14 available in Canada; helicopters, the biggest tractor train operation in Canadian history up to that time, truck, barge, canoe and dog team. …

This, then, is the story of Special Contract; of its accomplishments and its difficulties. Above all, it is the story of people, of seven people initially, growing to 1,254 at maximum, supervising line contractors employing another 5,500 men, then reducing to zero as the work was completed. Of people, Bell employees and others, who despite very real hardships, long hours and criticism, developed an esprit de corps which sustained the whole operation. To them I dedicate this story; for it is theirs.

- A.G. Lester

The Arctic Operational History Series

The Arctic Operational History Series seeks to provide context and background to Canada's defence operations and responsibilities in the North by resuscitating important, but forgotten, Canadian Armed Forces (CAF) reports, histories, and defence material from previous generations of Arctic operations.

Since the CAF's reengagement with the Arctic in the early 2000s, experience has demonstrated the continuity of many of the challenges and frictions which dominated operations in decades past. While the platforms and technologies used in previous eras of Arctic operations are very different, the underlying challenges – such as logistics, communications, movement, and sustainment – remain largely the same. Unfortunately, few of the lessons learned by previous generations are available to today's operators. To preserve these lessons and strengthen the CAF's ties to its northern history, this series is reproducing key reports and histories with direct relevance to CAF operations today.

Adam Lajeunesse

Series Editor

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INTRODUCTION

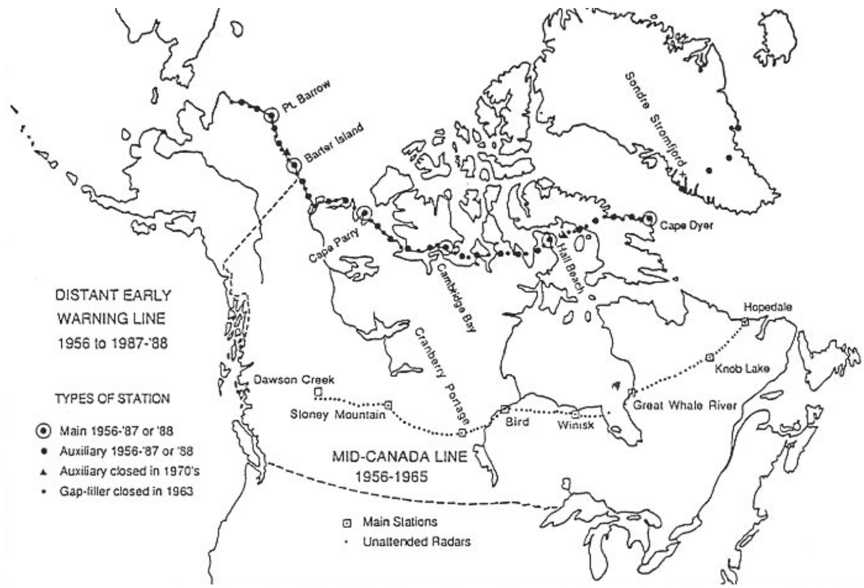
Situating the Mid-Canada Line, 1953-1957[1]

Jeff Noakes with P. Whitney Lackenbauer

> It would be desirable for Canada to construct the mid-continent line alone because with American participation there would be less Canadian control, costs would almost certainly be greater and the delays would likely be considerable. Furthermore, by undertaking the project alone and quickly Canada could demonstrate to the United States its active participation in continental defence.
>
> Minister of National Defence Brooke Claxton, 30 June 1954[2]

Geography and Canada's intensifying defence cooperation with the United States ensured that Canada would be directly involved in the expansion of North American air defences after the Second World War. Three major radar networks extended across Canadian territory (in whole or in part) during the 1950s. The Pinetree Line, which ran roughly along the 50th parallel and then along the Labrador coast to Baffin Island, consisted of 33 main stations, provided "last minute" warning of targets approaching the main North American population belt. The Distant Early Warning or DEW Line, running along the Arctic coastline, pushed early warning radar coverage into the far north, with extensions along the Aleutian Islands in the west and across the Greenland ice cap in the east. The third major radar system, the Mid-Canada Line (MCL), was built between 1954 and 1957.

Although initially planned in conjunction with the United States, the MCL was an entirely Canadian-designed and built system stretching roughly along the 55th parallel. Unlike the Pinetree and DEW Line systems, it was based on a simple principle of an electronic "fence" or "tripwire" that used the Doppler effect to indicate the passage of an aircraft. Since the equipment had originally been developed at the outset of the 1950s as a joint research product involving McGill University, the Defence Research



Board (DRB), and the Royal Canadian Air Force (RCAF), the system was often dubbed the "McGill Fence." This "fence" differed in principle from more conventional radar systems, which by this time in history could determine a contact's location, course, speed, and altitude with considerable certainty.[3] Nevertheless, this new Canadian technology offered the prospect of aircraft detection with a high degree of accuracy at a lower cost than conventional radar equipment (in particular because its automation required far fewer personnel). Although a radar line using this equipment would not have been feasible in an area with heavy air traffic, the modest number of flights that transgressed 55° North made it appropriate.[4] This same isolation, however, posed significant challenges for construction of the Line itself.

The Mid-Canada Line was the largest all-Canadian air defence project ever undertaken, as well as the most difficult. Built between 1954 and 1957, the line operated for seven years until it was closed down, abandoned in place, and soon faded from the national consciousness. The Pinetree Line to its south and the DEW Line to its north received more attention from the public, and contemporary journalists and historians usually see the MCL (if at all) as an interesting example of Canadian engineering and construction, and a success story for Canadian technology and engineering overcoming a harsh northern landscape.[5]

While a recent spate of works on North American air defence and its significance for Canadian-American relations have focused renewed attention on the broader political context in which the MCL was constructed, the construction of the lines and its attendant problems and controversy should be better known.[6] The previously unpublished account by Alex Lester, former head of Bell's Special Contract Division, in this volume offers a systematic, first-hand description of the people and political machinations behind the construction of the Pole Vault tropospheric scatter system and the MCL itself. Written in the 1970s, Lester's insights have reached a limited audience, but they have had a clear influence on historians of Canadian telecommunication industry, who discuss the MCL project with varying degrees of accuracy.[7] By making Lester's memoir accessible to a broader readership, we hope to make his insights into the complexity of the Mid-Canada Line project and the organization that built it more accessible.

As Lester reveals, planning and engineering the radar system proved a complex and arduous undertaking. Given the urgency to build the MCL, planning and technical development became interdependent, leading to major revisions in layout and equipment – with attendant consequences for the construction effort and escalating project costs. Furthermore, the sheer scale of the MCL was daunting: when completed, it consisted of 102 sites, 7 of them major bases, running roughly along the 55th parallel from the British Columbia-Alberta border to the Labrador coast. It required 264 permanent buildings ranging from small service structures to large hangars, two major and 10 minor airstrips, 370 towers, including some more than 350 feet high, for its detection and communication equipment, 16 large tropospheric scatter dishes for rearwards communications, 322 diesel-alternator units, and the electronic equipment necessary to make the line work. All of this represented some 200,000 tons of materials and equipment that had to be transported into Canada's North via rail, tractor train, sea, and air. The construction effort began in June 1954 and was completed, after two years of field work, in August 1957.[8]

As Lester explains in chapter 18,

> In telling the story of major projects like the Mid-Canada Line, one tends to concentrate and enlarge on the visible, active construction in the field. The story is fluid, sometimes spectacular, and the elements of the struggle with Nature in a rugged climate, with the associated problems of people, places and things, present an ever-changing

> picture to the interested reader. Without discounting the problems, successes and failures of the field activity, it must be remembered that the whole purpose of the exercise, the raison d'etre for all the construction, was to house the detection and communications equipment which together formed this early warning line, and to accommodate the people required to man it.

That stated, the trials and tribulations of building a radar system on this scale, and the relationships between government departments and contractors, are essential parts of the MCL story – and that of the Cold War in the Canadian North more broadly.

Radar, Continental Defence, and the Early Cold War

As early as 1946, Canadian and American authorities considered the possibility of building a radar chain in the Arctic to give advanced warning of a transpolar Soviet bomber attack.[9] At that time, the available technology could not guarantee complete coverage of the northern frontier or accurate tracking of aircraft, so investing huge sums in an ineffective early-warning system was ill-advised. After the Soviets detonated an atomic device in 1949 (earlier than intelligence estimates had expected),[10] strategic assessments began to change. That November, the USAF Chief of Staff General Hoyt Vandenberg noted to the Joint Chiefs of Staff that "almost any number of Soviet bombers could cross our borders and fly to most of the targets in the United States without a shot being fired at them and without being challenged in any way." If the Soviet Union could destroy fifty major American cities and the retaliatory power of Strategic Air Command (SAC), the United States would be defeated. Accordingly, he promoted a concerted effort along the lines of the wartime Manhattan project to develop an effective air defence system and secured $50 million for a Radar Fence or Permanent Radar System project.[11] Although the US continued to focus on offensive capabilities associated with SAC, the potential benefits of early warning radar systems to protect the deterrent became more appreciable.

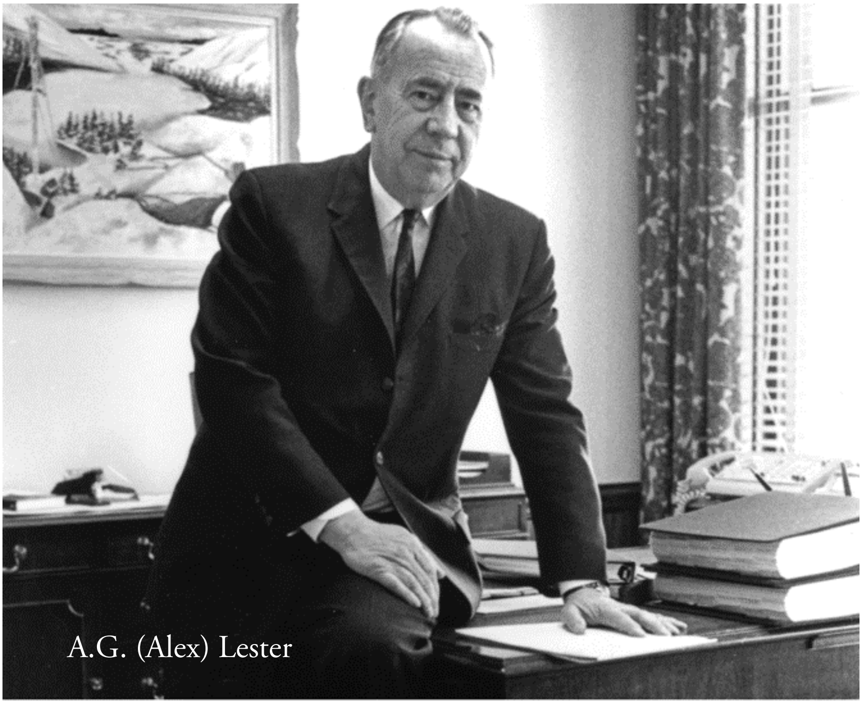
The United States produced NSC-68, its "blueprint for the Cold War," in early 1950, highlighting the dangers posed by growing Soviet military power and aggressive behavior. Declaring that the Soviet Union wanted "to impose its absolute authority over the rest of the world," defence analysts highlighted that the Soviets were approaching technological parity in bombers and atomic weapons, and the most direct route for those bombers to the military and industrial heartland of North America was over the Arctic. In their calls for massive increases in defence spending, American strategists elevated the importance of improved continental defences that would allow the United States to survive a Soviet air attack and respond in force.[12] "By extending the air defence system northwards such bombers could be engaged before reaching their intended targets," Canadian strategist R.J. Sutherland explained. "Almost equally important, by extending the area of radar coverage the risk of saturation of the defences could be reduced. Finally, by locating strike aircraft or refuelling aircraft on the northern bases, the range and speed of response of the strike forces could be improved."[13] In short, the North American allies sought strategic defence in depth. By extending their military outposts to the farthest reaches of the continent, they might gain four to six hours notice before Armageddon – enough time to get their own strategic bombers in the air and respond in kind.

The outbreak of the Korean War that June served as a catalyst for more decisive action when North American defence analysts worried that Chinese-backed aggression on the Korean peninsula marked the first step in a global communist offensive. Both the US and Canada announced dramatic increases in military spending and committed to improve their air defence systems. Sensational media coverage on the superpower race to develop a hydrogen bomb, as well as growing Soviet capability to launch an aerial attack on North America, created a crisis atmosphere, driving defence planners, the military, and politicians on both sides of the Canada-US border to propose and accept increasingly ambitious continental defence plans in the early 1950s.[14] The initiation of the joint Canadian-American Pinetree Line and its extensions, with many of the stations completed from 1951-54, as well as new or upgraded RCAF bases built across Canada, were an initial reaction to this threat.

A.G. Lester, Bell, and the Postwar "Military-Telephone Complex"

In his important history of the telecommunications industry in Canada, Jean-Guy Rens suggests that a "military-telephonic complex" took shape in the postwar period to devise technological solutions to emerging defence threats. "During the Second World War, the major military telecommunications projects had been conducted by telephone companies outside of the associative structure," he observes. "Many mobilized Bell engineers and technicians found themselves in the Royal Canadian Signal Corps, leading to a certain cultural rapprochement, which was concretized after the war in a little-known and unusual institution: the National Defence College in Kingston." To enhance mutual understanding between the military and industry, the college admitted a small number of private sector managers to participate in its senior officers' course. Bell Canada was the first to send a representative: "a bright young member of the élite," Alex G. Lester, who "was subsequently involved in every aspect of cooperation between Bell and the military."[15]

Lester was seconded to the Electronics Division at the Department of Defence Production (DDP) in May 1952, where he began grappling with solving communications problems associated with the chain of Pinetree Line stations along the Labrador coast. A necessary part of any air defence network is the ability for its various elements to be able to communicate with each other in a timely and reliable manner. In the early 1950s, seven separate communications channels or circuits, for instance, were required for the "handing over" of the tracking of enemy raids or enemy aircraft from one radar station to another. As the number of stations increased, so did the


A.G. (Alex) Lester

number of communications channels required. Communication of other sorts of information, as well as communication between the ground and interceptor aircraft, further complicated the task, as did the need for backup systems to guard against the possibility of enemy sabotage or jamming of signals or against equipment failure. This information could be passed by telephone lines, but isolated locations often required the installation of additional lines or even the installation of microwave communications links in situations where the latter could be more flexible and economical.[16]

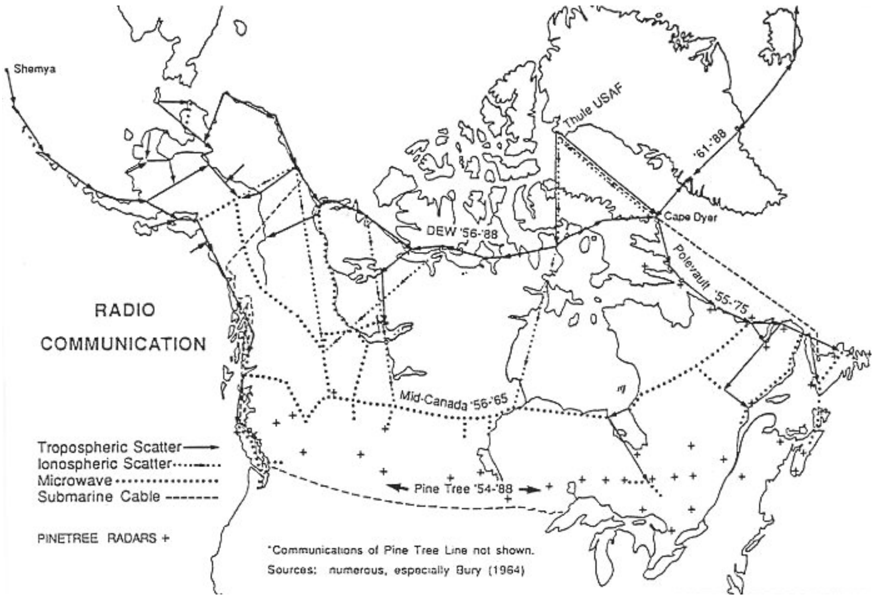
As part of the building of the Pinetree Line, the RCAF began work on ADCOM, a microwave air defence communications network in northern Ontario and Quebec.[17] Microwave communications technology, which used high frequency radio signals in a tightly focused beam, offered the prospect of secure voice and data communications over short ranges (the transmitters and receivers had to be within line of sight of each other) and could transmit a broader range of information than conventional wire communications. In isolated areas, the ability to transmit along a line of sight path using equipment mounted on towers offered cost savings over conventional pole and line communications links, even after the greater capabilities of microwave transmission were taken into account. The technology was then in its early stages, and Bell Canada recommended that the RCAF rent communications circuits from common carriers (including Bell Canada), but the RCAF decided to go it alone. Design and equipment problems meant that the initial $3 million cost ballooned to over $10 million by 1952, and then to $22 million before the system was operational.[18]

Private sector telecommunications companies saw the RCAF's decision to undertake ADCOM itself as a business opportunity being denied to them. The major national telecommunications companies in Canada – Bell Canada, Canadian National Railways, and the Canadian Pacific Railway – had recognized the potential inherent in air defence systems and their communications requirements. As a result, by early 1950 there was an active behind-the-scenes competition in Ottawa for communications work associated with the Pinetree Line.[19] Representatives from CP, CN, and Bell formed a committee to allocate communications circuits to each company – a committee, Lester recalled, that reached its decisions "depending on who had the facilities available or who was in the best position to build them."[20] While apparoches to politicians and senior military and government officials were intended to be covert, Lester's committee soon replaced the individual lobbying efforts of the telecommunications companies with a more concerted effort. Given the generally competitive relationship between the three companies in question, this co-operation was an interesting sideline to the continental defence projects of the 1950s and early 1960s, and would warrant further examination in its own right.

The most immediate goal would be to secure a private sector role in addressing the problem of communications in Labrador. For Pinetree communications outside of Ontario and Quebec, as well as for general command and administrative facilities in Canada, the armed forces leased commercial telephone and telegraph circuits. The exception was along the Labrador coast, an area where population was so sparse that commercial communications links were nonexistent.[21] Thus, an innovative solution would be need to facilitate communications between the nine radar stations of the Pinetree chain, stretching from St. John's to Stephenville and Gander, then along the Labrador coast, including Goose Bay and eventually reaching Frobisher Bay (now Iqaluit) on Baffin Island. Given the rough terrain, the shallow waters of the continental shelf, high tides in Frobisher Bay, heavy ice every winter, and a short construction season, a physical link using landlines and submarine cables was not a viable option. In northern areas, magnetic disturbances in the atmosphere cause short-wave radio blackouts, so other systems had to be used to provide voice and data communication links. In mid-1952, the Pinetree Project Office, responsible for the Pinetree Line, was working with DDP to come up with a suitable communications system.[22]

Bell Telephone and the Canadian military soon worked together to devise and construct a groundbreaking communications system to connect a series of isolated early warning radar stations. The Canadian government was not interested in establishing a Crown corporation to undertake such projects, and it had to reassure the Americans that Canadian interests could perform the task – an important consideration if the government wanted to extend preferential treatment to Canadian contractors and suppliers. At Lester's prodding, Bell offered its services to manage the programme, taking advantage of its organization and personnel with telecommunications experience.[23] Accordingly, the private company secured the management contract for project POLE VAULT.

DDP initially planned to update and adapt a tactical micro-wave system, which had been used for rearward Army communications late in the Second World War, to the Labrador situation. The original



communications equipment, which would have required twenty stations linking Gander to Goose Bay as the first phase of the network, was superseded by a tropospheric scatter system that offered much greater range between sites. While conventional microwave links had their range limited by the curvature of the earth, the tropospheric scatter system used a magnified signal strength to bounce microwaves off the troposphere to distant receiving stations. Large dish-type antennas (sometimes called "billboards") were necessary to send and receive the signal, but the greatly increased range (and corresponding reduction in the number of sites required) made their construction worthwhile. As one historian later put it, POLE VAULT "was a reliable, expensive, brute-force method of obtaining at least 70 voice channels."[24]

The first test signals were passed along the POLE VAULT system on 14 February 1955, but additional requirements from the USAF (including housing for personnel and increased signals capacity at the northern end of the network) set the overall completion date for 31 December 1956.[25] On a technical level, POLE VAULT represented the first large-scale implementation of tropospheric scatter links – an important communications technology that tied together the radar stations and military bases that began to dot the Arctic in the 1950s. Furthermore, POLE VAULT marked the substantive beginning of Bell's involvement with military communications projects in Canada. "Pole Vault was a bold and joyous adventure for the new Department," Lester described: "new technology, the first such system in the world, challenging climate and logistics, and most importantly, a clear mandate from the United States Air Force, via Canadian Commercial Corporation and the Department of Defence Production, to get on with the job with full responsibility and commensurate authority." The Mid-Canada Line project, which occupied most of Lester's time with Bell's Special Contract division from fall 1955 to mid-1957, "started in the same atmosphere, but it developed into a grim battle, or rather two battles": one to overcome climatic, transportation, design, material, and human resource problems, and the other over "direction, control and coordination of the project."[26]

First Plans, First Decisions

While the Pinetree Line was under construction, defence planners (particularly in the United States) remained concerned about expanding Soviet offensive capabilities, prompting recommendations to expand continental defences further north into Canadian territory. On the surface, the calculus for more northerly radar lines was simple: Canada, and especially northern Canada, lay astride many of the most obvious approach routes for aircraft flying from the Soviet Union to targets in southern Canada and the United States. The farther north that early warning radars could be placed, the greater the warning time that could be given to mobilize active air defences in the industrial and political heartland. Passive defences, which included air raid alerts and other civil defence measures, could also take advantage of the increased warning time.[27] The air bases of the United States Air Force's Strategic Air Command, which housed many of the bombers that were the primary means of delivering the United States' nuclear arsenal, would also benefit from increased warning in order to get their aircraft in the air before a Soviet attack destroyed them on the ground. Canada, in the words of one subsequent commentator, would become the "northern glacis" for continental defence.[28]

American studies and reports in the early 1950s weighed the costs and benefits of early warning radar systems, eventually concluding that technological innovation and the threat environment not only made such investments feasible but essential. The report from Project Charles in August 1951 underlined the value of early warning, but concluded that northern radar lines were not feasible (with little explanation of why). Some of its other recommendations, however, laid the groundwork for more robust air defences: most notably automated systems as part of SAGE (Semi-Automatic Ground Environment) and the creation of an air defence research institution, the Lincoln Laboratory, in late 1951.[29] Lincoln Labs, which was closely associated with the Massachussets Institute of Technology (MIT) and formed part of a burgeoning military-industrial-academic complex, revised assessments of the continental defence threat and advocated for a comprehensive radar chair spanning Arctic North America.[30] In the spring of 1952, Project East River promoted an outer warning network 2,000 miles from the continental limits of the United States,[31] prompting the formation of a Lincoln Laboratory Summer Study Group (composed primarily of scientists and engineers) to explore options that summer. It concluded that a successful Soviet attack on North America could inflict up to twenty million deaths.[32] "To stave off such a disaster," historian Joseph Jockel notes, "there was only one possible course of action. Echoing East River, the group called for the improvement of the national air defence system 'to the point where it can exact almost complete attrition against a very heavy attack.… *We believe that such a defense can be created*.' Essential to such an effort was early warning."[33]

While the Summer Study Group had focused on the creation of an Arctic-based DEW Line, the military arguments also bolstered the case for a Mid-Canada Line, and many resulting plans envisaged the construction of both lines.[34] By January 1953, the United States decided to forge ahead with plans for northern early warning systems and formally requested use of Canadian territory as part of experimental operations for what would ultimately become the DEW Line. As a condition of its acceptance in February, Ottawa insisted that a Canada-US Military Study Group (MSG) be created to study continental air defence. After receiving briefs from Canadian and American air defence commanders about the importance of an early warning line along the 55th parallel (the undertaking that would ultimately become the Mid-Canada Line), the MSG asked the Canada-US Scientific Advisory Team (CUSSAT) to carry out a study of the value of such a line. In its assessment, CUSSAT concluded that it would be a valuable undertaking.[35]

In August 1953 the Soviet Union tested a new and powerful nuclear device, which they claimed was a hydrogen bomb capable of being delivered by an aircraft. Although Western analysts soon determined from the analysis of airborne fallout that it was a "boosted" atomic bomb rather than a true hydrogen bomb,[36] this demonstration provoked concern that the Soviet Union had beaten the US to the creation of a practical hydrogen bomb[37] and sent tremors through the North American public, resurrecting public cries for better continental air defences.[38] Given the vastly increased destructive power of the weapon and the greater speed of the Soviet long-range bombers that carried it, continental defences would not only have to be more effective but warning timea would have to be reduced and air defences more capable for North America to withstand a Soviet attack.[39]

Subsequent American studies on continental defence assigned top priority to the building of the MCL. The Bull report (named after the study group chairman, Harold R. Bull, and endorsed in amended form as US National Security Council policy paper 159/4 on 24 September) recommended prompt construction of what it called the "Southern Canadian Line" – what later become the Mid-Canada Line.[40] The Cabinet Defence Committee acknowledged increased American pressure to act at its 6 October 1953 meeting,[41] and two days later the Military Study Group recommended "that there be established at the earliest practicable date an Early Warning Line located generally along the 55th parallel between Alaska and Newfoundland."[42] The Cabinet Defence Committee soon concurred that a Mid-Canada Line should be established, with the Canadian section of the MSG completing the selection and specifications for equipment, and the RCAF (in conjunction with the USAF) conducting a detailed survey of the proposed route and possible sites for its detecting equipment.[43] By assuming responsibility for the MCL and thus contributing to the continental defence effort, Canadian officials hoped to avoid sharing the costs of what proved to be a vastly more expensive Arctic system.

The Mid-Canada Line promised to be useful on various fronts. On the surface, it was an essential part of a network of radar lines that bolstered continental defences. As a project planned by Canadians, built using Canadian equipment, and operated entirely by Canadians, it avoided another influx of American personnel akin to the Pinetree Line experience and guaranteed that Canadian contractors would be awarded the construction work. Furthermore, the MCL provided a secure market for advanced technology designed and manufactured in Canada.[44] Finally, as a Canadian-financed project, the MCL helped limit Canada's financial commitments to continental defence while affirming its partnership.[45]

An Alternate Approach to Defence Construction

Shortly after the 3 November 1953 Cabinet Defence Committee meeting that endorsed the construction of an MCL along the 55th parallel, the Defence Research Board estimated that its proposed version of the line would cost $69.7 million to build. The RCAF had estimated another version at $85 million.[46] In light of the differences, the air force established a special projects directorate to select sites, determine the best means of access, and identify construction needs by 1 June 1954.[47] In the interim, the Associate Minister of National Defence directed the other services to assist the RCAF with this new undertaking.[48] The project's scale meant that the standard approach for the construction of defence infrastructure was not implemented. Officials felt that the unprecedented demands being placed on government and industry necessitated new partners and new approaches, so the Department of Defence Production turned to a management contractor which would assume responsibility for the overall supervision and coordination of the programme.[49]

In December 1953, C.D. Howe held initial discussions with T.C. Eadie, the President of Bell Telephone, indicating that he would ask the major Canadian telephone companies to design and build the MCL through the Trans Canada Telephone System (TCTS).[50] Made up of all of the major provincial and commercial telephone companies in the country, the TCTS had been created with the chief purpose of permitting the creation of an integrated and reliable transcontinental telephone system.[51] Experience in basic planning and systems engineering was essential, and the various provincial telephone companies that composed the TCTS could furnish requisite local knowledge. Accordingly, the Bell Telephone Company acted as the TCTS's project agent during the creation of the MCL, drawing on the personnel and experience of its Special Contract Division under Alex Lester. In addition to its own experience with communications, operations, and industrial relations, Bell also offered access to the Bell Telephone Laboratories in the United States and their deep experience with defence communications technology.[52]

The RCAF proposed to form a Systems Engineering Group (SEG) within the air force, with members from industry working alongside service personnel as required, to organize and plan for the project, deal with design and engineering concerns, and let contracts for specific engineering studies. Lester would later argue that the decision to create the SEG reflected the

RCAF's attempt to retain full responsibility for the basic design of the MCL, as well as the authority to monitor its construction.[53] Bell's representatives argued that the use of a SEG precluded the RCAF from accessing the full capabilities of the telecommunications industry. Representatives from various firms would only bring their own knowledge to the SEG, rather than the broader expertise of their companies as a whole.

As Lester indicates in his account, Bell preferred a prime contractor approach, with the company assuming full responsibility for meeting the RCAF's operational requirements. As with POLE VAULT, Bell would be responsible for development, engineering, and construction. By the end of a meeting on 30 December, Bell's representatives made a counter-proposal offering the services of Bell and the other six members of the TCTS as prime contractor. Personnel from the members of the TCTS and the electronic and construction industries would thereby form a special group to perform the task, and Bell would remain responsible for overall co-ordination of the programme even though it was intended that sub-contractors would be widely used.[54] This arrangement was apparently acceptable to the RCAF, although no formal agreement on the matter was reached at this time and sources vary about the RCAF's willingness to accept it.[55]

The RCAF ultimately agreed to use Bell as a prime contractor while also retaining the SEG, which would grow to thirty people (some of them senior engineers from the electronics industry) by April 1954.[56] The group's initial task was to determine project requirements and costs. Since the MCL would be part of an integrated continental air defence system, the RCAF consulted with its American counterparts on operational requirements, its end points, and the path it would take across Canada.[57] The first name assigned to this project was TAMARACK, but it changed in early 1954 to MONGOOSE after lax security compromised the original name.[58] By October of that year, MONGOOSE was itself abandoned and replaced by the more descriptive title of "Mid-Canada Line project."[59] The undertaking was to proceed in two phases: Phase I, including a technical study and report, and a cost estimate for the project, and Phase II, also known as the implementation phase, which would involve the creation of the system, and included engineering work, procurement, transportation, construction, and installation of the electronic equipment.[60]

The Mid-Canada Line would use Canadian technology and would be entirely Canadian operated, which in the federal government's view helped avoid problems with construction, supply, and sovereignty. The contentious issue of the nationality of contractors was also avoided – as a Canadian project on Canadian soil, the contractors and suppliers would naturally be Canadian.[61] Thus, on 25 June 1954, the Cabinet Defence Committee recommended:

> that an aircraft warning line in the vicinity of the 55th parallel of latitude from Hopedale in Labrador to the mountains on the B.C.-Alberta border be constructed by Canada at a cost estimated to be of the order of $120 million, the money to be provided from current appropriations for the Department of National Defence and the appropriations now contemplated for the next few years; it being understood that the construction of the section of the line from the B.C.-Alberta border to the Pacific Ocean would be considered at a later meeting following further studies.[62]

The proposed construction schedule would have the line operational by the end of 1957.[63]

In the meantime, the contract demand for Phase I of the MCL had been issued on 22 June. TCTS received a letter of intent three days later, which was replaced by a purchase order at the end of August.[64] This became a binding legal contract that, amongst other things, set out the responsibilities of the management contractor and the government agencies involved with the MCL. The SEG was designated the design authority, and the management contractor had to provide SEG with an acceptable implementation plan for the project, develop an overall schedule, perform surveys, determine site locations, and make the necessary tests of equipment, structures, or systems as required.[65] Accordingly, the RCAF retained considerable responsibility for the planning and supervision of the line's construction,[66] as Lester emphasized in his account.[67] The failure at this stage to produce a formal contract that clearly defined each agency's role and place in the undertaking would haunt the project, and, many would later argue, contributed to confusion, delays, and escalating costs.

The drive to complete the line as quickly as possible compounded these problems. In June 1954, the Chiefs of Staff Committee emphasized "the need for the speedy construction of the line. Intelligence estimates indicate that by 1956 the USSR will have the capability to launch air attacks against the North American continent. Although assurance must be made that the mid-Canada line [*sic*] is satisfactory when completed, every effort should be made to better its completion date of 1957."[68] The Cabinet Defence Committee noted that "the emergence of [thermonuclear weapons] meant that greatly reduced facilities would be required for a devastating attack on North America, and that, technically speaking, air defence was now an area problem rather than a simple point defence question. In this regard, the provision of the Mid-Canada and distant early warning lines were most useful."[69] Accelerated plans to have the line operational by the *beginning* of 1957[70] affected every element of the project.

Although operational requirements were not formalized until early 1955, pressure to meet this deadline meant that decisions about the location of MCL sites and the detection and communications requirements were made in the first half of 1954.[71] The initial selection of site locations was dependent on a thorough knowledge of the terrain through which the line would pass, and the creation of maps with a sufficient degree of accuracy for the project presented a major challenge in and of itself.[72] Surveying the MCL stretched Canada's mapping ability, necessitating a redrawing of national mapping programmes. 408 Squadron and civilian operators photographed a strip up to forty miles wide, from coast to coast, in the spring of 1954. Army and civilian cartographers required a year to create accurate contour maps for this entire strip, which allowed surveyors to determine potential sites for Doppler detection equipment.[73]

The Chiefs of Staff Committee discussed the changing plans for the MCL on 21 September 1954. Even at this date, the RCAF and Bell Canada articulated differing opinions about the method and timing for construction: the air force favoured the commencement of stockpiling in the

fall of 1954 prior to the selection of sites, while Bell wanted to wait until the details of the line had been determined and the final selection of its sites had been made. "These differences were being resolved," the minutes optimistically noted, "and in any event the line should be operative by December, 1956."[74]

While specialists identified the route, development of detection equipment continued apace. Four possible detection systems were evaluated, consisting either of variations on the Doppler detection equipment or combinations of the Doppler gear with other systems:

Mark I Doppler:	Two lines with stations 35 miles apart and 2 miles apart north south.
Mark II Doppler:	A single line with stations connected in a way that gave the same results as two lines of stations, supplemented by identification radars in heavy aerial traffic areas.
Composite Line	Mark II Doppler System with radios [radars] every 120 miles
Lincoln Composite System	Single line of radars with low level cover provided by Doppler system[75]

SEG initially recommended the use of the Mark II detection equipment, and secured consent from the Chiefs of Staff in September 1954.[76] Problems with its development, however, meant that the Mark I equipment (an earlier version using two separate detection lines) was ultimately chosen in January 1955.[77] This meant that sites initially selected for Mark II Doppler detection systems were not suitable for the Mark I equipment, so new sites had to be chosen[78] – again delaying the project and driving up costs.

Final decisions on equipment and its deployment relied on the outcomes of full-scale evaluations. Tests of the prototype equipment began in the summer of 1954, and the final tests of equipment and operations continued at a test line in the Ottawa Valley through September 1955.[79] Not until 29 June 1956 was the final System Specification covering all the RCAF's technical and physical requirements issued, and by that time much of the construction was nearing completion. In many ways, the specifications were more a record of what had been built rather than what was required.[80] Much of the planning, in other words, was done "on the run."

The confused lines of responsibilities and command over project management would inhibit efficient planning and construction. The TCTS, as Management Contractor, was responsible for co-ordinating the engineering, construction, and installation of the system,[81] with the Bell Telephone Company of Canada as its project agent. In his memoirs, Lester explains (and laments) why DDP insisted on control of procurement, and why TCTS accepted these conditions and continued with the project. While admitting he was not "privy to the inner councils of Ottawa officialdom," Lester argues that "the change must have been initiated, or at least endorsed, at the policy level in Government," and suggested three reasons for the change: political and commercial considerations, a Canadian tendency to consider that large projects should be undertaken through government or government agencies, and concerns that TCTS might be unable to accomplish its task without government direction.[82] DDP's direct involvement in procurement would allow Ottawa to take political credit for the awarding of contracts to influential construction firms, and the use of government agencies may have offered the promise of greater flexibility in the awarding of contracts. Lester notes that Bell's purchase of "virtually all its telecommunications equipment from Northern Electric may well have influenced both the electronics manufacturers and Government towards DDP direction of contracts."[83] DDP's efforts as a procurement agency allowed Ottawa to extract maximum benefits from the Mid-Canada Line for Canadian electronics firms, rather than awarding the work to a single firm (Bell) with strong corporate ties to the United States.[84]

Lester's second argument centers on his observation of the greater Canadian proclivity towards the use of government or government-owned agencies, such as Crown corporations, for the implementation of large projects, particularly those where a connection to government exists. "In my opinion," he argues, "our Government and civil service people, and perhaps the public generally, have much less faith than their opposite numbers in the U.S.A. in the capacity of private enterprise, and the desirability of giving private industry a free rein to do a job."[85] Howe, he argues, had wanted the project implementation co-ordinated and pushed by the telephone companies. The unspoken implication is that the decision to revise the arrangements for the MCL was made somewhere below ministerial level. In retrospect, Lester's comments on private industry seem somewhat disingenuous, given the monopolistic tendencies of the TCTS, its member companies, and their counterpart in the United States, the Bell System, but his observation about Canadian tendencies towards the use of government agencies, including Crown corporations, to accomplish major tasks, is worthwhile and consistent with broader observations of the issue.

Lester also cites concerns that Bell, acting as project agent for the TCTS, might not be able to accomplish the task without considerable government involvement.[86] Bell was a recognized telecommunications expert but there were doubts about its construction and transportation capabilities, even though it was currently undertaking the POLE VAULT project along the Labrador coast. While it may be reasonable to assert, as Lester does, that Bell's ability in this undertaking "did not register fully" with people in Ottawa, the comparison is forced. POLE VAULT involved the installation of additional equipment at existing Pinetree line sites along the Newfoundland and Labrador coastline. Ocean access to these sites, although often difficult and limited by the northern shipping season, made the task of establishing construction facilities and supplying and provisioning the project considerably easier than the supplying of most of the MCL sites.

Lester argues in *Special Contract* that there were two reasons for the TCTS to agree to the conditions and go ahead: "the feeling that the job was vital to the national interest, and, probably persuaded by Mr. Howe's initial approach, that the telephone companies might be the only nationwide private agency capable of its implementation. As in the case of Pole Vault, there was also a strong element of duty as a Canadian corporate citizen." Pride in Bell's accomplishments and capabilities also factored into its decision.[87]

Rising Costs, Growing Uncertainties: Building the Mid-Canada Line

If reaching an agreement for the implementation of the Mid-Canada Line was challenging, its actual construction was a problematic undertaking fraught with challenges that included climate and terrain, organizational problems, and conflicts between the agencies involved. As a result of these problems, costs increased above initial estimates and the ability of the project to meet its deadline of January 1957 became increasingly doubtful. Construction work for the Mid-Canada Line was in some ways more difficult than work in the far north because of variable weather and surface conditions, especially muskeg, that posed considerable obstacles to summertime surface transportation. Spring thaws and autumn freeze-ups also prevented surface transportation for a couple of months every year, and at this point, Canadians did not yet possess the experience or equipment for such work.[88] Building the Mid-Canada Line, however, would provide valuable lessons in these fields.[89]

The decision in January 1955 to revert from Mark II to Mark I Doppler equipment led to changes in the sites of all the DDS in the western section and brought about considerable modifications to tractor train activity, which had already been scheduled to deliver construction materials to the initial DDS sites.[90] The Defence Construction Limited (DCL) annual report for 1955-56 briefly described the project, noting that:

> transportation of men, materials and equipment presented a difficult problem. Most of the winter transportation was provided by tractor trains, operating on a scale never before undertaken in Canada. These were supplemented by helicopters and fixed wing aircraft. The results were satisfactory and work has been progressing faster than was estimated a year ago. About one third of the required construction has been put in place. It is estimated that construction work will be sufficiently advanced to permit operation of the communication system when required.[91]

By early 1955, construction had begun on a runway at Great Whale River to serve the Sector Control Station and the local construction effort, while airlift and tractor train operations began to lay down caches of fuel in Labrador, Quebec, Ontario, and Manitoba.[92] Sites for all of the Sector Control Stations were chosen by June, but the change in detection equipment required a new survey and selection effort for the Doppler Detection Station locations that wound up taking rather longer. A series of aerial operations during the year used RCAF and USAF helicopters to survey site locations along the line.[93] Valuable experience in helicopter operations that would stand the RCAF and commercial helicopter operators in good stead in upcoming years was gained during these operations. This had, in fact, been one of their intended functions. The operations were largely successful and with the exception of one crash were completed largely without serious mishaps.[94] In years to come, firms like Okanagan Helicopters would benefit from the continued need for helicopters during

the Mid-Canada Line's operation and maintenance, and experience gained in these fields would be applied to other undertakings.

Doubts about Bell's ability to meet estimates and deadlines arose in the first half of 1955, when DCL personnel expressed concern about increasing costs and unrealistic implementation plans. TCTS's implementation plan was bluntly described as "a list of good intentions…with very little detail to show the actual course of action which is contemplated to get the work going."[95] The threat of dramatically increased costs to complete the project on schedule had also been raised at a Cabinet Defence Committee meeting in early March 1955.[96] These comments set out clearly the emerging conflicts between costs and deadlines. In the end, neither costs nor deadlines won out.[97]

These concerns were symptomatic of underlying problems. By June 1955, deteriorating relations between the various agencies involved in the project prompted a meeting between Bell and DDP[98] which yielded a revised description of the role of Bell as Management Contractor. The results were never officially promulgated, however, nor were the purchase order or contract document amended during the construction phase to reflect these changes.[99] While Alex Lester had prepared and circulated

among his staff a memorandum explaining the new arrangements, Assistant Deputy Minister of Defence Production W.H. Huck did not circulate copies to other government agencies involved in the project (despite Lester's request that he do so). The RCAF later argued that Huck's department believed Bell had already conceded too much to the air force, and that matters in the field had improved to the extent that they could carry on without any official notification of changes in project control.[100] The confused and unclear division of authorities and responsibilities had already caused problems, however, and DDP's questionable decision not to promulgate information about the revised agreements only aggravated the situation.

Work on the Mid-Canada Line continued to ramp up in 1956.[101] The air transport requirements were substantial. Fifty chartered fixed-wing aircraft and forty-three helicopters from the Canadian and US military and from civilian operators supported operations during that year.[102] Surface transportation requirements were also significant. That year's tractor train operation was the largest undertaken to date and supported the construction of the MCL west of Hudson Bay.[103] Bureaucratic logjams continued to plague the project, however, and throughout 1956 DCL and DND personnel worried about deadlines and cost targets.[104] Claude Maxwell, DCL's assistant chief engineer, noted that Bell's policy seemed to be to slow down work in order to reduce costs and because the buildings would be ready before the electronics. He pointed to delays in the transportation of materials to the construction sites which he attributed in part to Bell's ignoring expert advice and criticized Bell's failure to use the "know how" of the prime contractors. Maxwell concluded that:

> we feel that there is an attitude of complacency on the part of the MC and a tendency to over-exaggerate the amount of progress that has been made just because the shells of several buildings have been erected. They seem to consider this a finished product. Actually the major part of the work is in the interior and this is far behind, although, in our opinion, the work accomplished to date falls far short of what we consider should have been accomplished and costs on all sites are mounting. It has also been brought to our attention that the staff maintained by the MC on practically all sites is far in excess of any organization which DCL would have provided, and the salaries being paid, taking into consideration overtime and allowances, appear to us to be very high.[105]

The Systems Engineering Group dealt with similar concerns and criticisms, identifying poor coordination in cost accounting and control as yet another consequence of the ambiguous authority and poor communications.

That fall, government officials recognized that completing the MCL would necessitate a significant influx of additional funds.[106] Bell's revised estimate in September 1956, which raised the total from $169 million to $179 million owing to construction costs, validated many of their concerns. In response, the RCAF and the MCL Executive Committee requested a complete review of the project's costs, and the resultant estimate submitted in early October projected a $206 million price tag. TCTS requested more information, and on 31 October Bell produced an estimate of $203.4 million for construction and $6.4 million for interim maintenance until the line was completed.[107]

As 1956 drew to a close, concerns about Mid-Canada cost overruns continued to grow.[108] In a mid-January letter to R.G. Johnson, the president of DCL, Lester attempted to allay concerns about construction costs, suggesting that disconcerting figures were "tentative" and "had not been assessed in detail either by your people or our own." DCL officials were dismissive, adding in the margins of Lester's letter that it was "absolute twaddle" and suggesting that it showed "how far [Bell representatives'] heads are in the sand."[109]

Looking back on the project, Lester noted that "for whatever reason, we stayed with the overall figure of $169 million too long," although at the time he argued that a contributing factor was the RCAF's delay in supplying complete building plans, which were not available until the middle of 1956.[110] Politicians, especially C.D. Howe, were concerned that the costs not increase above $203 million. Lester later noted that "the emphasis had obviously changed from doing everything possible to meet the target date, to making sure that costs were kept within limits."[111] In the struggle between the control of costs and the meeting of deadlines, the former was gaining the upper hand.

The initial deadline for the Mid-Canada Line to begin operations had passed. While the line west of Hudson Bay and parts to its east went into operation in January 1957, the line as a whole was certainly not ready. By now, it was both late *and* over budget. When revised estimates from Bell suggested once again that available funds would not be sufficient, cost controls began to win out over the drive to meet deadlines. As part of these cost-control efforts, RCAF, Bell, and DCL representatives visited all of the major sites along the line later that month and arranged to defer work on all non-essential components. According to a 1959 DND report, the RCAF's goal was to reduce Bell's commitment to the project and to avoid paying additional overhead costs that would result from the company's continued involvement. Remaining construction was dealt with by fixed price contracts supervision by DCL or in some cases by special RCAF Construction and Maintenance Units (CMUs). Faced with an undertaking that had exceeded its budget and had not met its deadline for completion, the RCAF sought an expedient solution that would control costs and yield a finished, functioning product as soon as possible.

Lester highlighted that the air force had always resented Bell's position as management contactor. By progressively excluding Bell at this stage, the RCAF reasserted its control over the project. The air force provided more engineers to overcome remaining problems at various sites, and interim and final take-over procedures were established to allow the government to accept individual elements of the line from contractors as they were completed beginning in the fall of 1956. [112]

The western half of the Mid-Canada Line was finished in January 1957, and the remainder later in the year.[113] On 1 January 1958, the line became fully operational – a year behind the desired deadline but in keeping with the original target date. At its peak, it consisted of eight Sector Control Stations and 90 unattended Doppler Detection Stations. Its final estimated costs, as noted in the table below, were in the vicinity of $225 million, with some $15 million to cover the costs of RCAF helicopters alone.[114] As of the end of September 1959, the revised value of the construction contracts – as opposed to transportation or electronics costs – was $95,562,623.17.[115]

The MCL as finally completed consisted of eight staffed Sector Control Stations spaced some 400 miles apart,[116] with ninety unattended Doppler Detection Stations spaced some 30 miles apart placed in between the SCS. Locations for the DDS were chosen in order to meet requirements for the Doppler detection system and the microwave communications linking the various sites. The microwave communications system carried data from the Doppler equipment, telemetry data, and voice communications between the SCS sites. The detection equipment was set up as two separate lines, and the final design involved the linking of alternate stations by the Doppler equipment, resulting in two detection lines some 3 to 6 miles apart in a north-south direction, capable of detecting aircraft flying as high as 65,000 feet or as low as 200 feet.[117] Conventional air surveillance radar was also installed at three SCS (Knob Lake, Cranberry Portage, and Stoney Mountain) in order to better identify heavier civilian air traffic through their areas of responsibility.[118] The eight sites varied in cost from $7 million to $24 million each, and one of the sites required the transportation of 10,000 tons of materials over some 400 miles by winter tractor train.[119] Line Clearance Airdromes for local unscheduled bush flights crossing the line were built in western Canada at Fort McMurray, Buffalo Narrows, and Lac Laronge.[120]

Rearward communications links for the MCL were provided from Knob Lake, Winisk, Cranberry Portage, and Dawson Creek. Three such links were provided by commercial carriers, while Winisk, far from commercial facilities, required the construction of a tropospheric scatter system with five installations. First used on a large scale in the POLE VAULT project along the Labrador coast, tropospheric scatter used powerful microwave communications signals bounced off the troposphere, a layer in the atmosphere, to points a considerable distance away.[121] Stretching across

James Bay and linking it to the SCS at Great Whale River, the tropo scatter system then ran south down the west coast of James Bay and connected with Bell Telephone's microwave system at Ramore, Ontario, which then provided a connection to the ADCOM system at North Bay, Ontario.[122] Direct links rearward from the DEW Line were possible through the POLE VAULT system along the Labrador coast in the east and by ionospheric scatter (a longer range version of tropospheric scatter) from Dawson Creek, Stoney Mountain, and Bird in the west.[123] While the construction of the links was an American responsibility, Bell supervised the construction of the necessary facilities at the SCS sites.[124]

These Sector Control Stations were fully equipped bases with permanent staffs of some 150 personnel. In addition to receiving, interpreting, and passing signals from the MCL to command and control centres further south, the SCS personnel were also responsible for maintaining the DDS in their station's area of responsibility. Each SCS was largely self-sustaining in terms of equipment, food, and fuel stores to meet these duties, its own equipment needs, and the requirements of its personnel.[125] The more numerous DDS sites were designed for unattended operation, but included basic facilities for visiting maintenance crews and for the personnel necessary for the line's initial set up operations in addition to space for the detection equipment and the diesel generators. Because of variations in the height of terrain and the need for the antennae of the detection and communications equipment to be directly visible to each other, the towers for the Doppler detection and microwave communication equipment at the DDS and SCS ranged in height from some 50 feet to 350 feet. They were the most vulnerable to adverse weather of the MCL's facilities, and as such were designed to withstand winds of 120 miles per hour even when encased in a layer of two inches of ice.[126]

In the Public Eye

The completed Mid-Canada Line was a tangible expression of Canadian Cold War concerns. Stretching from the Rocky Mountains in the west to the Labrador coast in the east, the project had used Canadian technology and Canadian private and public sector agencies to erect an important element of the North American air defence network. Driven by apprehensions about Soviet capabilities and intentions – particularly with the advent of the hydrogen bomb and more capable long-range bombers – the MCL was also a response to concerns about American designs for continental defence and their implications for Canada. The MCL allowed Canada to be seen to be "doing its part" in defending the continent while avoiding what the Canadian government feared would be the significant financial entanglements of a joint Canada-US DEW Line or US involvement in the Mid-Canada Line. By "going it alone" on the MCL, Canada also guaranteed that the industrial and commercial benefits of the undertaking would go to Canadian firms; this would not be the case in a joint undertaking. In part, the government's decision appears to have been driven by the early, optimistic cost estimates – at the time of initial Cabinet approval in June 1954, the figure had been some $120 million. By the time the MCL was completed some three years later, however, that figure had almost doubled. While the Mid-Canada Line had thus served a number of Ottawa's economic, industrial, and commercial policy goals and objectives, it was no longer quite the bargain it had seemed before.

The Mid-Canada Line's problems and cost overruns attracted critical public attention. Lester notes in his memoirs that of the articles on the MCL, "the most critical, though badly distorted as to fact, was the two-part series by Arnold Edinborough in Toronto *Saturday Night* in March 1959.

The burden of his criticism was waste, confusion of command, and frustration of Government Departments, contractors, and of Special Contract itself."[127] Edinborough's primary argument was that at least thirty million dollars could have been saved in the construction of the MCL. He laid much of the blame for these overruns on the confused and conflicted authorities assigned to the agencies – both governmental and private – involved in the process.[128] The construction of the line, he argued, was far more expensive than it need have been, and the blame lay with "the lack of proper supervision occasioned by the peculiar fashion in which authority for construction of the line had been apportioned."[129]

While the absence of a formal contract document until late in the project was one of Edinborough's explanations for the problems on the line, the confusing administrative structure and the involvement of a large number of departments and agencies was also blamed, and he referred to "inter-departmental muddle and wasteful animosity…which led to tape recordings of executive committee meetings being wiped clean by the secretaries after the edited version of what had gone on had been written."[130] Edinborough's final criticism was that the expenditure of money on the MCL had apparently left Canada without the money for interceptors – he pointed to the Avro Arrow, only recently cancelled – or the civil defence network that could be alerted by the Distant Early Warning, Mid-Canada, and Pinetree Lines.[131] In some ways, his last point was wishful thinking. By the mid-1950s, even the Canadian government conceded that the primary purpose of the radar lines was to alert the USAF's Strategic Air Command so that its bombers would not be caught on the ground by a Soviet attack. Defending against any such attack took a back seat to maintaining the means to deliver US nuclear retaliation.[132]

Robert Collins, a later commentator on Bell and the MCL, notes that Edinborough's article was based on a memorandum from an RCAF advisor with added marginal notes from Lester, which included a claim that "this whole report can be construed as a monument of Air Force impertinence and harmful interference." Collins also argues that although Edinborough's articles "lacked a full appreciation of the northern conditions, and leaned heavily upon one set of allegations (many of which were later refuted) he made a valid point: haste and divided authority had caused an estimated $30 million worth of waste."[133] The confused division of authorities and responsibilities, and the accelerated deadline for the project, had contributed to delays and cost overruns. Edinborough also highlights the acrimonious relationship between the various agencies, and while not explicitly describing it as such, notes the organizational cultures and the problems they caused.

In drawing public attention to these issues, Edinborough's articles produced a small flurry of inter-departmental correspondence.[134] Ultimately, Minister of Defence Production Raymond O'Hurley delivered a statement to the House of Commons supply committee in July 1959 that, while factually accurate, downplayed many of the problems and points of conflict that had plagued the project.[135]

Taking Stock of the MCL Project

Faced with the delays and cost overruns of the Mid-Canada Line, the agencies involved, both public and private, sought explanations. In his statement to the parliamentary committee on the construction effort and associated problems, O'Hurley attributing the increased costs to various factors, including additional buildings (from 120 to 185), increased size of buildings (cubic content increased by 31%), two additional rearward tropospheric scatter communications sites, three additional Doppler Detection Sites, harbour work at Winisk, additional airstrips, fire losses at Knob Lake, extra foundations and access roads. The increased number of sites required a corresponding increase in towers, electronic equipment, generators, and transportation costs. The original estimates also did not include many of the transportation costs incurred by the project, nor did they include the equipment to be left on site in order to allow the RCAF to carry out maintenance or the two years' worth of spares also required. Poor shipping conditions in Hudson Bay and a record cold winter in Eastern Canada were also blamed for the rising costs. The "crash" nature of the operation, O'Hurley argued, also contributed to increased costs.[136]

The reversion from Mark II to Mark I Doppler detection equipment had led to requirements for more Doppler Detection Sites, which had undoubtedly led to increased costs. Transportation was another major component of MCL expenditures, eventually amounting to some $42 million of the line's estimated $228 million total cost. For many sites, supplies had to be flown in to frozen lakes in wintertime, or delivered by tractor trains over hundreds of kilometers. Fuel for the eastern section of the line was delivered by train to Knob Lake, then in the fuel tanks of aircraft to the various campsites where it was siphoned out into drums for storage – a

necessary and expedient but decidedly inefficient measure. Shipping conditions in Hudson Bay were also problematic, where wintertime conditions trapped supply ships in the ice; a ship was also crushed and sunk in James Bay one winter.[137] As O'Hurley noted, early estimates had also not included significant aspects of the construction effort, which only served to make the final cost overruns seem even larger. While the factors he set out certainly contributed to delays and increased costs, his explanation omitted and obscured some of the more fundamental problems that plagued the project. The planning and construction of the Mid-Canada Line suffered from insufficient clarity in the division of responsibilities and authorities between the government and private agencies involved, was hindered by competing organizational cultures, lacked adequate project management procedures, and was affected by the pressures on continental defence efforts the Cold War that turned it into a "crash" project.

Almost from its outset, the Mid-Canada Line construction effort suffered from insufficient clarity of responsibility and authority. All of the agencies with significant involvement in the project – DDP, the RCAF, Bell, and DCL – acknowledged this confused organization. O'Hurley's 1959 report, for instance, explained that the precise division of responsibilities took some time to determine because the initial plans had assigned almost complete control to the management contractor, but the later revisions had divided it between the four agencies.[138] The SEG was less sanguine about the allocation of authorities and responsibilities,[139] but after reassessing the official paperwork did not concur with the RCAF's then-current negative conclusion about the management contractor, which he argued, arose mainly out of hindsight. Instead, the author reached the more positive conclusion that "any agency heading the project, distinguished by whatever

Table 1: Mid-Canada Line Cost Estimates, 1952-1960[140]

Date of Estimate	Source of Estimate	Amount
1 December 1952	DRB Report #100/RCAF	$85.5 million
17 November 1953	DRB Report #101	$69.7 million
30 June 1954	Cabinet approval	$120 million
9 June 1955	TB Minute 487704	$170 million
Nov/Dec 1956	TB approval	$204 million
May 1957	TB Minute 516986	$239,782,750
28 Feb 1959	DND report	$224,566,830
28 March 1960	Ministerial statement	$227,718,302

name, should have been accorded facilities permitting control of operation within clearly defined limits of authority and responsibility." In the case of the MCL, "the Bell Telephone Company, as the Management Contractor, tried to carry out their assignment within the most nebulous terms of reference"[141] and no formal contract document to clarify respective roles.[142] Professional relationships were affected, and the personality clashes that emerged led to the conclusion that the task would have been better handled without TCTS as management contractor. SEG also criticized DND's administrative control, claiming that RCAF reports and recommendations – including those from SEG itself – had frequently been ignored or put aside in favour of their counterparts from Bell.[143] "No criticism is directed towards the MC for pressing his point to carry out his duties as he saw them," the SEG digest concluded. "Too often, however, personnel appointed by a particular department to settle controversial issues had neither the qualifications nor experience to do so. In so many of these cases, decisions were made on the basis of "who was right" rather than "what was right."[144]

Alex Lester held similar opinions about the effect of strained interpersonal relationships and competing organizational cultures on the project. In his assessment, the MCL was a difficult task in which 35% of his time was spent in "warding off government people" and 65% in accomplishing his task.[145] He disagreed that the delay in securing a formal contract caused construction problems, arguing instead that the contractual terms themselves were to blame.[146] Furthermore, if the Mid-Canada Line construction effort suffered from the unclear division of authorities and responsibilities between the agencies involved, it also encountered problems due to the disjunctures and clashes between organizational cultures of those agencies. While DDP, the RCAF, and DCL had gained experience in working together as a result of the Accelerated Defence Programme, the introduction of the TCTS and its agent, Bell, complicated the situation.[147] Government agencies now had to deal with a private sector firm that was given considerable say in planning and building the MCL. Lester insists that the RCAF's Construction Engineering section wanted to carry out the full job themselves, but the government decided otherwise, which meant that "they were in the frustrating position of being on the sidelines of this, the biggest post war construction job the Air Force had tackled."[148] By contrast, Bell personnel wanted to demonstrate that they could do the job themselves, and tended to sideline air force personnel as a result. Lester admitted that this situation may have been unavoidable, but he conceded that "a greater degree of diplomacy could well have been shown by our people."[149]

For its part, the RCAF leveled accusations against Bell that it failed to show sufficient leadership or initiative, that it was not sufficiently flexible in dealing with and accepting RCAF requirements and suggestions, and that it established poor relations with the RCAF and other government agencies.[150] Predictably, Lester and other Bell representatives disagreed. According to notes kept by Lester, at a September 1957 meeting, DCL president R.G. Johnson commented "on the rigidity of attitude in our construction organization, and not adequate use of resources of construction contractors."[151]

The Department of Defence Production had broader criticisms of Bell, voicing at a 16 September 1957 meeting that the private company had contributed nothing to the management of the contract, had done nothing to save the taxpayer money, and had done little or nothing to expedite the project. Lester dismissed these charges, presenting his own criticisms of government actions in reply.[152] Lester contended that Bell had brought a team of skilled engineers and managers to the task, with previous experience on defence work through the POLE VAULT project that had garnered them commendations for efficiency and timeliness from senior USAF officers.[153] Furthermore, Lester attributed "a fair part" of the difficulty encountered in the building of the MCL to "a strong trend towards magnifying minutiae" on the part of DDP personnel, along with the atypical nature of the project.[154]

Subsequent commentators also highlighted problems with organizational cultures in blaming the overly complicated government procedures for cost overruns. Furthermore, the Mid-Canada Line may have been built to too high a standard.[155] At a time when defence expenditures were at a postwar high, the possibility that the line was overbuilt should not be surprising – limits on defence spending were not imposed until the late 1950s. Before then, the Accelerated Defence Programme and the funding that followed allowed the military to procure infrastructure and equipment on a scale not seen since the Second World War. As Minister of Defence Production C.D. Howe notoriously informed Parliament in 1952, "if the army decides they want a gold-plated piano, and they send along a requisition accompanied by a certificate of encumbrance, we buy the gold-plated piano."[156]

The importance of planning and scheduling for a large-scale, complex project like the Mid-Canada Line cannot be underestimated, and some of the criticisms levied against Bell included accusations that the company had failed to provide for "slippage" in the delivery of supplies when it put together its construction timetables, and that when "slippage" occurred the consequences were serious.[157] Bell, on the other hand, criticized "the Government people" for failing to make use of or refer to its 1955 implementation plan, which was received with mixed reactions. Lester also noted that the corporation had not set up or continuously updated a master plan. Instead, while a general framework was maintained for reference, detailed plans – which changed constantly with weather, delays in delivery of materials and plans, etc. – were set up for various elements of the job, while key dates were watched in an effort to ensure that they were met.[158] The absence of more capable project management techniques, coupled with Bell's failure to keep an up-to-date master plan, also contributed to the problems experienced in building the MCL.

The haste with which the Mid-Canada Line was undertaken also contributed significantly to its delays and cost overruns. While the line had originally been scheduled to begin operation by the end of 1957, the decision in June 1954 to move the deadline forward a year had profound and lasting consequences.[159] Not only did the original programme of development, testing, and construction have to be condensed, but the shortened schedule led to substantial equipment changes. The delay in selecting the detection equipment and determining its appropriate spacing reverberated through the project, leaving precious little time to meet the January 1957 deadline.

The hastened schedule for the completion of the MCL also acted synergistically with the challenges of transportation and construction in a northern environment. Opportunities for the transportation of supplies, construction materials, and equipment were constrained by the spring thaw or fall freeze that prevented both ocean and tractor train operations, often leaving airlift as the only option. While air transportation was widely used for the construction effort, particularly in the mountainous terrain east of Hudson Bay, the compressed schedule for the MCL meant that any significant interruption of transportation or construction – epitomized by the range of problems suffered at the Sector Control Station at Winisk – would create a situation where only expensive measures (particularly the use of air transport on a much larger scale than originally planned) could rescue the situation.[160]

The End of the Line

The use of civilian contractors for the operation and maintenance of the line represented yet a sensible and pragmatic element of the Mid-Canada Line project. At an early stage in construction, the military and government decided that while operation and control of the line, which included the identification and control of aircraft, the assessment of alarms, and the issuing of warnings, should be a military responsibility, the service, maintenance, and logistics of the line should be undertaken by civilian contractors in order to relieve the RCAF of administrative duties and to avoid having to increase its personnel ceilings.[161] The TCTS and Canadian Marconi were awarded the initial operation and maintenance contracts, but TCTS was not interested in the contract after the initial two-year period ended on 31 March 1959.[162] Bell's area of responsibility on the line was subsequently taken over by Canadian Aviation Electronics (CAE), which had apparently also been involved in MCL maintenance work since 1957.[163]

By January 1961 some of the Mid-Canada Line's equipment was being removed as surplus to operational requirements. Search radars used to monitor civilian air traffic crossing the line had been removed from the Sector Control Stations at Knob Lake, Cranberry Portage, and Stoney

Mountain.[164] The warning time provided by the MCL shrank as aircraft speeds increased, and in a time of limited defence budgets it became harder to justify the annual $15 million costs to operate it.[165] Furthermore, the successful Soviet testing of an intercontinental ballistic missile (ICBM) in late 1957 (which the line could not detect) called into question the seriousness of the Soviet bomber threat compared to other strategic delivery systems.[166] Parts of the eastern and western extensions of the MCL were closed in early 1964, including the SCS at Bird, Cranberry Portage, Stoney Mountain, and Dawson Creek, while the western DDS and a few eastern DDS were also shut down. The remainder of the line was closed in April 1965.[167] With the exception of some facilities at a few Sector Control Stations, the Mid-Canada Line was abandoned in place. The Doppler masts were toppled to remove the danger to aircraft, while the individual detection stations were padlocked and left to the bush and muskeg.[168] In the years that followed, the Mid-Canada Line largely disappeared from Canadian public awareness, although more recently attention has turned to addressing its toxic legacy and particularly its impacts on First Nations. In recent years, remediation efforts have targeted several sites, especially in the James Bay area.[169]

Endnotes

[1] This introduction is largely derived from Jeff Noakes, "Under the Radar: Defence Construction Limited and Military Infrastructure in Canada, 1950-1965" (unpublished Ph.D. dissertation, Department of History, Carleton University, Ottawa, 2005).

[2] Cabinet Conclusions, 30 June 1954, 3, Library and Archives Canada (hereafter LAC), RG2, series A-5-a, vol. 2655.

[3] The Doppler detection system used the differences in frequency between the signals sent directly from one transmitter to another and those that were reflected from a contact passing between those two stations to detect the contact's passage. James Rennie Whitehead, a scientist at McGill who worked on the development of the equipment, later described the principle as follows: "When you receive broadcast TV and an aircraft flies across the line between the TV transmitter and your receiver, the signal fades in and out in a regular way. This is due to the waves reflected from the moving aircraft having a slightly different frequency from those

that go directly, because of the Doppler effect. At the receiver the waves reflected from the aircraft interfere with the direct waves to produce the pulsation that you see. The McGill fence used a refined version of this phenomenon in which the circuits were designed to enhance this effect rather than the transmitted data. Conventional Doppler radars have the transmitter and receiver in the same location. Ours was called 'double' because the transmitter and receiver were at opposite ends of each link." James Rennie Whitehead, *Radar to the Future*, Chapter 7, http://www.whitehead-family.ca/drrennie/chap7.html, last accessed 12 February 2019.

4 The "McGill Fence" moniker seems to have been in use by 1951. A.G. Lester, *Special Contract: A Story of Defence Communications in Canada*, Canada, Department of National Defence, Directorate of History and Heritage (hereafter DHH), 78/512, 50 (please note that citations in this preface are to the copy on file at DHH, not the version published in this book); DND, "History of the Mid-Canada Line," 1959, 2, DHH 181.009 (D266); B. Bruce-Briggs, *The Shield of Faith: A Chronicle of Strategic Defense from Zeppelins to Star Wars* (New York: Simon & Schuster, 1988), 75. Despite its "tripwire" nature, however, the MCL included – or at least was originally intended to include – facilities for the identification and control of interceptor aircraft. Minutes of the 580th meeting of the Chiefs of Staff Committee, 30 May 1955, 3, DHH 73/1223, series 3, box 62, file 1308A.

5 See, for instance, D.H. Thorne, "The Mid-Canada Line, 1958-1965," *Communications and Electronics Newsletter*, 1982/1, 39-52; NBC Group, *A History of the Air Defence of Canada, 1948-1997*, (Ottawa: 71 Film Canada, 1997), 35-38; Larry Milberry, *Sixty Years: The RCAF and CF Air Command, 1924-1984*, (Toronto: CANAV Books, 1984), 294-299.

6 Joseph Jockel, *No Boundaries Upstairs: Canada, the United States, and the Origins of North American Air Defence, 1945-1958* (Vancouver, UBC Press, 1987); NBC Group, *A History of the Air Defence of Canada, 1948-1997*; Andrew Richter, *Avoiding Armageddon: Canadian Military Strategy and Nuclear Weapons, 1950-63* (Vancouver: UBC Press, 2002).

7 Rens' *The Invisible Empire* provides an interesting and useful account of the emergence of a "military-telephone complex," but its discussion of the Mid-Canada Line is often inaccurate. Incorrect dates – including that for the beginning of construction – are provided, DCL is described as a Crown corporation created solely for the construction of the MCL and given responsibility for supplies, while the Department of Defence Production, which *was* the agency responsible for supplies and other procurement functions, is completely absent. Jean-Guy Rens,

The Invisible Empire: A History of the Telecommunications Industry in Canada, trans. Käthe Roth (Montreal & Kingston: McGill-Queen's University Press, 2001), 227-233. Robert Collins' earlier *A Voice From Afar: The History of Telecommunications in Canada*, (Toronto: McGraw-Hill Ryerson, 1977), while offering a more grounded description, provides little background on Bell's involvement with the Canadian military in this era.

8 Systems Engineering Group (hereafter SEG), "A Digest on the Building of the Mid-Canada Line," 1959, 1-2, DHH 181.009 (D266).

9 On the ambitious Air Warning and Air Interceptor plan, see Jockel, *No Boundaries Upstairs*, 17-20; Kenneth Schaffel, *The Emerging Shield: The Air Force and the Evolution of Continental Air Defense, 1945-1960* (Air Force History Support Office, 1991), 130; and Steve Zaloga, *The Kremlin's Nuclear Sword: The Rise and Fall of Russia's Strategic Nuclear Forces, 1945-2000*, (Washington, DC: Smithsonian Institution Press, 2002), 12-16.

10 See, for example, Michael S. Goodman, *Spying on the Nuclear Bear: Anglo-American Intelligence and the Soviet Bomb* (Chicago: Stanford University Press, 2007), 45-46.

11 Memorandum by Chief of Staff of the U.S. Air Force for Joint Chiefs of Staff on Radar Fence Program, November 23 1949, RG 218 Records of the Joint Chiefs of Staff Central Decimal File, Box 213, File CCS 413-44 (7-1-8) Sec 2, NARA; Harry R. Borowski, *A Hollow Threat: Strategic Air Power and Containment Before Korea*, (Westport, CT: Greenwood Press, 1982), 191.

12 On this landmark document, see Ernest R. May, ed. *American Cold War Strategy: Interpreting NSC 68* (New York: Macmillan, 1993); "NSC-68: United States Objectives and Programs for National Security (April 14, 1950)," in *Containment: Documents on American Policy and Strategy, 1945-1950*, eds. Thomas H. Etzold and John Lewis Gaddis (New York: Columbia University Press, 1978), 387, 398-400; John Lewis Gaddis, *Strategies of Containment* (Oxford: Oxford University Press, 2005); Jockel, *No Boundaries Upstairs*, 35; and Steven Casey, "Selling NSC-68: The Truman Administration, Public Opinion, and the Politics of Mobilization, 1950–51," *Diplomatic History* 29, no. 4 (2005): 655-690. While the Soviet Union had tested its first atomic bomb in August 1949 and had a growing number of Tu-4 bombers – reverse-engineered from the American B-29 – in service, the number of nuclear weapons available to Soviet forces was extremely limited, and the Tu-4 was less reliable and capable than the B-29 original. Most importantly, the Tu-4 had about half the range of the B-29, which greatly reduced the number of targets

within its reach. These limitations were not readily apparent to Western intelligence agencies, which credited the Tu-4 with performance comparable to the B-29. The Soviet capability to deliver a nuclear attack against North America in the early 1950s, therefore, was extremely limited, but this was not immediately apparent to the West. Zaloga, *Kremlin's Nuclear Sword*, 5-18; Schaffel, *Emerging Shield*, 181; and Norman Friedman, *The Fifty Year War: Conflict and Strategy in the Cold War* (Annapolis: Naval Institute Press, 2000), 199-201.

[13] R.J. Sutherland, "The Strategic Significance of the Canadian Arctic," in *The Arctic Frontier*, ed. R. st. J. MacDonald, (Toronto: University of Toronto Press, 1966), 267.

[14] On this debate, see for example Schaffel, *The Emerging Shield:*; Richter, *Avoiding Armageddon*, 37-47; James Eayrs, *In Defence of Canada, vol. 3: Peacemaking and Deterrence* (Toronto: University of Toronto Press, 1972), 356-372; Eayrs, *In Defence of Canada, vol. 4: Growing Up Allied* (Toronto: University of Toronto Press, 1980), 275-283; Jockel, *No Boundaries Upstairs*, 40-78; Bruce-Briggs, *Shield of Faith*, 73-89; and Friedman, *Fifty Year War*, 144-148, 198-207.

[15] Rens, *Invisible Empire*, 227.

[16] An early 1954 summary of some elements of Canadian postwar air defence noted at its outset that "air defence systems in England, USA and Canada are all similar and concepts have changed little since World War II. Aircraft speeds have increased and radar has improved but except for these changes, systems have been built on proved practices of the last war. Research which is being conducted to improve air defence systems has not reached the stage where improved techniques can be accepted." "Some Aspects of Canada's Air Defence System," 15 March 1954, LAC, RG2, series B2, accession 90-91/154, box 28, file D-28-3, pt.2, "Department of National Defence – Canada-United States Defence Relations – Official".

[17] According to the early 1960s Glassco Commission, which had received briefs on the subject from the Department of National Defence, ADCOM had been chosen in 1951 because it was anticipated that it would be relatively inexpensive. Purchase was chosen over lease from commercial carriers because the necessary commercial facilities did not exist. Canada. Royal Commission on Government Organization (hereafter RCGO), *Report, Volume 2: Supporting Services for Government*, (Ottawa: Queen's Printer, 1962), 241-242. The Commission's report merely mentions that changes to the air defence system a few years later required substantial changes to ADCOM. Presumably this was the result of the introduction of the SAGE (Semi-Automatic Ground Environment) equipment as part of the CADIN (Continental Air Defence INtegration North) programme in the late 1950s and early 1960s.

[18] Lester, *Special Contract*; T.W. Eadie, Vice-President, Bell Telephone Company of Canada, to Secretary, Canadian Commercial Corporation, 5, September 1950, LAC, MG27 IIIB20, vol.195, file SD.10, "Radar Division". On microwave communications in the early postwar years, see Philip L. Cantelon, "The Origins of Microwave Telephony – Waves of Change," *Technology and Culture* 36:3 (July 1995), 560-573.

[19] See the correspondence in LAC, RG30, vol. 13170, file V7345-1-1, "Canadian Overseas Telecommunications Corporation, Formation Of – Radar – Micro-Wave," 1949-1950.

[20] A.G. Lester, "Taped Recollections," DHH 77/493, 7-8.

[21] Lester, *Special Contract*, 4.

[22] Roy J. Fletcher, "Military radar defence lines of northern North America: an historical geography," *Polar Record* 26:159 (October 1990), 265-276; Lester, *Special Contract*, 7-19.

[23] *Ibid.*, 8-9.

[24] *Ibid.*, 20-23; Fletcher, "Military Radar Defence Lines". Typical Pole Vault installations consisted of four parabolic antennae 60 feet in diameter, an equipment building, a diversity building to help handle signal traffic, a diesel generator building, two fuel storage tanks, raceways to carry waveguides and cables, and enclosed corridors connecting the various buildings. Lester, *Special Contract*, 39.

[25] *Ibid.*, 40-42. In conjunction with POLE VAULT, the Pinetree installations, work at Goose Bay and at the American bases in Newfoundland, the United States was making a considerable outlay of money. A Canadian estimate made in 1954 was that by the end of 1954, the United States would have completed construction in the Canadian areas of the Northeast Command worth some $325 million. R.A. MacKay, "Report of Visit to United States Northeast Command, 10-19 September 1954," 10, LAC, RG2, series B2, accession 90-91/154, box 28, file D-28-3, pt.2.

[26] Lester, *Special Contract*, 5-6. The Canadian Commercial Corporation, a Crown corporation responsible to the Minister of Trade and Commerce, was established in 1946 to help Canadian exporters access government procurement markets of other nations through government-to-government contracting. On its role in defence construction, see C.A. Ashley and R.G.H. Smails, *Canadian Crown Corporations: Some Aspects of their Administration and Control* (Toronto: Macmillan, 1965), 116-119.

[27] See, for example, Laura McEnaney, *Civil Defense Begins at Home: Militarization Meets Everyday Life in the Fifties*, (Princeton, NJ: Princeton University Press, 2000); Andrew D. Grossman, *Neither Dead nor Red: Civil Defense and American Political Development during the Early Cold War*, (New York: Routledge, 2001); and Andrew Burtch, *Give Me Shelter: The Failure of Canada's Cold War Civil Defence* (Vancouver: UBC Press, 2012).

[28] In the early 1950s, Strategic Air Command (SAC) made extensive use of overseas bases for its medium-range bombers, but its bases in the United States were also quite significant, and grew in importance as the decade progressed and the overseas bases became increasingly vulnerable to Soviet attack or political objections on the part of the host countries. The general assumption in discussions surrounding northern early warning systems was that SAC would be using the time provided by an alert to prepare and launch a retaliatory strike. Debate still surrounds the plans for SAC's use, however, including the question of whether the United States would have fought a preventive nuclear war or attempted to pre-empt a Soviet attack had warning been obtained in time to strike Soviet bombers while they were still at their bases. Strategic Air Command, Directorate of Information, History and Research Division, *History of the Canadian Refueling Base Program*, (SAC Historical Study No. 87, 1962),1-2; Bruce-Briggs, *Shield of Faith*, 75-79. The "northern glacis" reference comes from *ibid*, 73.

[29] The Valley Committee was created in December of 1949. Bruce-Briggs, *Shield of Faith*, 52-56; Jockel, *No Boundaries Upstairs*, 61-62; Schaffel, *Emerging Shield*, 144-145, 197-198.

[30] Bruce-Briggs, *Shield of Faith*, 48, 79-80; Matthew Farish, *The Contours of America's Cold War* (Minneapolis: University of Minnesota Press, 2010), 153-64.

[31] The National Security Resources Board had been established to advise the President on co-ordinating military, industrial, and civilian mobilization. Jockel, *No Boundaries Upstairs*, 63-64; Schaffel, *Emerging Shield*, 172-174.

[32] *Ibid*, 174-177; Jockel, *No Boundaries Upstairs*, 64-65. Jockel notes that "it appears now, in the light of research done since 1952 on the effects of atomic weapons, that the summer Study Group may have underestimated the effects of such a nuclear strike. Twenty million deaths now seems a small figure, if such a thing can be said about such an unparalleled catastrophe, in comparison with current estimations that a full-scale thermonuclear exchange could today [1987] take the lives of 100 to 150 million North Americans as a result of increases in the number and destructiveness of Soviet weapons. In 1952 the figures were newly appalling. The group struggled to

put it all into perspective by pointing out that U.S. military losses during the First World War had been 126,000 and in the Second World War 300,000." *ibid*, 65.

[33] *Ibid*. Emphasis in original.

[34] Opposition to the Summer Study Group report, however, was strong within the American military and government. Foremost among the criticisms were accusations that the recommendations would lead to a "Maginot Line" mentality that could supplant the USAF's central offensive role. Jockel, *No Boundaries Upstairs*, 67-68; Schaffel, *Emerging Shield*, 176-184; Bruce-Briggs, *Shield of Faith*, 83-85.

[35] Jockel, *No Boundaries Upstairs*, 70-71; Lester, *Special Contract*, 50; DND, "History of the Mid Canada Line," 1-2. The motives for American support for the MCL were perhaps more complicated than might appear on the surface; for details, see Jockel, *No Boundaries Upstairs*, 73-76, 80-84.

[36] See Friedman, *Fifty Year War*, 146; Zaloga, *Kremlin's Nuclear* Sword, 31-35, 71-72.

[37] While the United States had tested a hydrogen bomb in 1952, this had been an experimental device completely unsuited to weapon use; not until 1954 would the Americans develop and test a "deliverable" H-bomb, and its first Soviet counterpart would not be tested until late 1955. Zaloga, *Kremlin's Nuclear Sword*, 35.

[38] Schaffel, *Emerging Shield*, 192-193.

[39] Memorandum, DL(1), "The Air Defence of North America," enclosure to Memorandum, USSEA to SSEA, DEA/50209/40, 8 December 1954, *DCER*, vol. 20, 1055-1056; Ambassador in United States to SSEA, Despatch 1723, "Meeting of Consultation with United States Officials on September 24, 1954," *ibid*., 1100.

[40] The earlier of the two reports was the Kelly Report, named after the chair of the study group, Mervin J. Kelly, President of Bell Telephone Laboratories – an institution with strong ties to air defence systems. Schaffel, *Emerging Shield*, 185-191. Jockel gives the date for approval of NSC 159/4 as 24 September. Jockel, *No Boundaries Upstairs*, 75.

[41] Fearing that Canadian sovereignty could become a casualty of continental defence, the committee decided that "U.S. authorities should continue to be reminded of the vital concern of Canada in all continental defence plans and of the necessity for consultation of Canada at an early stage in the development of the plans." Minutes of 95th meeting of the Cabinet Defence Committee, 6 October 1953, 1-2, DHH 73/1223, series 3, box 65, file 1330. Subsequent correspondence

between Minister of Defence Production C.D. Howe and Minister of National Defence Brooke Claxton, however, revealed some concerns about security, particularly in one article that had disclosed information about the "McGill Fence." On the Howe-Claxton discussion of security leaks, see correspondence from October 1953 in C.D. Howe Papers, LAC, MG 27 III B20, vol.195, file SD-10, "Radar Division." The two articles that concerned Howe were Marquis Childs' "Canada Looks to Northern Air Ring" on 11 September and "Arctic Defense is Joint Undertaking" on 12 September, both in the *Washington Post*.

[42] Lester, *Special Contract*, 50.

[43] *Ibid.*, 51; Minutes of 96th meeting of the Cabinet Defence Committee, 3 November 1953, 1-2, DHH 73/1223, series 3, box 65, file 1330. Emphasis added.

[44] Eayrs, *In Defence of Canada, vol. 3*, 370.

[45] *Ibid.*, 369-370; Minutes of 96th meeting of the Cabinet Defence Committee, 3 November 1953, 1-2.

[46] DND, "History of the Mid-Canada Line," 2.

[47] *Ibid.*, 2-3.

[48] The RCAF approached the Army with requests for assistance through representation on the Steering Committee and Coordinating Staff, the provision of photographic interpretation services, route selection on the ground, map production, and the provision of certain equipment. "Report on Army Participation in RCAF Project "MONGOOSE" (to 31 May 54)," DHH 143.004 (D3).

[49] In 1959, DDP would defend its decision by arguing that neither the RCAF, nor DCL, nor the department itself had sufficient staff available for the task. Draft Memorandum, "The Mid-Canada Early Warning Line," 1959, 9.

[50] According to Howe, the alternatives to such an approach were that the RCAF could do the work itself or a Crown corporation could be formed for the purpose, but either case would require a considerable number of personnel from the telephone companies and would interfere with their operations. Canada. House of Commons. House of Commons, *Debates*, 8 July 1959, 5698; Lester, *Special Contract*, 51-52; Lester, "Taped Recollections," 24-25. Rens makes the worthwhile observation that at this point, construction of POLE VAULT was not yet finished, and construction of the trans-Canada microwave telecommunications network was just beginning, so heavy demands were being placed on the telephone industry at the time it took on its role in building the MCL. Rens, *Invisible Empire*, 233.

[51] *Ibid.*, 208-209.

[52] Lester, *Special Contract*, 52-53; Draft Memorandum, "The Mid-Canada Early Warning Line," 1959, 2-3, DHH 181.009 (D266); House of Commons, *Debates*, 28 March 1960, 2541. Canadian railways and Bell had been competing for defence communications business in 1950, but had subsequently agreed to adopt a more co-operative and co-ordinated approach to the subject. LAC, RG30, vol. 13170, file V7345-1-1, "Canadian Overseas Telecommunications Corporation, Formation Of – Radar – Micro-Wave," 1949-1950; A.G. Lester, "Taped Recollections," 7-8.

[53] Lester, *Special Contract*, 56. The ad-hoc nature of SEG's creation led to some organizational problems. Due to problems with other units in Air Force Headquarters not formally recognizing its existence, the group's existence was formalized at the end of August 1955, with the order made retroactively effective until the end of the year. While at first SEG reported to the Air Member for Technical Staff (AMTS) through the Chief of Construction Engineering (CCE), in September of 1955 it was ordered to report directly to AMTS. DND, "History of the Mid-Canada Line," 3.

[54] Lester, *Special Contract*, 55.

[55] According to some accounts, by March 1954, the RCAF was apparently eager to have a management contractor appointed to the project as soon as possible. This contrasts strangely with a DND summary from early 1959 that notes that DDP had pressed for the appointment of a Management Contractor, something the RCAF was "reluctant to accept…two attempts were made to avoid the decision being forced on them." In any event, the deputy ministers of National Defence and Defence Production were discussing the appointment of the TCTS as Management Contractor by May of 1954. "Progress Report No. 2 – Project Mongoose, Period from 10 March to 30 April 1954," 6, DHH 143.004 (D3); DND, "History of the Mid-Canada Line," 3; C.M. Drury, DM/DND to R.M. Brophy, DM/DND, 22 June 1954, DHH 181.009 (D266).

[56] RCAF officers made up most of the remainder of the group, although early in the process a number of their USAF counterparts participated in the planning efforts.

[57] Lester, *Special Contract*, 56; "Progress Report No. 2 – Project Mongoose, Period from 10 March to 30 April 1954," 1, 6-7, DHH 143.004 (D3). RCAF representatives also visited experimental radar facilities in the United States in order to gain more information about technical approaches that could be used for the MCL. The progress report refers to visits to experimental facilities for the DEW Line in the United States, as well as to MIT's Lincoln Laboratory.

[58] CAS to AOC, Tactical Air Command, Edmonton, 8 February 1954, "Electronic Fence – Code Word," DHH 181.002 (D294), formerly RCAF file S.704-9-1, "Operations – Project Taramack".

[59] CAS to Air Officer Commanding, 1 Tactical Air Command, Edmonton, 29 October 1954, "Mid-Canada Early Warning Line," DHH 181.002 (D294). The project names for the electronic, logistic, and construction engineering studies were BACK LOG, BACK UP, and BACK LASH, respectively. CAS to AOC, Tactical Air Command, Edmonton, 19 February 1954, "Nickname," DHH 181.002 (D294).

[60] In light of the final costs of the line, the $77,000 price tag for Bell's work in Phase I seems minuscule. Draft Memorandum, "The Mid-Canada Early Warning Line," 1959, 1-2; C.M. Drury, DM/DND to R.M. Brophy, DM/DDP, 22 June 1954, DHH 181.009 (D266).

[61] Department of External Affairs officials, however, expressed concern that making the DEW Line an exclusively American undertaking would affect Canadian Arctic sovereignty and generate domestic political sensitivities. C.D. Howe and the National Defence were more concerned with the two countries' shared interests in air defence. "Report by the External Affairs Observer on the Canada-United States Military Study Group," 4 June 1954, annex to memorandum from A/USSEA to SSEA, "Continental Defence – Recommendations of the Military Study Group (MSG)," 4 June 1954, *DCER*, vol.20, 987-989; Memorandum, A/USSEA to SSEA, "100th Meeting of Cabinet Defence Committee to be held on Friday, June 25, 1954," 23 June 1954, *DCER*, vol.20, 992-993; Memorandum, A/USSEA to SSEA, "Distant Early Warning (DEW) – 3rd Interim Report of Military Study Group – Discussion at Permanent Joint Board on Defence," 17 July 1954, *DCER*, vol.20, 1000-1001; Richter, *Avoiding Armageddon*, 37. General Foulkes, Chairman of the Chiefs of Staff Committee, also articulated concerns that an entirely Canadian MCL and entirely American DEW Line would give the impression that "the U.S. was assuming responsibility for, and control of the Canadian Arctic." Memorandum, A/USSEA to USSEA, "Briefing on November 5 by Chairman of Chiefs of Staff on Proposed Radar Chains," 6 November 1954, *DCER*, vol.20, 1029-1030.

[62] Minutes of 100th meeting of the Cabinet Defence Committee, 25 June 1954, 5, DHH 73/1223, series 3, box 65, file 1330. The minutes of the Chiefs of Staff Committee meeting that agreed to the submission of this plan to the Cabinet Defence Committee (CDC) were amended prior to the approval of the CDC recommendation by Cabinet. Minutes of the 563rd meeting of the Chiefs of Staff

Committee, 17 June 1954, 1-2; Minutes of the 564th meeting of the Chiefs of Staff Committee, 28 June 1954, 1-2, DHH 73/1223, series 3, box 61, file 1307B.

[63] Memorandum, MND to CDC, "Continental Defence – Mid-Canada Warning Line," 18 June 1954, enclosure with Memorandum, A/USSEA to SSEA, "100th Meeting of Cabinet Defence Committee to be held on Friday, June 25, 1954," 23 June 1954, *DCER*, vol.20, 994-994; Cabinet Conclusions, 30 June 1954, 2-4, RG2, series A-5-a, vol.2655. The tentative programme developed by SEG in June 1954 also proposed completion of the line by the end of 1957. Draft Memorandum, "The Mid-Canada Early Warning Line," 1959, 6, DHH 181.009 (D266).

[64] On changes to these purchase orders and confusion over responsibilities and authorities, see Noakes, "Under the Radar," 191-92.

[65] Draft Memorandum, "The Mid-Canada Early Warning Line," 1959, 6, DHH 181.009 (D266), 3-4.

[66] This contrasted with the American approach on the DEW Line, where the civilian prime contractor had been assigned these responsibilities. C. Maxwell to R.G. Johnson, "Mid-Canada Line," 6 January 1955, LAC, RG83, vol.4, file 122-7-12-T6-0; Minutes of the 580th meeting of the Chiefs of Staff Committee, 30 May 1955, 3.

[67] Lester, *Special Contract*, 56.

[68] Minutes of the 564th meeting of the Chiefs of Staff Committee, 28 June 1954, 1.

[69] Minutes of the 101st meeting of the Cabinet Defence Committee, 12 November 1954, 12.

[70] In early 1954, the tentative timing was "system and equipment specifications to be completed during the fall of 54, setting up test section of the line during winter and summer of 55, siting for a final line in summer of 55, deliver of construction materials in winter 55-56 for construction in spring and summer of 56, procurement of electronics equipment for delivery in early 57 and installation by the end of 57. This will permit operation of the line by January 58." "Progress Report #3 – Project "Mongoose," Period From 30 April 54 to 31 May 54," 1, DHH 143.004 (D3); Minutes of the 563rd meeting of the Chiefs of Staff Committee, 17 June 1954, 1-2; Minutes of the 564th meeting of the Chiefs of Staff Committee, 28 June 1954, 1-2; House of Commons, *Debates*, 8 July 1959, 5697.

[71] This programme for the construction of the MCL was part of ongoing plans for the expansion of North American air defence; at the time that approval was given to

the final SEG report in August of 1954, the Chiefs of Staff Committee was already discussing the expansion of radar coverage to fill the gap from existing radar stations to the MCL. Some of these plans would ultimately lead to the construction of additional air defence infrastructure in Canada. Minutes of the 568th meeting of the Chiefs of Staff Committee, 21 September 1954, 5; Minutes of the 569th meeting of the Chiefs of Staff Committee, 2-3 November 1954, 5-6; Lester, *Special Contract*, 56.

[72] According to the Army's Director of Military Survey, preliminary studies for the MCL were "seriously hampered by the lack of minimum topographical map coverage over a large part of the area. It is furthermore apparent that this lack of maps is going to hinder final surveys and construction, and, in some areas at least, it may impede air navigation and the resupply of the stations." Lt-Col C.H. Smith, Director of Military Survey, to Director of Special Projects, AFHQ, "Tamarack: Air Photography and Mapping," 11 February 1954, DHH 143.004 (D3). 1955 helicopter survey operations found that in some areas the lack of detail on available maps and the low altitude of helicopter operations hampered operations, while the availability of good maps in other areas proved beneficial. "Report on Operation Back Lash II, Part I: Operation Back Lash II (E)," 10, DHH 181.003 (D1217).

[73] Accurate terrain contours were necessary because the signals for the Doppler detection equipment only operated along a direct line of sight. The transmitting and receiving equipment for each of the Doppler installations therefore had to be directly "visible" to its immediate neighbours along the "line," with no interference from intermediate terrain. While the characteristic towers for the detection equipment helped compensate for terrain and the earth's curvature, there were limits to what they could overcome. Furthermore, the taller the towers, the greater the expense and challenge would be in their construction and maintenance. The required contour maps, which would make preliminary studies and calculations of these detection sites possible, were produced by early 1955. Radar contour information was not required for the James Bay-Bird section of the line, where the DDS site locations were dependent on beach ridges and firm ground rising above the surrounding muskeg. "Minutes of a conference to discuss the survey requirements in the Quebec sector of "Mongoose," held in the office of the Chief of Air Operations at 1100 hours, 25 February 1954," DHH 143.004 (D3); R.A. Cline to CAS, 9 May 1955, 4, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (pt.1); C.M. Drury, DM DND to Marc Boyer, DM DMTS, 3 June 1954, DHH 143.004 (D3); Col. G.A. Turcot, Army Member, Steering Committee, Project Mongoose to Chairman, Steering Committee, Project Mongoose, "Project Mongoose: Additional Mapping Requirements," 12 March 1954 DHH 143.004 (D3); Lester, *Special*

Contract, 57; RCAF Operation Order No. 5/54, 10 February 1954; Operation Order No. 7/54, 16 February 1954, DHH 181.002 (D294). On the survey operations, see Morris Gates, Clifton Kinney, Ron Cleminson, Alex Saunders, Noel Funge, Paul Nyznik, Wally Kasper, Grant Pennington and Morrie Konick, *408 Squadron: The Rockcliffe Years, 1949-1964*, (Ottawa: 408 (Goose) Squadron Ottawa Group, 2014), 232-241, 432-437.

[74] Identification radars would be installed at Waterways (Stoney Mountain), Flin Flon (Cranberry Portage), and Knob Lake, with additional radars "to assist the difficult James Bay crossing." The line could be extended westward from Dawson Creek, but they recommended the use of the existing Pinetree Line radar network in this area and argued that coverage along the Labrador coast from Hopedale to Cape Race was largely an American interest. Minutes of the 568th meeting of the Chiefs of Staff Committee, 21 September 1954, 4-5. On the Hopedale-Cape Race "gap filler" radar coverage, see Noakes, "Under the Radar," 108, 197.

[75] Ambassador in United States to SSEA, Despatch 1723, "Meeting of Consultation with United States Officials on September 24, 1954," *DCER*, vol. 20, 1100.

[76] Minutes of the 568th meeting of the Chiefs of Staff Committee, 21 September 1954, 4-5.

[77] Among the reasons for the reversion to the earlier detection system was that the Mark II equipment could not be developed and produced in time to meet a January 1957 operational date. Minutes of the 568th meeting of the Chiefs of Staff Committee, 21 September 1954; Lester, *Special Contract*, 57-58. A May 1954 progress report from the SEG noted that "nothing firm has yet accrued from the study on system composition. Reconciliation of the detection and communication equipments presents the greatest problem. Solution of this problem, which is basically one of propagation and siting, is mandatory before firm recommendations can be made regarding types and deployment of equipments. There are, however, several systems under study, each based on different configurations involving either scanning radars, or CW Doppler or a combination of both. Each system is being studied and developed to include the other necessary telecommunications aspects and thus provide a comparison of the relative merits of the various systems to assist in final selection of the system or systems to be used." "Progress Report #3 – Project "Mongoose," Period from 30 April 54 to 31 May 54," 4, DHH 143.004 (D3); Draft Memorandum, "The Mid-Canada Early Warning Line," 1959, 6, DHH 181.009 (D266). The Executive Committee decided to abandon the Mark II detection equipment and revert to a line using its Mark I counterpart at some point

in January of 1955. R.A. Cline, Chief Engineer, TCTS, to CAS, 12 February 1955, 1, RG83, vol.9, file 122-7-12-T6-0-8 (pt.1).

[78] Furthermore, alternate sites for the deployment of Mark I with 40 mile (64 km) and 60 mile (97 km) spacings between installations also had to be determined, since it was unclear whether or not the Doppler equipment could successfully operate over a 60 mile distance. R.A. Cline, Chief Engineer, TCTS, to CAS, 12 February 1955, 1, RG83, vol.9, file 122-7-12-T6-0-8 (pt.1). Not until May 1955 was DRB able to confirm the separation of the detection stations at 60 miles; until that point, determining the sites for the stations with any certainty was virtually impossible – the “office selection” of sites from mapping information had been proceeding on the basis of both 40 and 60 mile spacings until early May. Bell was informed by SEG of the DRB approval on 27 May. DND, “History of the Mid Canada Line,” 5; R.A. Cline to CAS, 4, 9 May 1955; R.A. Cline to CAS, 1, 13 June 1955, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (pt.1).

[79] Whitehead, *Radar to the Future*; LAC, RG83, vol.9, file 122-7-12-T6-0-8 (pts.1 and 2).

[80] *Ibid.*; Lester, *Special Contract*, 58.

[81] C. Maxwell to R.G. Johnson, “Mid-Canada Line,” 6 January 1955, LAC, RG83, vol.4, file 122-7-12-T6-0; House of Commons, *Debates*, 8 July 1959, 5696; 28 March 1960, 2541.

[82] Lester, *Special Contract*, 77-78.

[83] Lester, *Special Contract*, 77.

[84] On Howe’s interest in maximizing the benefits of the MCL for Canadian electronics firms, see Eayrs, *In Defence of Canada, Volume III*, 370.

[85] Lester, *Special Contract*, 77-78.

[86] Lester, *Special Contract*, 78.

[87] *Ibid.*, 78; Eadie to Golden, 15 November 1954; C.M. Drury, DM/DDP to D.A. Golden, DM/DDP, 18 November 1954, DCC in-house file 011-5, “Information – Historical – MCL”. On these changes, see Noakes, “Under the Radar,” 207-209.

[88] Collins, *A Voice From Afar*, 243.

[89] See, for example, R.G. Johnson, “Nostalgia,” speech delivered to DCL’s 25th anniversary reunion party, 14 November 1975; R.G. Johnson, “The Position of the

Canadian Construction Industry in 1958," 1-2, DCC in-house file "Summaries of U.S.-Canada Diplomatic Agreement Affecting DCL."

[90] The Patricia Transportation Company, for instance, was ordered to reassign its efforts from providing transportation services between marshalling points and DDS locations to a feasibility exercise for tractor train transportation between Gillam and Cape Henrietta Maria . J.D. McIlveen, MCL Project Manager, DCL, to G/C E.C. Poole, "Re: Mid-Canada E.W. Line – Monthly Report," 5 January 1955; J.D. McIlveen, MCL Project Manager, DCL, to G/C E.C. Poole, "Re: Mid-Canada E.W. Line – Monthly Report," 8 February 1955; J.D. McIlveen, MCL Project Manager, DCL, to G/C E.C. Poole, "Re: Mid-Canada E.W. Line – Monthly Report," 2 March 1955, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (pt.1).

[91] *DCL annual report for 1955-56*, 7. Defence Construction (1951) Limited, generally referred to as "Defence Construction Limited" in contemporary documents, is a Crown corporation. At this time, its primary role was to serve as the contracting and supervisory authority for the Deparment of National Defence's infrastructure projects. Now known as Defence Construction Canada, its current madate is to meet the infrastructure and environmental needs of the Department of National Defence and the Canadian Armed Forces.

[92] K.J. Holmes, *The History of the Canadian Military Engineers: Volume III, to 1971*. ed. J.R. Newell, (Toronto: Military Engineering Institute of Canada, 1997), 126.

[93] Operations Back Lash II and Back Lash III in the summer of 1955 used Canadian and American H-19 helicopters as well as some support aircraft from 408 Squadron to survey site locations and to transport Bell technicians and their Doppler propagation testing equipment to various proposed sites. Operation Right Flash in the fall of 1955 used USAF helicopters and their crews to survey and mark sites for proposed Doppler detection sites between Flin Flon, Manitoba, and Lesser Slave Lake, Alberta R.A. Cline to CAS, 12 July 1955, 3, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (pt.1); Holmes, *History of the Canadian Military Engineers*, 127; "Report on Operation Back Lash II," DHH 181.003 (D1217); "Report on Operation Back Lash III," DHH 181.003 (D1294); "Report on Operation Right Flash," DHH 181.003 (D1216); Gates *et. al*, *408 Squadron: The Rockcliffe Years*, 432-436.

[94] "Report on Operation Back Lash II," 2, DHH 181.003 (D1217). During Back Lash II, one RCAF helicopter "became temporarily misplaced for a period of approximately fifteen hours," while one USAF helicopter crashed. As a result of this crash, "it was decided to repaint remaining five helicopters yellow. The present green camouflage was considered dangerous from search point of view." Two USAF airmen were also sent home for becoming involved with "Treaty Indian girls who

were also underage." "Report on Operation Back Lash II, Part I: Back Lash II (E)," 8; "Report on Operation Back Lash II, Part II: Operation Back Lash II (W)," 11, DHH 181.003 (D1217). See also Larry Milberry, *Air Transport in Canada* (Toronto: CANAV Books, 1997), 346-351.

[95] Memo to R.G. Johnson (possibly from J.P. Stirling, DCL Chief Engineer), "Re: Mid-Canada Line," 3 May 1955, DCC in-house file 122-7-12-T6, "Mid-Canada Line". Similar concerns among DCL employees about the schedule for completion of the line continues to emerge in the surviving files from the fall of 1955. Some problems centered largely on the provision of towers and prefabricated buildings, although there were more fundamental problems with the availability of the requisite plans and specifications to the various prime contractors hired by Bell, which, not surprisingly, led to problems with the production of accurate estimates and schedules by the contractors. See, for instance, C.A. Wheatley to J.P. Stirling, "Mid-Canada Line Schedule," 16 September 1955, LAC, RG83, vol.2, file 122-7-12-T6-0-10; C.Maxwell to J.P. Stirling, "REPORT – Week Ending September 23, 1955: Mid-Canada Line," 23 September 1955; C. Maxwell, "Montreal Office Report for Week Ending July 29/55: Mid-Canada Line," LAC, RG83, vol.2, file 122-7-12-T6-0-8A.

[96] Minutes of the 104th meeting of the Cabinet Defence Committee, 3 March 1955, 7, DHH 73/1223, series 3, box 65, file 1329.

[97] As part of the terms of the contract, the TCTS was required to provide quarterly forecasts of expenditures. The first was submitted to the Executive Committee on 4 May 1955, and laid out an overall estimated cost of some $169 million, of which $16.7 million would be required for project management. This revised estimate was the product of more detailed studies that were made possible by more specific knowledge about increased requirements for the line, including additional Doppler Detection Stations, taller towers, increased power requirements, larger helicopters, and additional building space. This estimate was to remain unchanged until August 1956, when it would be increased to some $179 million. House of Commons, *Debates*, 8 July 1959, 5697; Minutes of 105th meeting of the Cabinet Defence Committee Decision, 105th meeting, 7 June 1955, 3-4; R.A. Cline to CAS, 1, 9 May 1955, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (pt.1).

[98] SEG, "A Digest on the Building of the Mid-Canada Line," 6-7.

[99] The purchase order was being used as a contract document at that time. Draft Memorandum, "The Mid-Canada Early Warning Line," 1959, 4-5, DHH 181.009 (D266).

[100] The construction digest noted that Bell and DDP had agreed that Bell had the responsibility and authority of the "Engineer" for the project, and should act for DCL in supervising the construction contractors. Bell's role was to co-ordinate the efforts of the RCAF, DCL, and the general contractors, but authority for the planning and direction of the complete construction task was no longer to be the sole responsibility of Bell, which was instead to direct construction by co-ordinating the views of the RCAF, DCL, and DDP in areas where those government agencies were involved. SEG, "A Digest on the Building of the Mid-Canada Line," 7-11.

[101] DCL, *Annual Report*, 1956-57, 6.

[102] Fletcher, "Military Radar Defence Lines of Northern North America."

[103] SEG, "A Digest on the Building of the Mid-Canada Line," 17-20, 25.

[104] C. Maxwell to R.G. Johnson, 31 January 1956, LAC, RG83, vol.1, file 122-7-12-T6-0-4.

[105] *ibid.*

[106] See, for example, C.A. Wheatley to F.T. Shearns, "Mid-Canada Line – Financial Status," 19 September 1956, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (vol.3); DCL Inter-Office Memorandum, C. Maxwell to R.G. Johnson, "Re: Mid-Canada Line Costs," 2 October 1956, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (vol.3).

[107] Lester, *Special Contract*, 198-199; House of Commons, *Debates*, 8 July 1959, 5697; A.G. Lester to CAS, 6 September 1956; A.G. Lester to CAS, 31 October 1956, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (vol.3). Lester's memoir dates the revised estimate to August of 1956, while the September 1956 report to the RCAF is worded in a way that points to the revision taking place in September. The 31 October report from Bell apparently made no mention of the problems and cost increases caused by the delays in the production of plans and specifications because of "violent objections" on the part of A/V/M Hendrick, even though Bell considered it to be a "very vital point". DCL Inter-Office Memorandum, C. Maxwell to R.G. Johnson, Personal & Confidential, "Report from M.C. dated October 31," 8 November 1956, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (vol.3).

[108] Meetings were held on 28 December, and also appear to have been held on the 27th. G/C E.C. Poole, RCAF/DSEG, "Report on Visit to Mid-Canada Line, January 23-29, 1957," LAC, RG83, vol.9, file 122-7-12-T6-0-8 (vol.3); A.G. Lester to R.G. Johnson, 16 January 1957; D.B. Mundy, Director, Electronics Branch, DDP, to A.G. Lester, 28 December 1956, LAC, RG83, vol.1, file 122-7-12-T6-0-

4. A number of other meetings on this issue also appear to have been held at about this time.

[109] A.G. Lester to R.G. Johnson, 16 January 1957; handwritten annotation on same; R.G. Johnson to A.G. Lester, 18 January 1957; comments by C.A. Wheatley on DCL transmittal slip, R.G. Johnson to J.P. Stirling, 12 February 1957, LAC, RG83, vol.1, file 122-7-12-T6-0-4. Lester's letter makes reference to a December 17 letter from Johnson, and a late November letter from Johnson to Lester also addresses this issue, dealing specifically with the large labour force remaining at Great Whale River. R.G. Johnson to A.G. Lester, "Re: Mid-Canada Line Close Out," 26 November 1956, LAC, RG83, vol.1, file 122-7-12-T6-0-4.

[110] Lester, *Special Contract*, 193; A.G. Lester, "Mid Canada Line – Performance of Management Contractor, Memorandum C: Comments on particular points raised by Government representatives at meeting in Ottawa on Sept. 27, 1957," 8, 29 November 1957, DHH 181.009 (D276), vol.2.

[111] Lester, *Special Contract*, 199.

[112]Acceptance involved inspection by the prime contractor, the management contractor, DCL, and the RCAF. Once any deficiencies that were noted were rectified, Bell would then take custody of the "units" of construction and occupy and maintain them until DND accepted larger elements of the project. "Mid-Canada Line: Interim Take-Over Procedure for Construction, Draft No.9," 12 November 1956, 1, 4; "Mid-Canada Line: Final Take-Over Procedure for Construction," 12 November 1956, LAC, RG83, vol.1, file 122-7-12-T6-0-7 (pt.2). This was the final draft of the procedures. By September 1956 some "units" of the MCL were ready for inspection and the interim take-over procedures had already been under development since at least July of 1956. DCL Inter-Office Memorandum, C. Maxwell to all DCL Zone Engineers, "Interim Take-Over Procedure for Construction," 13 September 1956, LAC, RG83, vol.1, file 122-7-12-16-0-7, pt.2; handwritten notes, "Meeting of 30 July," LAC, RG83, vol.1, file 122-7-12-T6-0-7 (pt.2); Lester, *Special Contract*, 196. See also C.A. Wheatley to N.J. Smith, 12 November 1956, LAC, RG83, vol.1, file 122-7-12-16-0-7, pt.2.

[113] Collins, *A Voice From Afar*, 245; Lester, *Special Contract*, 204-212.

[114] Collins, *A Voice From Afar*, 244.

[115] "Mid-Canada E.W. Line – Financial Condition of Contracts to Date 30/9/59," LAC, RG49, vol.465, file 200-3-4-4-2, vol.1, "Radar Screens – Mid-Canada". Out of this total, DCL had awarded nine major construction contracts with a total value of over $90 million, in addition to forty minor contracts for freight delivery, small-

scale tractor train operations, and minor local construction worth a total of over $2.3 million. Finally, some $1.3 million was made available to TCTS to provide miscellaneous requirements for the contract, including transportation and materials. House of Commons, *Debates*, 28 March 1960, 2541-2.

[116] From east to west, the eight SCS were located at Hopedale, Knob Lake, Great Whale River, Winisk, Bird, Cranberry Portage, Stoney Mountain, and Dawson Creek.

[117] Lester, *Special Contract*, 59.

[118] *Ibid.*

[119] "An Introduction to Defence Construction (1951) Limited," n.d., 7, DCC in-house holding.

[120] Lester, *Special Contract*, 60.

[121] Conventional microwave communications systems, like those used for parts of the ADCOM air defence communications system, were limited to "line of sight" transmissions. Details of the principles of tropospheric scatter communications are provided in Chapter Two. Frank A. Gunther, "Tropospheric Scatter Communications: Past, Present, and Future," *IEEE Spectrum*, September 1956, 79-82, 91; Lester, *Special Contract*, 20-23. For a concise discussion of some aspects of microwave communications during these years, see Philip L. Cantelon, "The Origins of Microwave Telephony – Waves of Change," *Technology and Culture* 36:3 (July 1995): 560-573

[122] Lester, *Special Contract*, 59-60. Initial plans for coverage across the northern end of James Bay had involved conventional radar installations, but these were later replaced by Doppler detection links that included two stations on Bear Island. R.G. Lester to D.A. Golden, 4 December 1957, Appendix 1, "Basic Systems Design: Major Changes from Appendix D of August 27, 1954, Report of Systems Engineering Group," DHH 181.009 (D276), vol.2; Minutes of the 568th meeting of the Chiefs of Staff Committee, 21 September 1954, 4-5; Systems Engineering Group Brief: UHF Scatter," October 1955, appended to CAS to Controller of Telecommunications, Department of Transport, 19 October 1955, LAC RG12, vol.2400, file 14-13-8-5 (pt.1). The TCTS' July 1955 progress report also refers to plans for a rearwards communication link to Senneterre, Quebec, although these plans were changed to a link to North Bay – both locations had been proposed as alternate end points for the scatter links from the west side of James Bay at an earlier date. R.A. Cline, Chief Engineer, TCTS, to CAS, 5, 15 August 1955; R.A. Cline, Chief Engineer, TCTS, to CAS, 12 April 1955, 7; R.A. Cline to CAS, 13 June

1955, 9, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (pt.1); "Systems Engineering Group Brief: UHF Scatter," figure 1.

[123] Ionospheric scatter systems operate on the same principle as tropospheric scatter systems, but in 1955 offered much longer ranges – some 900 miles as opposed to the 150 miles for the POLEVAULT tropospheric scatter links or the 600 miles for the tropospheric scatter link from Cape Dyer to Thule. At this time, the main limitation of ionospheric scatter systems was the limited number of communications circuits (three to four) possible with the equipment. Fletcher, "Military Radar Defence Lines of Northern North America." A variety of plans for DEW Line rearward communications were discussed, including the use of tropospheric scatter circuits for some links, which caused some concern in the Department of Transport. F.R. Miller, DM/DND to DM/DOT, 29 November 1955, LAC, RG12, vol.2400, file 14-13-8-5 (pt.1).

[124] Lester, *Special Contract*, 60. The facilities were built by MCL contractors, while Canada was reimbursed by the US for a portion of the cost, with the US share at $347,0000 and the Canadian share, which covered foundations and some access roads, at $200,000. The Canadian contractor invoiced Bell Telephone who had the sub-contract with Western Electric which had the contract with the US government. Western Electric was the design authority. DEW Line rearward communications project summary, n.d., DCC in-house file, "DEW Line Treaty". A number of meetings were held with the Americans on this issue; a TCTS representative met with a senior planner for the DEW Line in April of 1955 to obtain information regarding the coordination of rearward communications, while SEG and TCTS representatives met with USAF and Western Electric representatives in New York at the end of August 1955 to discuss DEW Line rearward communications. R.A. Cline, Chief Engineer, TCTS, to CAS, 9 May 1955, 4; R.A. Cline, Chief Engineer, TCTS, to CAS, 12 September 1955, 4, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (pt.1). The possibility of Canadian operation of the rearward communication links was also discussed by Cabinet in 1955; External Affairs appears to have been particularly concerned that Canada be involved in providing the logistic support and rearward communications necessary for the DEW Line. Cabinet Conclusions, 06 July 1955, 4-5; 28 September 1955 6-7, LAC, RG2, series A-5-a, vol. 2658, reel T-12184.

[125] Lester, *Special Contract*, 61-62.

[126] *Ibid.*, 60-61.

[127] *Ibid.*, 48. Edinborough, "A Story of Waste," 9-13, 49; and Edinborough, "Administrative Muddle," 9-11, 48. The journalist had access to classified official

documents, including the SEG construction digest from which he quoted extensively. Edinborough used direct quotations from a number of documents: SEG, "A Digest on the Building of the Mid-Canada Line," 1959, 1-2, DHH 181.009 (D266); Memorandum, SEG/CL2 to C/Co-Ord, "Report on TD to Cranberry Portage, Stoney Mountain, Dawson Creek, and The Pas," 24 July 1956, 3, DHH 181.009 (D276), vol.1; and especially W/C L.V. Carver, SEG/CL, "Report of 12 Day Visit to SCS Sites 400-500-700-800-900 and DDS Sites 627 and 630 During Period 22 Apr to 3 May 56, DHH 181.009 (D276), vol.1. Additional statements by Carver about his visit can be found in W/C Carver, SEG/CL, "Conclusions from Report of 12 Day Visit to Sites 400-500-700-800-900-627-630 between 22 Apr and 3 May 1956," 7 May 1956, LAC, RG83, vol.9, file 122-7-12-T6-0-8 (pt.2).

[128] Edinborough, "A Story of Waste," 9-10.

[129] *Ibid.*, 49.

[130] Edinborough, "Administrative Muddle," 48.

[131] *Ibid.*, 48.

[132] See, for instance, Jon B. McLin, *Canada's Changing Defence Policy, 1957-1963 : The Problems of a Middle Power in Alliance*, (Toronto: Copp Clark, 1967), 28; House of Commons, *Debates*, 1956 (V) 5208-5211; Canada, Department of National Defence, *Report on National Defence*, (Ottawa: Queen's Printer, 1957), 24. Edinborough's autobiography makes a brief reference to these articles, describing them as "an investigative piece on the waste in constructing the DEW line [sic], material for which had been leaked to me after a casual conversation in the men's room of the Royal York Hotel in Toronto. This prompted the government to make noises about prosecution under the Official Secrets Act." Given that at least one of the documents in question was classified "Secret", this was perhaps not surprising. Arnold Edinborough, *Arnold Edinborough: An Autobiography*, (Toronto: Stoddart, 1991), 131.

[133] Quoted in Collins, *A Voice From Afar*, 245.

[134] A/C C.F. Johns, ADM(Construction & Properties)/DND to MND, "Article "Saturday Night," March 14th, 1959," DHH 181.009 (D276), vol.2; DCL Inter-Office Memo, N.J. Smith, Secretary, to R.G. Johnson, "Mid-Canada Line Costs – Saturday Night Magazine, March 14, 1959." 7 April 1959, DCC in-house file 011-5, "Information – Historical – Mid Canada Line"; D.B. Mundy, Director, Electronics Branch, DDP, to A/C C.F. Johns, ADM (Construction Engineering & Properties), DND, 21 April 1959, DHH 181.009 (D276), vol.2; W.H. Huck,

ADM/DDP to R.G. Johnson, 28 April 1959; Draft Memorandum, "The Mid-Canada Early Warning Line," 28 April 1959, DCC in-house file 011-5, "Information – Historical – Mid Canada Line".

[135] House of Commons, *Debates*, 8 July 1959, 5693-5699. See also *Debates*, 9 July 1959, 5765, and 28 March 1960, 2541-2543 for more questions and answers about the construction of the MCL.

[136] House of Commons, *Debates*, 8 July 1959, 5697-5698. A letter from Lester to David Golden in December of 1957, proposing an increase in the contractor's fee for Bell, also pointed to the increase in physical requirements since the 1955 estimates, and furthermore noted the substantial changes that had been made to the basic design of the line since the issuing of the August 1954 report of the Systems Engineering Group. R.G. Lester to D.A. Golden, 4 December 1957, Appendix 2, "Major Changes in Physical Pattern and Items Composing the Line," Appendix 1, "Basic Systems Design: Major Changes from Appendix D of August 27, 1954, Report of Systems Engineering Group," DHH 181.009 (D276), vol.2.

[137] Collins, *A Voice From Afar*, 244-245.

[138] House of Commons, *Debates*, 8 July 1959, 5696.

[139] "A Digest on the Building of the Mid-Canada Line," n.d., 45, DHH 181.009 (D266).

[140] DND, "History of the Mid-Canada Line," 2; House of Commons, *Debates*, 28 March 1960, 2543. Even in 1960, the final costs were not definitely known; according to Minister of Defence Production Raymond O'Hurley, as of 28 March 1960 the final audits of some DDP prime contracts had not yet been completed, and a reserve allowance of $500,000 to provide for outstanding liabilities was also included.

[141] SEG, "A Digest on the Building of the Mid-Canada Line," 5-6.

[142] Bell's interpretation of the situation was that it should have control in keeping with their responsibilities for construction of the MCL, while government agencies wanted to retain authority over the project's direction while leaving responsibility for implementing actions with Bell. SEG, "Digest on the Building," 6-7.

[143] The digest also argued that inaction on the part of the Minister of National Defence when "official reports of a serious nature telling of extravagance and forecasting further waste" reached his desk undermined morale at SEG, where the staff "felt they enjoyed neither the confidence or support [sic] of their seniors". *Ibid.*, 10-14.

[144] *Ibid.*, 14. The construction digest's author also argued that any future projects of this sort should be administered from a project control centre intended to facilitate the evaluation of progress and cost, their comparison with schedules and estimates, and provide a general overview of the project. One of the advantages of such an approach, the report argued, was that "controversial issues would also be resolved on the basis of factual presentation, as opposed to personal opinions or hearsay, thus preventing such issues from promoting acrimonious personal exchanges." *Ibid.*, 5.

[145] Collins, *A Voice From Afar*, 242. Lester made a similar statement in 1957. Lester, "Mid Canada Line – Performance of Management Contractor, Memorandum C," 5.

[146] Lester, *Special Contract*, 74.

[147] A 1959 DND report, for instance, argued that that the main lesson to be learned was that "future projects of this magnitude and complexity would be more efficiently and economically handled by utilizing the proven procedures already established between DND, DDP and DCL." DND, "History of the Mid-Canada Line," 8. The Accelerated Defence Programme, launched as a direct response to the outbreak of war in Korea, provided for the expansion and rearmament of Canada's armed forces. While much of the expenditure was on new personnel, training, and equipment, expansion and rearmament also required new infrastructure for the military.

[148] Lester, *Special Contract*, 5.

[149] *Ibid.*

[150] A.G. Lester, "Mid Canada Line – Performance of Management Contractor, Memorandum C," 5.

[151] A.G. Lester, "Comments of Government Departments on Bell Performance on Mid-Canada Construction Contract: Meeting held at Ottawa on Sept. 27, 1957," 4, DHH 181.009 (D276), vol.2. Johnson's comments reflected and were probably prompted by similar statements about Bell's inflexibility made earlier by Claude Maxwell, DCL's representative at the TCTS offices in Montreal. C. Maxwell to R.G. Johnson, 31 January 1956, LAC, RG83, vol.1, file 122-7-12-T6-0-4.

[152] A.G. Lester, "Mid Canada Line – Performance of Management Contractor, Memorandum B," 1.

[153] .G. Lester, "Mid Canada Line – Performance of Management Contractor, Memorandum B," 1.

[154] Lester also explicitly contrasted DDP's actions with those of DCL. "We were never in trouble with D.C.L.," he noted, "who stationed their Assistant Chief Engineer in Montreal and gave him full power to deal with us. D.D.P. stationed people in Montreal for short intervals, but they never had power of decision." A.G. Lester, "Mid Canada Line – Performance of Management Contractor, Memorandum C," 7.

[155] Noakes, "Under the Radar," 245-47.

[156] Originally quoted in an abbreviated form in Bothwell and Kilbourn, *C.D. Howe: A Biography* (Toronto: McClelland and Stewart, 1979), 257. Howe's original statement was made on 30 May 1952, and was intended to help describe the duties of the Department of Defence Production, and the circumstances where it could and could not intervene in the procurement process. He continued by stating that "if it is a nickel-plated piano we can object, because nickel is a scarce commodity. But as to a gold-plated one, we have no reason to object; we would go and buy it. An impossible situation would arise if the Department of Defence Production challenged the right of the armed services to buy what they said they needed, and for which they provide the financial encumbrance." House of Commons, *Debates*, 30 May 1952, 2781.

[157] Minute, SEG/PS to All SEG Staffs, 22 June 1956, on A.G. Lester to CAS, 19 June 1956, LAC, RG83, vol.1, file 122-7-12-T6-0-4.

[158] A.G. Lester, "Mid Canada Line: Performance of Management Contractor – Memorandum C," 4.

[159] Minutes of the 564th meeting of the Chiefs of Staff Committee, 28 June 1954, 1-2.

[160] At Winisk, problems with the landing of supplies from the annual sealifts and difficulty in establishing adequate foundations and drainage had compounded the normal challenges of northern construction. In the summer of 1955, DCL notified the RCAF that the sealift to Winisk had delivered far less cargo than was required – by early October of that year, only some 1,500 tons of the 12,000 tons that was a minimum requirement had been landed, at an average of some 27 tons per day under hazardous conditions that had led to the loss of a barge and the death of one worker. Later accounts would bluntly describe the 1955 sealift to Winisk as "unsuccessful." See "A Digest on the Building of the Mid-Canada Line," n.d. but mid-November 1957 or later, 20-24, DHH 181.009 (D266). Both Lester and Arnold Edinborough also make reference to this situation. Lester, *Special Contract*, 205-206. Lester also describes the RCAF idea for a winter airlift of materials and

equipment into Winisk and Great Whale River in order to finish the job earlier than might otherwise have been possible as a "sound, though expensive, move." A.G. Lester, "Mid Canada Line – Performance of Management Contractor, Memorandum B: Comments on General Criticism made by D.D.P. Officials at September 16, 1957 Meeting," n.d, but possibly 29 November 1957, 4-5, DHH 181.009 (D276), vol.2.

[161] Comparable arrangements had also been adopted for the POLE VAULT communications link along the Labrador coast and for the Distant Early Warning Line. Lester, *Special Contract*, 190; R. MacLeod, Manager, Special Services Division, CM, to Secretary, DDP, attn. Mr. J.S. Brown, "Re: Proposal 63-ROZIZ-R-001, Removal of Old Polevault Equipment," LAC, MG28 III 72, vol. 101, file "Miscellaneous Tenders – SSD, Part 1," 1959-1963; Bruce-Briggs, *Shield of Faith*, 139.

[162] Memorandum, CAS to MND, "Maintenance of the Mid Canada Line," 24 October 1958, DHH 181.009 (D276), vol.2. The interim maintenance contract dated 29 January 1957 along with subsequent amendments can be found in LAC, RG83, vol.1, file 122-7-12-T6-0-7 (pt.2); Lester, *Special Contract*, 208. In his memoirs, Lester notes that "neither Bell nor the other Trans Canada companies had any desire to be permanently in the maintenance contracting business." *Ibid.*, 213. Bell expressed interest in the MCL again in the early 1960s, but this time as a system that could be modified to form part of a trans-Canada route for civil and military communications. This optimistic proposal was dismissed by the government as an impractical use of the existing MCL facilities, which were not suitable for the operation and maintenance of high-quality voice communications channels. See correspondence from August 1961 to March 1962 in LAC, RG12, vol. 2400, file 14-13-8-5 (vol.3).

[163] Memorandum, CAS to MND, "Maintenance of the Mid Canada Line," 24 October 1958; and DM DND to DM DoT, "Use of Mid Canada Early Warning Line Facilities by other than the Department of National Defence," 18 December 1961, DHH 181.009 (D276), vol.2. The contracts were renewed on a regular basis; in 1962, Canadian Marconi was still responsible for the eastern sector, and was also required to maintain a training facility in Montreal, and was to work in conjunction with CAE to provide engineering services. Marconi Agreement between DDP and Canadian Marconi, 1 June 1962, DCC in-house file 122-7-12-T6. Canadian Marconi Corporation records on the operation and maintenance contract can be found in LAC, MG28 III 72, vol. 103. Marconi's contract included the DDS, Line Clearance Aerodromes, MCL rearward and DEW scatter communications sites, re-supply marshalling areas, lake head sites and airstrips.

[164] See January 1961 correspondence in LAC, RG12, vol.2400, file 14-13-8-5, vol.3.

[165] Fletcher, "Military Radar Defence Lines of Northern North America".

[166] Steve Zaloga, *Target America: the Soviet Union and the strategic arms race, 1945-1964*, (Novato, CA: Presidio Press, 1993), 143-145; and Zaloga, *Kremlin's Nuclear Sword*, 46-49.

[167] "Report on Meeting to Review Mid-Canada Line as a Possible Transcontinental Competitive Communications System," 25 August 1961; DADSI, "Aide Memoire on Closing the Eastern & Western Portions of the Mid-Canada Line," 7 January 1964; CAS to ADM(Air)/DOT, "Telecommunications – Frequencies – Mid Canada Line – Cancellations," 19 May 1964, LAC, RG12, vol. 2400, file 14-13-8-5 (vol.3).

[168] Minimal work was undertaken to dismantle abandoned sites. While documentation of the actual shutdown and abandonment procedures has not been found, minutes of meetings held to plan the close down of the MCL suggests that economic considerations played a major role in what was to be done with respect to removal and abandonment of equipment. "Minutes of a Second Conference held in AMTS Conference Room "B" Building at 1500 Hrs 18 Dec 63 to Discuss the Close Down of Parts of the MCL," 15 January 1964; DADSI, "Aide Memoire on Closing the Eastern & Western Portions of the Mid-Canada Line," 7 January 1964, LAC, RG12, vol. 2400, file 14-13-8-5 (vol.3). Some questions about other possible uses for the facilities can be found in House of Commons, *Debates*, 1964 to 1965, *passim*.

[169] On the environmental legacies of the MCL, particularly related to impacts on First Nations, see Leonard Tsuji, J. Kataquapit, Billy Katapatuk, and Guy Iannucci, "Remediation of Site 050 of the Mid-Canada Radar Line: Identifying potential sites of concern utilizing traditional environmental knowledge," *Canadian Journal of Native Studies* 21 (2001): 149-160; Tsuji, Kelly Cooper, and Harry Manson, "Utilization of land use data to identify issues of concern related to contamination at Site 050 of the Mid-Canada Radar Line," *Canadian Journal of Native Studies* 25, no. 2 (2005): 491-527; Tsuji, Wainman, Weber, Sutherland, Katapatuk, and Evert Nieboer, "Protecting the health of First Nation personnel at contaminated sites: A case study of Mid-Canada Radar Line Site 050 in northern Canada," *Arctic* (2005): 233-240; Tsuji, Bruce Wainman, Ian Martin, Jean-Philippe Weber, Celine Sutherland, and Evert Nieboer, "Abandoned mid-Canada radar line sites in the western James region of northern Ontario, Canada: a source of organochlorines for First Nations people?," *Science of the Total Environment* 370, no. 2-3 (2006): 452-

466; Brandy Sistili, Mike Metatawabin, Iannucci, and Tsuji, "An Aboriginal perspective on the remediation of mid-Canada radar line sites in the Subarctic: A partnership evaluation," *Arctic* (2006): 142-154. For press coverage of remediation efforts for Ontario sites, see Steve Ladurantaye, “Cold War relic 'Site 500' gets costly cleanup,” Globe & Mail, 27 May 2011, updated 1 May 2018, https://www.theglobeandmail.com/news/national/cold-war-relic-site-500-gets-costly-cleanup/article581124/, last accessed 15 February 2019; Marc Montgomery, “Cleaning up Canada’s Cold War radar sites,” Radio Canada International, 6 February 2014, http://www.rcinet.ca/en/2014/02/06/cleaning-up-canadas-cold-war-radar-sites/, last accessed 15 February 2019.

Editors' Note

The document has been reproduced *ad verbatim*, with some minor grammatical edits (particularly changes to punctuation) to improve readability. Towards this end, in most cases we have quietly corrected minor typographical errors and adjusted formatting, as would any copy editor during the normal course of preparing a manuscript for publication. Readers wishing to seek an unedited version can consult the original manuscript in the Department of National Defence, Directorate of History and Heritage (DHH) archives in Ottawa, file 78/512.

We have retained the original wording in the report to preserve its integrity as an historical document produced at a specific time and bearing the biases of the era in which it was written. Accordingly, some of the terms used by the author are no longer preferred usages for people or places, such as Fort Chimo for Kuujjuaq and Frobisher Bay for Iqaluit. For example, "Indians" are today referred to as "First Nations" or by the name of their specific people (eg. Cree), and "Eskimos" as "Inuit." Furthermore, "Natives" or "Native people" are now commonly referred to as "Aboriginal people(s)" or "Indigenous people(s)."

Please note that we have not converted units from imperial to metric.

List of Acronyms

A.D.C.	Air Defence Command
A.D.C.C.	Air Defence Control Centre
A.O.C.	Air Officer Commanding
A/V/M	Air Vice Marshal
BUIC	Backup Interceptor Control
C.M.U.	Construction Management Unit
C.N.	Canadian National
C.P.	Canadian Pacific
C.S.R.D.E.	Canadian Signals Research and Development Establishment
D.C.L.	Defence Construction (1951) Limited
D.D.P.	Department of Defence Production
DDS	Doppler Detection Stations
D.E.W.	Distant Early Warning
DND	Department of National Defence
D.O.T.	Department of Transport
D.R.B.	Defence Research Board
E.C.M.	Electronic Counter Measures
Gen.	General
G.P.	general purpose
L.C.M.	Landing Craft Mechanized
L.C.T.	Landing Craft Tank
M.C.	Management Contractor
MCL	Mid-Canada Line
M.S.G.	Canada-U.S. Military Study Group
M.T.	motor transport
N.E.A.C.	Northeast Air Command

N.E.Co.	Northern Electric Company
NORAD	North American Air Defence Command
O.M.I.	Oblate Order of Mary Immaculate
P.J.B.D.	Permanent Joint Board on Defence
P.P.O.	Pinetree Project Office
R.C.A.	Radio Corporation of America
R.C.A.F.	Royal Canadian Air Force
R.C.N.	Royal Canadian Navy
R.E.L.	Radio Engineering Laboratories
S/L	Squadron Leader
S.A.G.E.	Semi-Automatic Ground Environment
SEG	Systems Engineering Group
T.C.T.S.	Trans Canada Telephone System
USAF	United States Air Force

SPECIAL CONTRACT

A STORY OF DEFENCE COMMUNICATIONS IN CANADA

PROLOGUE

> "Bell has agreed to design and build a microwave system up the Labrador coast for the Federal Government for defence purposes. A Special contract Department is being formed to carry out the work. You are appointed Assistant General Manager, heading the new Department, and you do not have the right of refusal."

Such was my introduction to the Special Contract Department of Bell Canada, an enterprise which over the ensuing five years was praised by some, criticized by many, cursed by a few; while its members planned, built and tested defence communication systems from St. John's to Sondrestrom and Thule; from Hopedale to Dawson Creek, Cambridge Bay and Pine Point.

The Department spent directly on Government account or supervised the spending of over $300 million from the time of its formation June 4, 1953 to the final cleanup of accounts in 1959, a year after the last of the projects was finished. Pole Vault - the world's first tropospheric scatter system - was carried from incomplete basic design of equipment when the contract was signed in January 1954 to operational service over a 1400 mile route, from St. John's and Stephensville via Gander to Frobisher Bay, on Washington's birthday in February 1955, thereby winning a bottle of Canada's finest whiskey for a prominent member of the United States Air Force, for whom the system was built.

Telephone distribution systems were built at radar sites of the "Pinetree" chain across Canada (sites in the West and the Maritimes by the provincial Telephone Companies) and in Greenland, one tragic result being the death of three Bell men and eight U.S.A.F. crew members - with serious injury to three other Bell men - in an air crash at Thule.

The Mid-Canada Line was built from Hopedale, Labrador, to Dawson Creek, B.C., with communication feeder links to the south and connecting links north to the D.E.W. line (Distant Early Warning) from Stoney Mountain to Cape Parry, and from Dawson Creek to Camden Bay, Alaska.

These Northward links involved two of the first ever ionospheric scatter systems, with point to point hops of 900 miles; and from Great Whale River and Winisk a Tropospheric Scatter System to connect with Bell Canada lines to the south. The Line proper included a newly designed doppler detection system, supported by a microwave communication system throughout its full length.

As part of the Mid-Canada system, 102 sites were established - eight major air stations, 90 doppler and 4 tropo-scatter installations, over a distance of 2,800 miles. Something over 200,000 tons of material were transported to and distributed along the 55th parallel of latitude. This involved transport of every sort: rail, sea, major aircraft, including 12 Cansos of the total of 14 available in Canada; helicopters, the biggest tractor train operation in Canadian history up to that time, truck, barge, canoe and dog team. There were five fatalities in the course of the Mid-Canada project: two in a helicopter crash during the very early survey work, two men drowned in shipping operations in Hudson Bay, and a suicide at Knob Lake.

This, then, is the story of Special Contract; of its accomplishments and its difficulties. Above all, it is the story of people, of seven people initially, growing to 1,254 at maximum, supervising line contractors employing another 5,500 men, then reducing to zero as the work was completed. Of people, Bell employees and others, who despite very real hardships, long hours and criticism, developed an esprit de corps which sustained the whole operation. To them I dedicate this story; for it is theirs.

CHAPTER 1

AN OVERVIEW

Provision of communication facilities for defence purposes was not a new departure for the Canadian telephone companies. During World War II the build-up of air, naval and ground defence in Canada involved construction of extensive telecommunication networks on both coasts. While the military Signal forces built local command networks, the Maritime Telegraph and Telephone, New Brunswick Telephone and Bell Telephone Companies were deeply involved in the provision of long distance facilities on the East Coast, working with Defence Communications Ltd., a crown corporation. In the West, British Columbia Telephone and [Canadian National] (C.N.) Telegraphs provided extensive facilities in B.C., while Alberta Government Telephones worked hand in glove with the American military forces in building defence facilities through Alberta and North on the Alaska Highway. Defence requirements in central Canada were met by the tele-communication companies leasing circuits to the Military as required.

With the onset of the Cold War, and the outbreak of hostilities in Korea, the defence of North America from aerial attack attained high priority in the planning of both the United States and Canada. The industrial heartland of the continent was and is vulnerable to aerial attack, particularly from the North. Hence the planning of electronic early warning systems to give time to activate close defence of major cities and military targets further South, and to launch counter attacks. The whole North American Air Defence plan (NORAD) grew out of these requirements.

Three warning lines were planned across Canada. The first, Pinetree, extended roughly along the 50th parallel of latitude, or just north of the U.S. border, except on the East and West coasts, where it swung well north. The second and third lines, Mid-Canada and D.E.W. (Distant Early Warning), extended along the 55th and 70th parallels respectively. Pinetree was a joint U.S. and Canada venture, Mid-Canada was Canadian exclusively, and D.E.W. a U.S. responsibility. In all cases, as a matter of Canadian Government policy, Canadian contractors and materials were used extensively.

At the request of the Canadian Department of Defence Production, the telephone companies installed all outside plant (poles, wire, cable etc.) at the various sites of the Pinetree chain. For communication between sites and back to operational headquarters in the settled parts of the country, three solutions were adopted. In Ontario and Quebec the R.C.A.F. decided in 1950 to install their own micro-wave system (ADCOM). Construction of this system extended over a number of years, met with many vicissitudes, and is, in fact, a story in itself. It did finally go into service as part of the defence network and operated for several years. Later (about 1964) the R.C.A.F. requested Bell to take over the system at a negotiated price. This was done, with the useful portions integrated into the Bell network.

For interconnection of Pinetree stations outside of Ontario and Quebec and for general command and administrative facilities across the country, but excluding all requirements on the Labrador coast, the Armed Forces leased circuits from the Telephone and Telegraph companies. A formula as to rental and provisioning costs was developed and agreed upon in 1950, and for twenty years thereafter a very effective working committee of engineers from C.N., C.P., and Bell allocated the furnishing of facilities between Common Carriers to meet defence requirements as specified in contracts issued by the Department of Defence Production and its successors.

The East Coast Pinetree requirement for rearward communications, plus U.S. Air Force need for circuits to Greenland, and later to the eastern anchor of the D.E.W. line at Cape Dyer, resulted in a project which became known as Pole Vault. This project in turn brought about formation of Bell's Special Contract Department, to which I was so incisively introduced.

In the Fall of 1954 the Mid-Canada (originally called Tamarac, then Mongoose) project, several orders of magnitude bigger than Pole Vault became a Special Contract responsibility. During this period also outside plant work at several U.S. Air Force locations in Newfoundland and Greenland was undertaken.

The main concentration of Special Contract, however, was on Pole Vault from mid-1953 to mid-1955, and on Mid-Canada from the Fall of 1954 to its operational stage in mid-1957.

Pole Vault was a bold and joyous adventure for the new Department; new technology, the first such system in the world, challenging climate and logistics, and most importantly, a clear mandate from the United States Air Force, via Canadian Commercial Corporation and the Department of Defence Production, to get on with the job with full responsibility and commensurate authority.

Mid-Canada started in the same atmosphere, but it developed into a grim battle, or rather two battles. The first was with the physical problems of climate, transportation, design, material, people; all the elements involved in building a major network for 2800 miles across the Northern wilderness and building it in a hurry. That battle we won, we meaning the whole team - contractors, R.C.A.F., Department of Defence Production, Department of Transport, Defence Construction Limited, and other Government Departments as well as Special Contract. The line went into full operation between May and August 1957 - several months later than the target date, but in line with opinions expressed early in the day that mid-1957 was a more realistic service date than the January 1st goal which the Chiefs of Staff had set. In view of the fact that the last of the design work was only received in the Spring of 1957, and that the line west from Hudson Bay was actually ready in the Fall of 1956, the overall result, in my opinion, must be considered satisfactory from a timing standpoint.

To quote Mr. Ralph Campney, the Minister of National Defence:

> As a construction feat alone, (the line) will have an impact on the development of the Canadian North commensurate with that which the building of our transcontinental railway lines at the turn of the century had on the opening up of our Canadian West. In establishing these protective and early warning lines to meet the threat of thermonuclear war, we are rolling back the map of Canada more rapidly and to a far greater degree than our people realize.

Sonorous words indeed and perhaps too fulsome in their prophecy. But Mr. C. D. Howe too, Minister of Defence Production, and no mean judge of things technical, said he considered the line one of Canada's outstanding engineering achievements.

The second battle was for direction, control and coordination of the project. At best this was a draw between Special Contract, the R.C.A.F., Department of Defence Production and Defence Construction Ltd. Starting with a mandate to Special Contract to be fully a Prime Contractor the Government Departments rapidly changed to a view that they could not delegate full authority for a project of this magnitude. Special Contract on the other hand, while recognizing the necessity of Government retaining overall policy and design responsibility, felt its own responsibility was to get the job done, and chafed at the watered down and ambivalent authority with which it was expected to accomplish this.

Thus began an era of confusion and frustration on all sides, with conflicting responsibilities and authorities, both in our own activities and in dealing with contractors. It was perhaps, to quote one who was deeply involved, "Democracy in action." If so it was a wearing, time consuming, expensive, and at times acrimonious substitute for clear cut, directly delegated responsibility and authority to get the job done. Of this more hereafter.

Chapter 2

A Cry for Help

The problem was to provide lateral and rearward communications for nine radar sites, part of the Pinetree chain, extending from St. Johns and Stephensville (Harmon Field) through Gander and up the Newfoundland and Labrador coast to Goose Bay and Frobisher Bay - a total distance of 1400 miles. The coast is bleak, rugged and virtually unsettled, as a glance at the map will show. It is also subject to heavy and long lasting fog - an element to give pause to shipping; also to successful propagation of radio signals. Sites had to be accessible by air and/or sea, with sufficient amenities provided at each site to support life for considerable periods. The whole pointed to a project which would be:

(a) logistically difficult,

(b) very expensive, and

(c) would demand the greatest care in transmission design, structural design and overall reliability so as to establish permanent high quality communications.

In May of 1952 I had been loaned from the Bell company to the Electronics Division of the Department of Defence Production. Soon after arrival, I found that a substantial part of the Division's activity had to do with implementation of the Pinetree project, working with the Pinetree Project Office (P.P.O.). This was an organization containing American and Canadian Air Force and Engineering officers along with civilian Canadian representatives, their job being to direct the design and installation of the complete Pinetree chain of stations. The solution to the Labrador communication problem proposed by this group and being considered by D.D.P. was to modify a tactical micro-wave system which had been used for rearward Army communications during the last phase of the European war. It was a development of the Canadian Signals Research and Development Establishment (C.S.R.D.E.). While recognizing that the system had limitations as a permanent communications facility, C.S.R.D.E. and the Signals people in P.P.O. and D.D.P. were extremely anxious to have it updated in design and used for the Labrador project. They had in fact pretty well persuaded the U.S.A.F. to go along, though reluctantly.

The requirement for communications was urgent. The untried nature of the C.S.R.D.E. system, however, and the fuzzy, vague planning and scheduling which was going on to fill this requirement disturbed me, and generated a feeling that a competent outside agency should be charged with clearly defined responsibility and authority to provide the facilities, by whatever reliable means, for a specific date.

I therefore approached Mr. T. W. Eadie, at that time Vice President, Operations, (later President and Chairman) of the Bell Telephone Co. of Canada, and asked him to consider offering Bell's services for this purpose. He agreed to investigate, and discussions ensued between Mr. Eadie and Mr. Howe, and between other senior people in Bell, D.D.P., and P.P.O.

The dialogue extended over two periods, from August to November 1952, and from April 1953 to a formal contract dated July 23 of that year. During the earlier period detailed consideration was given to a number of alternative approaches regarding organization to do the job and the type of communication system to be used. As to organization, after considerable thrashing around in P.P.O. and D.D.P. three possibilities seemed to emerge.

(1) Recruit an engineering staff into P.P.O. or form a Crown Corporation along the lines of Defence Communications Ltd. in World War II. In other words have a Government agency do the job directly. Much of the staff would have to come from Bell.

(2) Turn the project back to Washington and indicate that Canada was not equipped to carry it out.

(3) Enter into a contract with Bell, as being probably the one organization in the country with adequate trained personnel to do the job.

Senior Government officials did not want to establish a new organization of the Defence Communication type, nor did they wish to greatly enlarge P.P.O. So Plan 1 was out. While there was a feeling in certain quarters against Canada taking the job on at all, the Canadian Government as a matter of policy had on many occasions stressed to the Americans their desire to have as much as possible of the work required by the U.S. in this country for defence purposes done by Canada itself. Consequently Plan 2, which reversed that position, was unattractive.

Plan 3 appeared to be the logical approach. Assuming that Bell, like Barkus, was willing, there remained the second and equally vital problem - what kind of communication system should be employed? The discussions were long and hard. Except for short stretches in the South, land line construction was impossible. Submarine cable was a possibility, but the technology of the time would have limited capacity to a few circuits. Laying the cable in the shallow, storm tossed waters above the continental shelf would be hazardous, and bringing the cable ashore at the six radar points up the coast extremely difficult, with no assurance that the severe ice conditions and heavy tides (forty feet in Frobisher Bay) would not result in many breaks and hence long inter-ruptions in service.

Micro-wave seemed to be the answer, but of what design? Bear in mind that in 1952 microwave was still a comparatively new instrument, though substantial systems had been built into the commercial telephone network in North America and to a degree in Europe. But the designers and engineers were feeling their way, hence the need to weigh carefully the reliability of any system proposed for this important requirement, recognizing that it was to be built in a very rugged and isolated part of the world.

It was proposed to do the project in two stages, with a system capacity of 36 telephone circuits or their equivalent:

(1) A microwave system from Gander to Goose Bay, a distance of 700 miles;

(2) Extension Northward from Goose Bay to Frobisher Bay. Later extensions were to be made southward to St. John's and Stephensville. Total overall length of the system would be 1400 miles.

Overall cost of the project was estimated at $41 million.

Bell made it clear at the outset that its recommendations would be chosen from proven microwave systems, making full use of the extensive experience and advice of the American Telephone and Telegraph Co. and Bell Telephone Laboratories. Review with A.T.&T. and Bell Labs people confirmed Bell's own opinion that the microwave system best able to fill the requirement was the T.D.2-4000megahertz system - the same as then (and now) widely used in the continental telecommunication network. This system, normally of large capacity, could be engineered on a "thin route" basis to provide the facilities required. The problems of access to sites and consequent site cost were of course common to any system chosen.

On November 4, 1952, Bell advised D.D.P. of its willingness to undertake "engineering advice and services" on this basis. A follow up meeting in Ottawa the next day, however, revealed that D.D.P. and the Pinetree office, working with several Canadian manufacturers and with the reluctant agreement of the U.S.A.F., were some distance down the road towards deciding on the unproven 2000megahertz C.S.R.D.E. system.

In view of Bell's conditional proposal, and after consultation with Mr. Howe, Mr. Reginald Brophy, Deputy Minister of D.D.P., decided that the whole matter should be reviewed again in Washington with Defence and other Government officials there.

There ensued a great silence, as far as Bell was concerned, for five months, from November 1952 to April 1953. Then on April 2, 1953 D.D.P. wrote to Bell and to several other firms inviting proposals to manage Phase I of the project - i.e. Gander to Goose Bay. The letter said that it had been decided by the Design Authority (P.P.O.) to use a 2000/400megahertz frequency diversity system for Phase I. Frequency diversity meant that the system would operate at 2000 or at 400 megahertz depending on transmission propagation conditions.

P.P.O. and C.S.R.D.E. had won their point, for it was the C.S.R.D.E. system, still not proven and not completely designed, which had been decided upon. Some survey work had been done and systems specifications had been prepared by the design authority. Propagation tests and construction specifications were still to come. In the meantime the target date for the system, originally 1953, had of necessity slid to 1954.

Bell was in a quandary. On the one hand, there was very real doubt as to the feasibility and quality of the C.S.R.D.E. system; consequently the hazard that the project would be a complete failure, with serious results to the Military, and harm to the reputation of all concerned, including Bell. On the other hand, the sense of being a good corporate citizen, of pride in technical ability, plus an element of old-fashioned patriotism - a word somewhat out of vogue nowadays - prompted them to take on the job. Before making the commitment, Mr. Eadie reviewed the whole situation with Mr. Howe, who seemed to be a party to every important Government decision in those days.

Bell made it clear that they would undertake the management of the project only if the risks that were being taken as to an untried system were understood and acknowledged. Those risks were the same as already being experienced in another Air Force project, namely ADCOM, which was to connect Pinetree stations in Quebec and Ontario with a microwave system, and which the R.C.A.F. had undertaken in 1950.

Finally in a letter of April 30th to D.D.P., Bell made the firm commitment that it would "undertake the management of Phase I of the microwave project in the Northeast Air Command area outlined in your letter of April 2nd, 1953." Bell was to be paid its direct costs plus a management fee of $250,000.

Functions for which Bell and others would be responsible were laid out in this April 30th letter.

> (i) "The Pinetree Project Office will have responsibility for all basic design considerations as set out in the System specification. There will be no responsibility on our part in this connection.
>
> (ii) "This Company will not have responsibility towards overall system performance; our responsibility will be limited to ensuring that the various major components, when installed, meet the performance requirements covered in the various specifications.
>
> (iii) "Certain electronic manufacturers have already undertaken design work to bring the specifications on the radio equipment and the related control and alarm equipment to the point where manufacture can begin. This work includes the complete development of major equipment and apparatus assemblies such as

> transmitters, receivers, control units, alarm systems, etc. This Company (Bell) would have responsibility to develop the necessary arrangements to interconnect the basic assemblies with other components such as power plant and multiplex equipment into a complete station layout.
>
> (iv) "A source of supply of power plant equipment to meet the specification is available.
>
> (v) "Sources of supply for the type of telephone multiplex equipment specified are available.
>
> (vi) "Factory inspection and test would be carried out by the Defence Inspection Service, but we would participate in such work.
>
> (vii) "Bell agrees to perform the Contract in accordance with the plans and specifications as supplied or approved by the Design Authority and will ensure that the various major components when installed will each in itself meet the performance requirements of the said Plans and Specifications, but inasmuch as Bell is not the designer of the micro-wave system it is understood and agreed that Bell will not be responsible for its overall performance."

Bell had done its best to clarify its role. In effect it was saying: "You are responsible for design and specifications although we will help with certain items. We will undertake full management of the project to completion in accordance with your specifications."

What response the other companies made to D.D.P.'s April 2 invitation to tender I do not know. Bell was accepted as Management Contractor. Meetings followed to familiarize all concerned with responsibilities, authorities and relationships between companies and agencies. The most important directive as far as Bell was concerned was given by D.D.P. at an Ottawa meeting on June 16th.

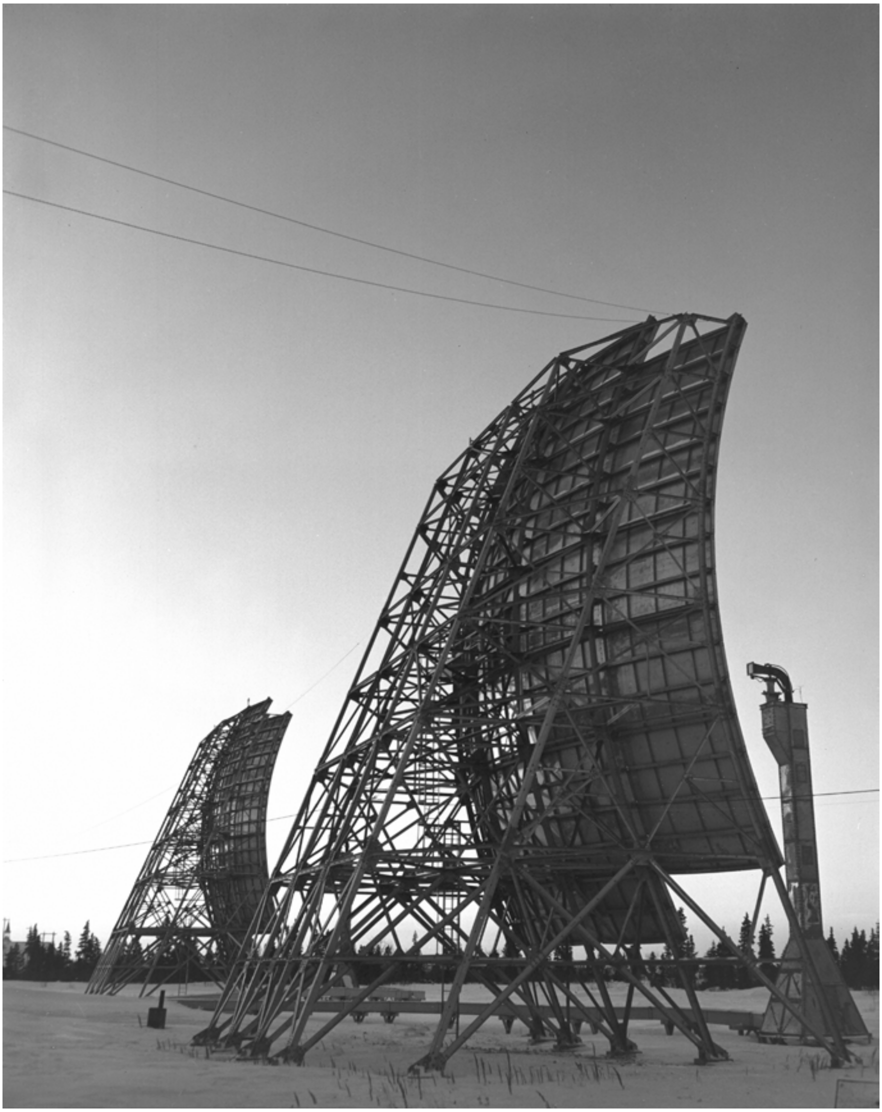
> "The Bell Company will be the prime contractor and all other work will be on the basis of subcontracts from Bell. These subcontracts will be in accordance with D.D.P. procedures and require D.D.P. approval before action is taken."

D.D.P. stuck to its word. Bell was in charge, and was seen to be in charge -perhaps of more importance. An equally unequivocal statement and follow through for the Mid-Canada project would have saved much confusion, frustration and cost.

A letter of intent covering the main features of the contract was sent to Bell by D.D.P. on July 23rd. The final contract, also dated July 23rd, followed. The die was cast. Bell, through its Special Contract Department, which had been established

June 4th, would be deeply involved in building defence communications for the next five years.

My cry for help had been answered, as I had hoped. Perhaps there was a certain amount of poetic justice in my being appointed to head the team which answered the call.



Chapter 3

Riding Three Horses

Summer and Fall is the best time of the year in Canada's Maritime provinces. Winter is damp and cold; Spring is late due to the ice coming down the coast from the North. But from July through October the weather is hard to beat; clear, balmy days, seldom un-comfortably hot, and towards Fall gradually cooler with bright sunlight.

In the middle of this idyllic weather we were flying up the coast of Newfoundland and Labrador as far as Goose Bay. It was September 1953, and Cliff Frost, my construction engineer, and I were looking over the sites which had been picked by the Pinetree Project Office for microwave towers and equipment. Twillingate, Grey Island, St. Anthony, Battle Harbour, Hawke Harbour, Cartwright; the outports stretched out below our Norseman plane. The coast is dented with bays, with small islands offshore. No deep fjords here like the British Columbia Coast or Norway, but plenty of steep coastal cliffs and rocky outcrops. As we cruised at about a thousand feet the updrafts at the cliff edges bounced our small plane. Out at sea the sun glinted on dozens of small remnants of icebergs and growlers. Here and there we could see a whale spouting.

It was a peaceful scene from the air. On the ground the reality of the problems of building and maintaining radio relay towers and sites on top of those promontories and islands was born in upon us. Ship docking facilities were non-existant, so off loading arrangements would have to be made, whether by temporary docks or lightering. In practically all cases road work would be needed from the off loading point to bring in heavy construction equipment as well as provide for future servicing of the station. In a number of locations roads would be impossible due to steep grades, so ropeways would be required. Obviously the time factor would be difficult and costs would be high.

One interesting episode was our arrival at the dock of an isolated outport to find the whole village population lined up to meet us. We were pleased but rather startled until we found that they thought I was Joey Smallwood! However, they managed to conceal their disappointment at the arrival of this much less important party, and were very hospitable to us.

Cliff (C.E.) Frost was one of the original members of Special Contract. As Construction Engineer he was in charge of the building of physical structures, whether towers, buildings, roads, airstrips or whatever. He dealt with construction and transportation contractors and through a staff of field engineers supervised their work. Since nothing in the way of a finished system could be produced without physical structures on site, and since those sites were invariably difficult of access and terrain, his job was a vital part of the department.

Other members of that initial team were:

- Don (D.J.) McDonald, Transmission Engineer, in full charge of transmission systems planning and coordination of all elements of the electronic apparatus to make sure the systems worked.
- Doug (D.J.) Pepper, Equipment Engineer, in charge of engineering all equipment details, i.e. equipment specifications, arranging for supply of equipment through D.D.P. or direct, installation on site and testing. We were dealing with a large number of equipment suppliers, some not familiar with the tight tolerances of tele-communications requirements, so coordination of the whole equipment and transmission situation by McDonald and Pepper was of vital importance.
- Gordon (W.G.) Dewar, Contract Coordinator, an essential function, for in the course of its history Special Contract was involved in hundreds of contracts, from major construction contracts to ships chartered into Hudson Bay; from acquiring landing craft from the British Navy to buying travelling wave tubes in California, diesel engines in England, and hiring Indians [First Nations people] to construct roads in Western Canada.
- Percy Lawrence, Accounts Supervisor. Percy was borrowed from the Accounting Dept. of Bell to keep all the engineers straight on accounting procedures - no mean task.
- Bob Booth, a lawyer who had worked for years in Bell's right of way group, and whose job was to vet contracts and agreements for the new Special contract Department.

This group of "founding fathers" was strengthened later by a number of key people, but for the moment they were at the hub of the wheel. The Department was being rapidly fleshed out behind them to handle the work load.

But back to the Labrador coast. Bell's contract called for us to perform and supply:

> Services, Engineering, Materials, and logistical support necessary to survey and construct the stations for a 36 channel microwave system between Gander, Newfoundland and Goose Bay, Labrador.

The work was to include "detailed engineering, procurement, construction, installation and testing to a master schedule; the placing of suitable sub-contracts-------and the testing of the microwave system and its connection to other systems as arranged for by the Crown.

Bell had also agreed "to assist the Design Authority (P.P.O.) in the preparation of plans and specifications for construction, equipment, coordination and installation of the work,-----to prepare to the extent required by the Design Authority surveys of the sites including the means of access thereto-----engineer and construct on the sites towers, buildings and associated structures-----to produce, deliver and install on site all necessary equipment-----to provide technical manuals and complete records."

Bell was to "use its best endeavours to complete the work provided for in this contract by the 30th of September, 1955."

Twenty sites were involved, including Gander and Goose Bay, spread along 700 miles of coast line.

As of the end of June (1953) when Bell started to operate as prime contractor, the Design Authority had available aerial survey maps of the sites, with sufficient detail to establish tower locations fairly accurately. Arrangements were under way to have Defence Research Board engineers carry out radio Propagation tests, the results to be made available to Bell. No ground survey or detailed site specifications had been made up to that time, but these were to be gone ahead with through the summer according to P.P.O. plans, so that on site construction could proceed in 1954. Surveys would have to include soil testing (rock testing at most of the sites) as well as determination of precise location for tower, anchors and building at each site. Anchors were particularly important, for winds of over 125 miles an hour had been measured at some locations on the East Coast.

Our hedge-hopping flight up the coast gave us an overall look at the route, and ground survey teams did a substantial amount of the detailed site investigation work during the Fall. However, other winds were blowing on this project. In the final analysis the only two sites where substantial construction took place were #117 and #118 - the two sites closest to Goose Bay.

The basic difficulty, as we had feared, was the microwave system itself. Three major equipment manufacturers had been chosen to redesign the equipment forming the C.S.R.D.E. system:

- Canadian General Electric Co. for 2000 megahertz equipment
- Canadian Westinghouse Co. for 400 megahertz equipment
- Canadian Marconi Co. for fault arrangements and various miscellaneous items

Multiplexing equipment, which would be superimposed on the radio system to provide the necessary number of circuits, also power equipment and towers, were not a problem, since well designed standard items were commercially available.

Bell had the job of riding these three horses, and coordinating their efforts so that compatible radio equipments could be integrated into a complete microwave system. What this really meant was that as of that point in time there was not a completely designed, let alone proven, system; that in fact design of the components and basic sub-assemblies needed more work. So a long period of concentrated design, engineering coordination and testing was required before we would have a system suitable and reliable enough to install in these isolated locations on the East Coast.

The engineers tackled the problem with a will. McDonald, Pepper, Krupski, Inkster and others in Special Contract worked with their opposite numbers in the three manufacturing companies. Gradually the major "bugs" were sorted out, and a system design started to emerge. But it took many months. By the spring of 1954, we had established a test line between the Bell building on Beaver Hall Hill in Montreal and Ormstown,[1] and it worked – on a trial basis. Obviously, however, it would take many more months of intensive systems desisn and testing before, as responsible engineers, we would be prepared to have equipment manufactured to the final design and installed to fill this important defence requirement between Gander and Goose Bay.

The problem was overtaken by events. By the end of 1953 introduction of the new Tropospheric Scatter technique changed the whole plan and speeded up the schedule.

Work continued on the microwave system design through much of 1954. Finally, however, when it became obvious that the Scatter system was going to be successful, the microwave work was closed off, and the equipment involved returned to the Government departments. In total just over $3 million was spent on this microwave system.

[1] *Editor's note:* Ormstown is a municipality on the Chateauguay River approximately one hour southwest of Montreal.

Chapter 4

Pole Vault - Off and Running

Every good General has a back-up plan in case his first plan of action (in this case the microwave system) goes awry. The senior officers of the United States Air Force were good Generals, and they had developed a back up plan which now came into operation. Back in August 1952, when the idea of Bell taking on the East Coast project was first broached, Bell reviewed thoroughly the available technology with their associates in American Telephone and Telegraph Co. and Bell Telephone Laboratories. In fact, as mentioned earlier, their acceptance of the Canadian Government request to manage the project was conditional on availability of support from these two important groups.

In the course of these discussions Bell learned that experiments were taking place on a concept called over the Horizon Microwave. Bell Laboratories, Lincoln Laboratories and others were involved, including several manufacturers. The newly proposed technique seemed to hold promise for use in remote areas, where access was difficult. It was obvious, however, that with a 1953 service date it would not be possible to employ any such new techniques for the first phase of the East Coast project, i.e. from Gander to Goose Bay. So a conventional microwave system was considered essential for this phase, as we have seen. However, there was hope that with a further year's experimentation, the new technique would be sufficiently advanced to permit its use for the Goose Bay to Frobisher section. It might also be used as a supplement or even substitute for the initial microwave system, giving a complete network on the new basis from St. John's and Stephensville to Frobisher Bay.

What was the new technique? Like Christopher Columbus, tele-communication engineers know that the earth is round. While long wave (low frequency) signals tend to follow the curvature of the earth, ultra high frequency waves or microwaves travel in a straignt line. Their full reception at normal tower heights above level country is therefore limited to the horizon, or about 30 miles. Higher elevations permit some increase in this distance, but in general microwave relay station spacing averages 30 miles or a little less. The radio signals are transmitted from each tower at a power of one-half to five watts, generally five watts in modern systems. The beam is very directional, and is picked up almost in its entirety by the receiving antenna at the next relay point. There it is amplified again and sent on its way. A wide band of frequencies can be transmitted over these systems, giving capacity for many circuits.

The concept of over the horizon transmission is that by greatly increasing the strength of the signal - by 500 up to 10,000 times - the microwaves can be projected in a straight line beyond the horizon towards the troposphere, and reflected from that layer of the atmosphere down to a distant point. Experiments showed that a large dish type antenna 150 or more miles away would collect sufficient of this reflected or "scattered" signal to provide a useful number of telephone and telegraph circuits of high quality.

As indicated, initial experimentation had been going on in early 1952. It was important, however, that full tests under field conditions should be undertaken. Bell agreed to furnish the manpower to do the tests under cold weather conoitions, with Bell Laboratories analysing the test results. The field work was carried out in Newfoundland, with Bell as a sub-contractor to Bell Laboratories, and J.V. (Vern) Leworthy in charge of the Bell team. Tests started in the Fall of 1952 and carried on for approximately a year. Parallel tests were going on in the Southern States. Results showed that while at frequencies of 2000 to 4000 megahertz transmission was poor, in the range of 500 to 1000 megahertz, good transmission was obtained over distances of 150 miles or more.

By the Fall of 1953, Bell Laboratories and Lincoln Laboratories were satisfied from the test results that the system could be used and would yield a sufficient number of circuits. Distances of 150 miles looked quite possible with the proviso that if this proved to be too ambitious, intermediate stations could be installed at the half way points.

The United States Air Force, concerned about the timing, cost and quality of the C.S.R.D.E. microwave system, decided to advocate a change of the whole project to the Tropospheric Scatter system. Since the radar stations of the Pinetree chain up the Labrador coast were approximately 150 miles apart, the Scatter relay points could be coincident with the radar sites themselves. This, of course, would greatly simplify manning, maintenance and cost. It would also in all probability reduce the initial problems of logistics and construction on site. To install a conventional microwave system from St. John's to Frobisher would require 50 relay points (30 miles apart), the vast majority of them at isolated, completely new locations, with consequent difficulty in off-loading of ships and/or planes, site preparation, construction and movement of personnel. It was also evident that overall costs for the microwave system would be well beyond the estimate of $41 million, and that the time schedule would be substantially extended.

On the other hand, the Scatter system would involve ten locations only, all at existing sites where the basic amenities of life had been established, and there were logistic facilities. Separate buildings and power plants to service the new system would be needed, plus elaborate antenna structures, but the whole project appeared more cohesive and do-able.

These discussions and experiments took place on a confidential basis until the U.S.A.F. were convinced of the viability of the concept. General Blake of the U.S.A.F. then undertook to cover the new approach with the Pinetree Project Office, with the objective of having it approved by the first of the year. He was as good as his word. Some members of P.P.O. and D.D.P. continued to have strong feelings in support of the C.S.R.D.E. system, and insisted, quite logically, that until the Scatter technique was further proven, work should not stop on the microwave design. This overlap extended through most of 1954, when it became clear that "Scatter" was going to be successful.

The underbrush had been cleared, and from January 1954 it was a drive to the finish - Washington's Birthday, February 1955. An adjustment to the Bell contract was agreed upon, specifying, as an *addition* to the microwave system, the provision of a Tropospheric Scatter system of "up to 36 channels" from St. John's and Stephensville through Gander and Goose Bay to Frobisher Bay. In actual fact, the system placed in service in February 1955 provided 36 channels as far north as Hopedale, with 24 channels from there to Resolution Island and 12 from Resolution to Frobisher. Increased capacity was added during 1955, as will be seen later. Bell's fee for the job, microwave plus Scatter, was to be $500,000. Part of the fee was absorbed by indirect costs, so the profit involved was very modest.

It had been pointed out by Bell Laboratories that none of the equipment used in the Newfoundland tests or available elsewhere for purposes of this system was of standard Bell System design. In view of the urgency of the project, we would have to utilize any suitable sources, such as those used for the field trials. The two major suppliers proved to be Radio Engineering Laboratories of Long Island City, for radio equipment, and D.S. Kennedy Co. of Cohasset, Mass. for the antenna structures.

Radio Engineering Laboratories was at that time a small electronics manufacturer, with two or three very capable engineers in charge of design. They were already working with some of the U.S. scientific agencies on problems of bouncing radio signals off the moon, and they were well advanced in design of radio equipment for the Tropospheric Scatter system. For the distances involved they proposed final amplification to 10 kilowatts at each transmitter - i.e. 2000 times the power output of a standard T.D.2 system transmitter. In later Trope systems, power output varied depending on the distance involved. The shot from Cape Dyer [on Baffin Island] to Thule [on Greenland], for example, a distance of 600 miles, used an output of 50 kilowatts. For our present purposes, however, the 10 kilowatt output was specified, and in the event proved satisfactory, even for the longest span of the system from Saglek to Resolution Island, a distance of 236 miles.

The D.S. Kennedy Co. was an engineering firm specializing in radio antenna design and fabrication. They had designed and built the 28 foot dishes used in the

Newfoundland trials. The new antenna dishes were to be 60 feet in diameter, structured of aluminum alloy members assembled to give a paraboloid shape.

We had been set a nearly impossible schedule. The Bell contract signed on January 7, 1954 said "Bell shall use its best endeavours to complete that part of the work comprising the tropospheric radio relay scatter system by the 31st day of December, 1954." So we had one year to carry a project in a remote part of North America from incomplete design to operational service. The urgency was real, for military readiness demanded the availability of early warning from the radar stations on the coast. Without rearward communications, information brought in by the radar sweeps was, of course, useless.

The key factor in organizing the project obviously had to be logistics, which in turn was dominated by climate. The Labrador current sweeps south between Greenland and Baffin Island, through Davis Strait, and down the Labrador coast. In Spring it brings with it icebergs, continued cold weather and fog, resulting in a late Spring in Newfoundland and Canada's other Maritime Provinces. More important for us, the icebergs and fog present a severe hazard to shipping, and in the case of fog, to air travel as well. This, coupled with the fact that the ice does not go out of Hudson Strait or Frobisher Bay until July 25th or sometimes early August, meant that our whole plan had to be based on having procurement completed and materials brought to the sites in a very precise schedule. Our goal was to have construction started on the northernmost sites by August so as to complete the whole project on time.

Tight planning was essential. Implementation of the project divided itself into four phases. Phase I was design and procurement. This meant a full out attack on design problems in the first two months, so that procurement contracts and orders for all materials could be placed in time to meet the shipping schedule.

Phase 2 was the whole logistic sequence, involving movement of all materials to site, essentially by sea, and under Bell's own direction. The Northeast Air Command had indicated that they did not wish to be saddled with responsibility for provision of sea or air transport for this project, except on an emergency basis. It was therefore up to Bell to charter ships and aircraft, and to schedule them to get the materiel from suppliers on time, matching materiel arrival with engineer and contractor presence on site to enable construction to proceed.

The third phase, of course, was on site construction and installation of equipment. It meant engaging suitable contractors for on-site work well ahead of time, arranging contractual details with them and transporting their personnel and tools to site, so that they could proceed as soon as building materials became available. Scores of problems occurred with contractors' personnel, of course, one of the persistent ones being security clearance. This was not a problem if a man stayed

on one site, but as soon as he moved to another site he had to be cleared to secret - a long and laborious proceeding.

Finally the fourth phase was the overall systems tests to ensure serviceability, and the cutover of the system for operational use. This was to be followed by initial run in maintenance by Bell, who at the same time would train military personnel to take over maintenance on a permanent basis. In turn this involved preparation of complete installation and maintenance manuals for continuous operation of the system.

For the first two or three months, Cliff Frost, Doug Pepper and Don McDonald concentrated on design and procurement problems, which in Frost's case included the important task of choosing construction contractors. In parallel with this, staff was being built up within the Special Contract Department to handle the work load, both as to transmission and equipment details at headquarters and with suppliers, and to supervision of physical construction on site.

We initiated discussions with the Radio Engineering Laboratories (R.E.L.) and with the D.S. Kennedy Co. a few days after the Bell contract was signed on January 7th, 1954, and arrangements were made for McDonald and Pepper in the case of R.E.L. and Frost in the case of Kennedy, to work closely with these companies on design problems.

Stemming from these discussions, Kennedy made a firm price quotation on January 30th for 36 antenna and horn structures, two for each of the three terminal points - St. John's, Stephensville and Frobisher - six at Gander, a three way relay point, and four at each of the other stations. On February 10th Bell accepted their quotation by a letter of intent. The contract covered antenna and horn assemblies, inspected, packed and ready for shipment - 10 complete units by July 15th, 8 units on each of August 15th, September 15th and October 15th, and the last two units November 15th, 1954. An allowance for tooling and a complete set of drawings was also included.

Bell undertook to assist Kennedy in expediting delivery of materials but the prime responsibility remained with Kennedy. The contract included a specification on electrical and mechanical requirements. Electrically the 60 foot dish antenna was to be designed for maximum transmission gain, but with minimum gain of 33 decibels at 565 megahertz, highest operating frequency to be 1000 megahertz. The dish was to be of paraboloid shape, with focal length of 25 feet. A reflector shape other than paraboloid was acceptable provided it would produce an equivalent gain. The unit was to be capable of transmitted power of approximately 20 kilowatts continuous wave, reflectivity of surface to be such that not more than one per cent of the incident power would be absorbed by or transmitted through the reflector at 1000 megahertz.

Mechanically, the dish was to be able to withstand, with minimum distortion, one inch of ice with 100 knot (115 miles per hour) wind, or no ice with a 120 knot (138 mile) wind. Design of the principal supporting structure - i.e. feet and rearward struts - to be such as to withstand ice loading of three inches measured radially. Design was to be rugged, to cope with rough handling as well as the winds on site, also reasonably light to facilitate erection without heavy crane equipment. Complete sandbag testing or its equivalent was to be performed on one antenna by the manufacturer to ensure that mechanical specifications had been met.

The R.E.L. contract, entered into at this same time, covered essentially the same kind of detail, but in this case, naturally, concentrated on the electrical and electronic performance features of the transmitting and receiving equipment. Ruggedness of mechanical design and packing, and the same tight completion schedule was imposed, with shipment starting in July and continuing through the Fall.

Bell engineers worked alongside the design teams of these two major suppliers of radio and antenna gear. Similar close attention had to be given to other equipment suppliers, and to drawing up complete plans and specifications for buildings, power installations and foundation structures for the elaborate antennae which were required.

Interestingly, the first problem we had with R.E.L. had nothing to do with design. In face we had very few problems of design or manufacture with this very competent company. No, the problem was money. Bell had given them a contract covering in the order of $6 million of manufactured goods, but they did not have the financial resources to get started. The banks were the obvious place to go for credit. However, a trip to two of New York's leading banks by R.E.L. representatives and myself was fruitless, despite the contract with Bell Canada, who in turn had been engaged by the Canadian and United States Governments! What price financial reliability? Finally the difficulty was solved by the board of directors of Bell guaranteeing the loan, after which, of course, the venturesome bankers were pleased to provide this get started financing. I am sure they never regretted it, for R.E.L. later went on to supply Scatter systems for the White Alice project[1] in Alaska and for many other systems in Europe and Africa.

The Kennedy Company did not have that particular kind of problem, but there proved to be some very real problems in design of the large antenna dishes. These were in two areas - safety factor and welding. In their initial design calculations Kennedy simply extrapolated their previous calculations for the 28-foot dish in proportion to the larger area. Also their concentration seemed to be on an aerodynamic structure, whereas this had to be secure to the ground and stand up under pressure from very high winds and substantial ice load. Working with Kennedy, Bell engineers succeeded in having the dish proper substantially strengthened in design. However, the heavy rearward struts supporting the whole structure were found in the field to be inadequate, consisting of butt-welded aluminum tubing. Several of these struts collapsed later under wind pressure, to the point that we replaced them with steel box girders at all high wind locations.

Welding aluminum is a difficult operation. The heated metal tends to draw towards the joint, thus weakening the adjacent structure, and unless metal is added, resulting in cracks. We had a lot of difficulty with this, finding cracks at joints in dishes before they had even been erected. It was the cause of a lot of discussion and argument with the supplier, and for a considerable period we held up payment for some of his work as being unsatisfactory. But I could get no support from my Government associates, so the bills were finally paid.

I must, however, give good marks to both these contractors, as well as others supplying diesels, building materials, etc., for their diligence and cooperation in

[1] *Editors' note:* The White Alice Communications System was a tropospheric scatter communications system that operated throughout Alaska from 1956-79. The system was designed by AT&T and built by the Western Electric Company from 1955-58.

meeting extremely tough delivery dates. Without their outstanding efforts, also those of the on-site construction contractors, the project would never have been completed in 13 months, as it was.

What of the other materiel? Suppliers for multiplex and power equipment, and for the hundred and one miscellaneous items needed on a project of this type, were identified, contracts let and orders issued during the winter months, to be ready for spring and summer shipment. Every piece had to be identified and procured, for at places like Saglek and Resolution Island there was no convenient Bell supply warehouse, or corner radio or hardware store to supply minor items someone forgot. If it was forgotten, it had to be sent in on the next charter flight, losing precious time and costing a lot of money.

Basic plans for the radar sites were available from the Northeast Air Command, but specific on-site locations for the scatter structures and associated buildings were determined by survey teams under Bell direction. Complete building and foundation plans were then drawn up for each of the ten sites.

Organization of the Special Contract Department for the logistics and construction phase of the project was based on three focal points, Montreal, Gander and Goose Bay. At department headquarters in Montreal, Cliff Frost, assisted by design, construction and scheduling people, was in full charge of construction and of movement of all material to sites. Field supervision of construction and movement was directed from two bases - Gander, with Max Narraway as District Engineer, and Goose Bay, with Russ Parke as District Engineer. Gander supervised the southern group of sites, and Goose Bay the Northern group, with site engineers at all locations to oversee detailed work of the construction contractor. Narraway and Parke reported direct to Frost.

The principal construction contractors were:

Frobisher Saglek Hopedale	A.F.Byers Co.
Resolution Island	Drake Merrit Co.
Goose Bay Cartwright St. Anthony	T.D.K. Rooney Co.
Gander	Pentagon Construction Co.
St. John’s Stephenville	Allied Construction Co.

The Rooney Co. also had responsibility for placing and installation of diesels at all sites, working closely with the Northern Electric Co. The Rourke Construction Co.

erected the antenna dishes at all sites on concrete pedestals built by the general contractor. Crawley-McCracken was the on-site catering contractor.

For equipment, Doug Pepper was in full charge from Montreal; he and his engineers wrote specifications, arranged contracts endorsed by the Department of Defence Production, dealt with suppliers, expedited delivery of materials and ensured that equipment - all equipment - was ready in time to mesh with the logistics plan. When equipment installation started, two of Pepper's men were at each site to ensure that equipment was installed to meet the system specification. On the side, they also set up a ham radio network between sites and back to Montreal that served us well throughout the project.

Working principally through ships brokers (Gillespie-Munro) we scoured the North American and European markets for ships available for chartering and suitable for the job in hand. Aircraft were also needed to move critical material, and of course personnel. The *D'Iberville*, pride of Canada's icebreaker fleet was borrowed to take materiel into Hamilton Inlet and Goose Bay in the late Fall of 1953, a period of heavy ice. Other ships, from substantial freighters to small sealers - which were particularly useful - and military landing craft were pressed into service. In the air C-119 cargo carrying planes of the Air Force, DC3s, Cansos (PBY in U.S. terms) and single engine Norsemen, Cessnas, etc. were all used as the problem of the moment dictated.

There were problems. One ship lost her rudder at sea and was damaged while under Bell charter. I found that when signing a ship's charter, one takes on complete responsibility for the ship and anything which might happen to it while on that charter - almost regardless of who was to blame. In this case, assessment of damages went to "General Averages" and was settled in Admiralty court in England some years later.

Unloading presented particular difficulty at some locations. Frobisher Bay has a 40 foot tide and experiences very heavy ice, both of which brought problems in their train. Resolution Island is surrounded by rough seas, without much protection for the harbour, which has a shelving underwater rock, permitting flat bottomed landing craft to be beached for unloading. There was an airstrip on the island, only 1500 feet long, sloping from its mid-point to both ends, and ending close to the cliff edge. I never did land on Resolution, but on one trip to Frobisher the pilot buzzed the island from *below* the cliff - not an easily accessible site.

The engineers and construction people tell many tales of this transportation period. One concerns a cook employed by Crawley McCracken at Saglek. On a day in late September, when days and particularly nights are very cold at that latitude, he decided he had had it, and wandered out of the station, clad only in his white cook's uniform. Saglek is surrounded by sea and wilderness, the nearest human habitation being Hebron, 35 miles south as the crow flies, and probably close to

100 miles following the coast. An air rescue operation was mounted searching the surrounding territory, but no cook. Finally after several days in the cold bush, he wandered into Hebron, apparently none the worse for wear, at least physically. He said that when he saw the planes overhead, he hid in the bush!

The *D'Iberville* story bears repeating. Russ Parke was the first Bell man in the field, charged with supervising the building of the first two sites out of Goose Bay for the original microwave system. They were in fact the only two such sites to be built. Russ left Montreal aboard the *D'Iberville* on November 11th, 1953, and headed north to Hamilton Inlet and Goose Bay, the ship well loaded with construction materials and vehicles. The *D'Iberville* had recently returned from Queen Elizabeth's coronation, and on the return journey had the bad luck to brush an iceberg. She sustained some damage, though it was not crippling.

When the Captain came to the really heavy ice near the construction site, he decided it was not a good deal, and headed back out to sea. Parke, a short, slim, but very determined engineer saw his whole project collapsing in front of him. So he pulled a few effective strings and the Captain was ordered back. The ship reached the site without further mishap, and the cargo was unloaded; but Parke was not exactly persona grata with the captain. Picture the young engineer climbing the boarding ladder of the *D'Iberville*, to be met at the gunwale by a tall, dignified but very annoyed gentleman with folded arms, saying "Who is captain of this ship, you or I?" We called Russ Parke "the little Admiral" after that episode.

Another story concerns the bitter cold. The boys had been issued down-filled parkas and trousers. The trousers could get pretty warm, so on this sunny winter day, the crew decided to wear the parka only. The sun was deceptive; the result frostbitten buttocks to the point that standing was the preferred position for several days.

But despite the difficulties - and frost bites - material reached the sites and construction began. In summary, Pole Vault took seven months to plan and secure materials, and six months on site to construct the necessary facilities, and to install and test the system.

Chapter 5

Pole Vault - Success

It was October again, and I was flying once more along the Labrador coast. With a few associates I had visited the Pole Vault sites down the coast from Frobisher - except Resolution Island. Construction was in full spate and equipment installation had started at most sites. By this time it was clear that the December date for service was too early, though equipment installation would be close to completion by that time. We were shooting for operational service by Washington's Birthday - February 16 - and the Chief Signal Officer of the United States Air Force had bet a bottle of Crown Royal whiskey that we would come through.

The Northern Electric Company was doing the equipment installation at all sites, a job which they performed expeditiously and well. Construction was tackled on a methodical basis, with the foundation pedestals for antennae given priority so that erection of these massive structures could go ahead as soon as they arrived on site. Diesel foundations and equipment buildings were next, and proceeded apace. Housing required for staff was not part of the initial contract, but additional buildings were called for by Northeast Air Command with the reinforcement job which was gone ahead with in 1955, as will be seen.

I have my notes of that trip, and they perhaps give a better feel of the project as of that time than I can possibly do in hindsight twenty-one years later. We flew from Montreal to Frobisher and started a site by site inspection there.

- Frobisher - October 9th.
    - Radio equipment building finished except doors and heat exchanger details.
    - Diesel building almost complete, and diesels placed temporarily. Duct work and painting going ahead.
    - Antenna dishes (2) up; one took 5 days, the other 4; foundations completed previously. Wave guides up. Northern Electric crew on site, 6 men, getting help in diesel installation from 5 men from Rooney Co. Precise setting of diesels on beds important.
    - Site engineer - Wilson - seems to know his job.
    - 2 Bell people on site helpful to N.E.Co. and Rooney. Have set up ham radio schedule.
    - Ate in construction camp. Food good and place clean.

  - Byers, the construction contractor, should be clear by end of the month, i.e. Oct. 31st.
- Resolution Island (from the air) - October 9th.
  - Diesel building complete.
  - Equipment building - final roof panels being installed.
  - All antenna dish foundations in; one dish completely assembled and ready for erection, with a second one partially assembled.
  - Dishes can only be erected when wind is less than 9 knots.
- Saglek -October 9th.
  - Station commander appears satisfied, particularly with quality of Bell construction men.
  - Equipment building ready for installation; some work still in heat exchanger room.
  - Accommodation for men a problem. 2 Bell men may sleep in equipment building. Site bulging at the seams.
  - Northern Electric (5 men) and Rooney (6 men) ready to start installation Oct. 11th. All equipment on site, but tools and specifications coming from Goose by boat. (Ship, an L.S.T., grounded at Saglek Oct. 12, causing a few days delay.)
  - Diesel building up; diesels set on pads but not connected up.
  - Antenna dish foundations - 1 set complete, second to be finished tomorrow (10th), [third and fourth] next week. Dish erection crews should start in 7 to 10 days.
  - Byers construction foreman – Huno - capable, and itching to go faster, a good sign.
  - Effect of 4160 volt power line in transmission path of antenna dish?
- Hopedale - October 9th.
  - Equipment building finished except for painting and tiled floors.
  - Northern Electric crew due tomorrow (10th).
  - Diesel building -a major foundation job; about ready to pour concrete.
  - Foundation for three dishes complete and fourth being poured today. Pier for one dish in wrong location; to be replaced.
  - 1 dish erected, and all scheduled for erection in next 10 days.
  - Site engineer - Vaughan.
  - Some tip sections of dishes do not match up by 1/2 inch. Bell Labs say tolerable, but not good. Any sections out by more

    than 3/4 inch to be laid aside. Washboarding of mesh between ribs, some requiring heat treatment.
  - Bell equipment men not happy with accommodation and other arrangements.
  - Station commander seerns happy about whole situation.
- Goose Bay - October 10th.
  - Fire in equipment building, burned for about an hour Partitions acted as effective fire break; fire got into panels but outside not charred. Roof panels damaged. New panels from Gander into Goose Sunday (today) should be in place Tuesday, and building ready for N.E.Co. in one week.
  - Diesel building foundations poured and building sides going up. Diesels in place in next few days.
  - All antenna dish foundations completed.
  - General conditions of camp, sleeping quarters, food, etc. good.
  - Site engineer (Redmond) and Rooney foreman (Loiselle) seem O.K.
  - Damage to telephone cable crossing Drake Merritt stone crushing mill. We should arrange to fix it.
- Cartright - October 10th.
  - Trouble with Crawley McCracken manager. (Site engineer later complained, and manager was changed, greatly improving on site morale.)
  - Check gauge of ground wire for diesels before foundations are finished.
  - Equipment building - roof battens still to go on, and some other work to be completed. Inside painting, tiling, etc. to be completed this week, ready for N.E.Co.
  - Diesel building frame up, and diesel foundations being poured.
  - Foundations complete for three of the four dishes; erection crews to arrive in 10 days.
  - Site engineer - Wilburton - appears good type.

My detailed notes run out with Cartright. Progress was up to date for the four Southern sites, namely St. Anthony, Gander, St. John's and Stephensville. Some of my general notes follow:

- Medical - Each radar site has a sick bay and attendant, but no doctor. Serious cases evacuated. Doctor at Frobisher in summer and now, but out soon.

- Site 118 (old microwave site) - Disposal of stove oil, cement and plywood. Indian Mission would like to have, but Ottawa decision necessary.
- All points awaiting fans for heat exchangers.
- Review program for supervision of line-up tests.
- Clearance through Pinetree Project Office to enable Bell to use military aircraft and transport when stuck.
- Official plans of all sites should specify that no buildings or other structures be built in front of antenna dishes. (Interference with signal, plus possibility of radiation damage.)
- Plumber strike action? (Unaccountably, mail to the sites encountered delays, so much so that the strike was over in Montreal by the time news of it reached the sites!)

Site engineers. A year after work started on the first sites, the boys had a party to celebrate arrival of the first Canadian construction engineer on the job! Initially these positions were all filled by Europeans – Scots, Irish, Dutch, German, English - who had come to Canada and moved early to the frontier. Our Canadian engineers seemed to prefer the more sophisticated, comfortable life of the South. The same thing happened on the Mid-Canada project to a degree. We had an ex-I.R.A. [Irish Republican Army] captain, plus a wide variety of other European graduates, but in this case, a greater representation of native born Canadians.

Perhaps the best description of the field construction phase appears in the completion reports for the various sites. Saglek is an example.

Saglek is located on a small promontory 170 miles down the coast from Cape Chidley, the entrance to Hudson Strait. The site is isolated, the nearest settled community being Hebron. The temperature reaches the seventies (F) in summer, but in winter only occasionally rises above freezing, and frequently drops to 20 to 30 degress below zero. But the main problem was the wind.

The radar site, with the Pole Vault installation adjacent to it, is built on the top of a very exposed cliff, some 1800 feet above sea level. Building and antenna structures had to be built on rough hilly ground close to the cliff edge. Work started in late July. Snow started in September and reached a total fall of thirteen feet by the time the job was completed in February. Winds, sometimes from the northwest, sometimes southeast, were high on most days and at times reached hurricane force. Records of nine major storms from July through February show peak velocity from 90 to 135 miles per hour. The storms usually lasted two days. For a full 24 hour period [on] Feb. 9-10, the wind never dropped below 75 miles per hour, and in storms of July 4th and October 24th, peak winds of 120 and 135 miles per hour respectively were recorded.

To quote the report:

"Transport to the site was affected by closure of the access road due to snow drifts. After the onset of cold weather, the increasing depth of snow and freezing conditions greatly increased difficulties both on the job itself and in the running of the construction camp. Space heaters had to be installed and maintained in all buildings; cold weather operation of equipment was difficult; concrete pouring was more protracted with added work involved in heating aggregates and water and in protection of freshly poured concrete; excavation necessary after freezing of ground had to be carried out with hand operated pneumatic breakers with resultant increase in unit cost of excavated material.

"Throughout the course of the job, several days were lost each month due to extremely bad weather conditions, the worst feature being the incidence of storms with very severe winds. Adverse weather on numerous other days, although not preventing work entirely, severely hampered outside construction."

Storm damage was substantial due to the high winds:

Aug. 27th - Five antenna sections still in their crates were so severely damaged they had to be replaced.

Dec. 19th - The screening ripped off three sections of one antenna. Roof of one building lifted and had to be reinforced.

Feb. 9-10th - Extensive damage. Several antenna structures (60 foot dishes) were completely wrecked, and screening ripped from other antennae. A section of roof was blown off, other roof panels and aluminum sheeting damaged.

The Pole Vault work at this site, as at most sites, consisted of:

(1) Four parabolic antennae, 60 feet in diameter, each mounted on seven mass concrete footings.

(2) An equipment building 62 by 32 feet to house electronic equipment, plus a small (10 by 10 feet) diversity building.

(3) A diesel building 54 by 36 feet, to house three 125 KVA (kilovolt amperes) diesel driven generators.

(4) Two 2500 gallon fuel storage tanks.

(5) Raceways to carry waveguides and cables.

(6) Enclosed corridors interconnecting buildings, total length in this case 520 feet.

The diesel building had a structural steel frame, with reinforced wall foundations and floor. The equipment buildings and corridors were erected on concrete piers 5 to 6 feet deep. Pre-fabricated panels, consisting of 6 inches of insulation enclosed between two metal sheets, were used for all walls and roofs, tied to columns and beams, and externally guyed as required.

An advance party of six men arrived on site on July 20th, and 15 more on July 28th. This grew to about 120 men, including catering personnel, at the peak of activity from October to December. The normal work week was 60 hours, with Saturdays and Sundays counting as ordinary days. Overtime at time and one half pay was extensive. The construction camp was five miles from the work site, and consisted of framed tents, twelve men to a tent. Initially Pole Vault personnel were fed at the U.S. mess, but from September on a civilian mess was operated for all contractor personnel by Crawley and McCracken as catering contractor. From September to February 60,793 meals were served, and from my own experience they were excellent meals. No construction project in an isolated location will succeed without first class meals for the men.

The shipping season opened July 24th and closed November 29th with departure of the last ship. During that period eight ships arrived, were unloaded, and departed. At Cartright, farther down the coast, 23 ships were handled in this same period, using U.S.A.F. docks and unloading facilities at the site. At Saglek there were no docks, so all cargo had to be off-loaded at sea, into LCU's (landing craft) and 'M' boats, which were then taken to shore and unloaded by crane onto road transport. Although most construction material arrived by ship, food supplies, mechanical spare parts, some additional materials, and personnel had to be sent in by air.

Not all the sites had Saglek's difficulties, but Hopedale, Cartright, St. Anthony and Frobisher had similar problems. Resolution Island if anything was worse, while Goose Bay, Gander, St. John's and Stephensville, being close to major settlements and therefore easy of access, did not have the same isolation or transport difficulties.

Finally the stage was set for Pole Vault operation. Tests of equipment, of diesels, of antennae, and of the complete system, section by section and over its full length, were made. And two days ahead of George Washington's birthday the first calls were made over the complete Tropospheric Scatter system: [the] first such system in the world, and completed in record time. Special Contract could be pardoned for being elated, which we certainly were. The General won his bottle of rye, the system went into operation. Bell continued with the training of military maintenance personnel, and with re-inforcement of the Northern part of the system which had now been requested by the United States Air Force. Eventually maintenance was taken over by the Canadian Marconi Co.

It was a rugged assignment for the Bell and contractors' people in the field. To quote the *Montreal Star* of Nov. 8, 1955, "For the men who did the job, life was tough. They lived in isolation, received mail intermittently, worked in high winds that some-times blew off the roofs of their buildings, and faced all the rigors of an Arctic winter." But as the Company magazine, the *Blue Bell*, expressed it "work is difficult, often lonely, sometimes hazardous, and thoroughly satisfying."

A word about our advisors. We had been promised support from the A.T.&T. Co. and from Bell Laboratories at the outset, and this was forthcoming when we needed it. Mr. George Gilman, Vice-President of Bell Labs was particularly helpful, and made several trips to the project during the installation period. His help, both in technical knowledge and in liaison with the United States Air Force, was greatly appreciated. Some of the air trips we took him on were anything but comfortable - the old Cansos, though airworthy, tend to bump all over the sky - but he stuck with it, and as I say, proved to be a good friend.

By the end of 1954, with Pole Vault rapidly becoming a successful fact, U.S.A.F. decided that the Northern section should be increased in capacity. It will be recalled that capacity of the system just being completed was 36 circuits as far North as Hopedale, with 24 circuits extending from there to Resolution Island, and 12 circuits from Resolution to Frobisher. Plans for the D.E.W. Line were being finalized, and circuits were needed connecting the new radar line at Cape Dyer to operational headquarters in the south. Bell was therefore asked to increase the capacity of the system to 36 circuits North to Resolution, with 18 circuits into Frobisher.

At the same time U.S.A.F. found they were short of barracks at a number of sites. They requested Bell to construct two ten room extensions to barracks at each of six stations - St. Anthony, Cartright, Hopedale, Saglek, Resolution Island, Frobisher Bay, and living quarters at the communication site at Gander. Building extensions were also required at three sites to accommodate the equipment extensions.

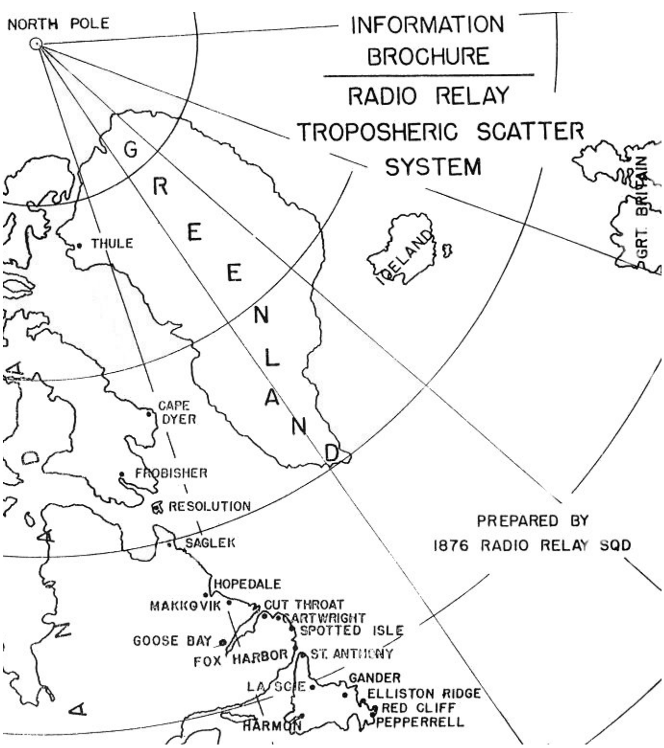
All told this represented a very substantial additional amount of work, amounting to $6.5 million in money terms, and continuing on site construction well into 1956. Russ Parke stayed on at Goose Bay to supervise construction, not only of this Pole Vault reinforcement, but also the Hopedale section of the Mid-Canada line and the Eastern end of the 1957-58 Quebec-Labrador Tropospheric Scatter system. All told he was five years on the coast.

Final details of the additional Pole Vault work were not incorporated in an amendment to the Pole Vault contract until September 1956, when most of it was finished. This amendment established several things:

1) It adjusted the original contract, deleting Bell's obligation to *construct* the microwave system (i.e. the C.S.R.D.E. system) and merely stated that Bell was to carry design of the system to the prototype stage, which we had done.
2) It changed wording so that the contract, except for the prototype microwave equipment, covered a Tropospheric Radio Relay Scatter system in all references.
3) It added the reinforcement and additional construction mentioned above as part of the whole project, and indicated an overall completion date for this work of Dec. 31, 1956. Total cost of the whole project was estimated at $24,072,004, and Bell's total fee was set at $565,000.

Bell's final claim on the Department of Defence Production, after all costs were established and paid, was dated October 14, 1958 in the amount of $27,190,000, including $2.6 million in recoverable duty and sales tax, for a net amount of $24,590,000.

So ended Pole Vault: a successful venture for Bell, the Canadian Government departments, and the United States Air Force.



Chapter 6

Outside Plant - and Tragedy

As part of the implementation plan for the Pinetree radar chain, the telephone companies across the country had undertaken to install, and in some cases maintain, the local telecommunications network in the various stations - i.e. poles, cable and wire, telephones and switching equipment. Each station was equivalent to a small automatic telephone exchange. When Bell formed the Special Contract Department, Bell's part of this telephone work came under its wing, directed by R.L. (Dick) Tivy and E.A. (Eddie) Goodier.

Starting in August 1953, work went ahead at Pinetree stations in Ontario and Quebec, with Bell acting as sub contractor to the prime installation contractor at each site. About 100 men were involved, and they completed the job in October at a cost of approximately $400,000. Continuing maintenance represented about $100,000 per year. So far so good. But now the East Coast stations came into the picture. With Special Contract having the task of providing the long haul communication system - Pole Vault - it was logical that we should also be asked to take on this local plant work. So through late 1953 and into 1954 the construction and installation crews were busy at seven sites on the coast. In these cases U.S.A.F. provided materials and transportation to the sites. Bell provided the necessary vehicles and tools, plus of course the men and knowhow to do the job.

As 1954 progressed, Pole Vault caught the interest and imagination of a lot of people in Northeast Air command and other echelons of the U.S.A.F. Justified or not, we acquired a reputation for getting work done in a hurry, and speed was what the Air Force was looking for. We were asked to take on more outside plant jobs, in Newfoundland, in Greenland, even in Iceland, and there was some mention of the Azores. We drew the line at Iceland and the Azores, feeling that other agencies available to the U.S.A.F. could do the work there. Under some pressure, however, we did agree to work in Sondrestrom, Narssarssuaq and Thule in Greenland.

This phase started with our agreement on March 23rd, 1954 to do work at Goose Bay, in accordance with plans and specifications supplied by Olmstead Air Force Base at Middletown, Pa., which was the contracting authocity. 65 men started on this outside plant job in mid-April and completed it in 6 weeks. Cost (installation only) was $165,000. On April 28th we were forwarding cost estimates for work at Harmon Field (Stephensville) and at Sondrestrom and Narssarssuaq in Greenland at a cost of $500,000. Work at Ft. Pepperell (St. John's), and Thule was also under discussion and was agreed to shortly after this. Three construction groups were organized; one was to move from the Goose Bay job, when completed, to

Sondrestrom and Narssarssuaq; a second group did the Harmon Field and Pepperell jobs, and group #3 was assigned to Thule. I should note that the air approach to one of the south Greenland sites required a sharp right-angled turn between cliffs to successfully get onto the runway, so broad daylight was a prerequisite. It was not at this site, however, that we ran into trouble.

Our reputation for fast completion of projects had one amusing side-light. All of the jobs were, of course, discussed between U.S.A.F officers and ourselves before formal agreement was put on paper. In this one case, I had agreed by telephone at 3.30 in the afternoon that we would take on a certain outside plant construction project. At 5 p.m. the same day I had a call from a different U.S.A.F. officer to ask if the job was completed!

To the Romans "Ultima Thule" meant the northernmost habitable region of the earth - the northern end of the world. It was vaguely identified with Iceland or the Shetland Islands. Modern Thule in Northwest Greenland is the site of a major U.S. military base, with a sizeable population; but I suspect the G.I.'s stationed there would still agree with its definition as the northernmost habitable region of the world. On a bleak coast, with the Greenland ice cap, up to two miles thick rising to the east, it is no one's idea of a summer vacation spot.

The Thule outside plant job was finally finished. It had involved some unusual features, caused basically by the climate, but it was completed; the telephones were working.

The crew was moving on to Narssarssuaq in southwestern Greenland. The big cargo carrying plane was on the tarmac and their two heavy construction trucks were aboard, securely lashed in place. The plane engines had been giving some trouble, so the aircrew revved them up for a lengthy period before they were satisfied to take off. Finally everything was ready. Three of the Bell men sat forward with the air crew, the remainder (five men) stowed themselves towards the rear of the plane.

The air strip at Thule is about 75 feet above the water level. The plane took off, but was quickly in trouble. The engines lost power and the pilot turned back to the airport. Losing altitude rapidly when coming in to the strip, a wing clipped nearby buildings, and the plane ploughed into the ground nose first. The trucks broke from their moorings and crashed forward. All eight of the air crew were killed, along with the three Bell men seated forward of the trucks. Four of the Bell people at the rear of the plane were injured, three seriously. The rear end of the plane broke off.

The Bell men killed were: J.E. Blair; D.W. Herbert; and J.E.G. Prevancher.

Injured were: C.A. Notman; J.B. Bryson; T.J. O'Rourke; and J.F.R. Major.

Of the injured, one man eventually had to have a leg amputated a second sustained permanent damage to one leg and the third had serious back injuries. The fourth, Rene Major, was thrown clear, and escaped with a broken rib.

The funerals in Montreal were sad occasions, the wives and children deep in grief as is always the case when accident takes a loved one in the prime of life. It was an accident; it happened; and the world carried on. But these three and their Air Force associates had given their lives in the cause of peace just as truly as if the end had come on the battlefield.

Death struck five more times during the life of the Special Contract Department, all of them contractors' employees. Two men were killed in a helicopter crash in the west when on preliminary survey work before field work started. We lost two people during shipping operations in Hudson Bay, and finally we had a case of suicide of a doctor at Knob Lake. Another man was badly hurt in a fall from a Tropo-Scatter antenna in the Hudson Bay area. These are the penalties which always seem to be exacted during major construction projects.

Early 1955 saw the end of the Pinetree-Greenland series of telephone construction jobs. Minor extensions of cable etc. were required at the East Coast stations through 1955-56, but these became part of the main Pole Vault effort. Local telephone networks were also part of the job at the eight main Mid-Canada sites; so a small but essential outside plant activity continued through 1955 and 1956.

Chapter 7

Tamarac[1] to Mongoose to Mid-Canada

It was late afternoon on an October day in 1954. On a flight back from Frobisher to Montreal, a not unusual event in that busy year, we had just taken off from Hopedale, north of the 55^{th} parallel. The bay opened up to our right, with a little river running down from the hills at bay's end. I went forward to the co-pilot's seat, and asked the pilot to turn right and fly west. For this was the country through which Special Contract, acting as project agent for the Trans Canada Telephone System, had agreed to supervise the building of an early warning line of electronic detection and communications stations.

We flew on for a hundred miles or so until the hills and valleys started to blur in the fading light, then turned southwest to the St. Lawrence River and home. The land God gave to Cain, Jacques Cartier called it. Perhaps looking at that rugged forest-covered coast as his little ships beat up the great river, he spoke from the heart. But Labrador and Northern Quebec is anything but a barren wilderness. Certainly not a placid, postoral landscape, it has a beauty all its own; a tumbled mass of hills, part of the Laurentian Shield, the oldest mountains on earth, interspersed with lakes and rivers, hundreds of them, with evergreen bush rolling away to the horizon. The trouble with all this scenery from my standpoint was that I was charged with stringing a line of stations - a trip-wire we sometimes called it - from east to west across Canada, including the 800 mile coast of Labrador and Quebec. But the hills run north and south. An overly ambitious entrepreneur once offered to build us a road across the 800 miles! He obviously hadn't looked at the map, or he thought we had 5 years and direct access to Fort Knox to do the job. My notes of the trip say "looks as though in this area a combination of fixed wing aircraft and tractor train should be possible." Actually, helicopters became the key instrument of transportation in this important part of the new venture.

The project's first code name was Tamarac, possibly indicating that at that stage we couldn't see the woods for the trees? This was early changed to Mongoose, which the dictionary defines as a small, ferret-like animal that destroys rats, and in India is noted for its ability to kill venomous snakes. Its logic as a code name for the detection line we were about to build, I suppose, might pertain to its ferreting out

[1] *Editors' note:* Lester used "Tamarac" rather than the more common spelling "Tamarack" for the preliminary survey project. We have retained his original spelling.

hostile aircraft, though the "killing ability" rested with interceptor forces further south. In any event the project later, and permanently, became known as the Mid-Canada Line.

During 1958 and 1959, with the Mid-Canada Line in full operational use, and some of the security wraps removed, a number of articles appeared in the press concerning its construction. Perhaps the most objective of these, certainly the best informed, was a three part series by Flying Officer S.G. French in *Roundel*, the R.C.A.F. magazine.[2] The most critical, though badly distorted as to fact, was the two part series by Arnold Edinburgh in *Saturday Night* in March 1959.[3] The burden of his criticism was waste, confusion of command, and frustration of Government Departments, contractors, and of Special Contract itself. Questions were raised in the House of Commons regarding costs - *Saturday Night*'s main point - and were answered in a rather complete statement by the responsible Minister as recorded in *Hansard* of March 28, 1960.[4]

True, the Mid-Canada project cost one-third more than Special Contract's first estimate. From today's vantage point of tremendous cost escalation in projects such as James Bay power and the Alberta tar sands development, the increase from our first estimate of $169 million to the final figure of $228 million may not look too startling but in the nineteen fifties it was a matter of great concern. The reasons for the increase will develop as we follow the story, but key factors were a 30 percent increase in the number and size of buildings substantial changes in layout and spacing of the stations, and tremendous transportation costs, which finally totalled $42 million.

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[2] *Editors' note:* Flying Officer S.G. French, "The Mid-Canada Line," *The Roundel* [three parts], vol. 10, no.3 (April 1958): 2-5, 31, no.4 (May 1958): 10-15; and no.5 (June-July 1958): 12-18, reprinted in *Northern Skytrails: Perspectives on the Royal Canadian Air Force in the Arctic from the Pages of* The Roundel*, 1949-65,* eds. Richard Goette and P. Whitney Lackenbauer, Documents on Canadian Arctic Sovereignty and Security (DCASS) No. 10 (Calgary and Waterloo: Centre for Military, Strategic and Security Studies/Centre on Foreign Policy and Federalism/Arctic Institute of North America, 2017), docs. 6-1 to 6-4, pages 211-231.

[3] *Editors' note:* Arnold Edinburgh, "A Story of Waste on the Mid-Canada Line," *Saturday Night* (14 March 1959): 9-13, 49, and "The Administratie Muddle of the Mid-Canada Line," *Saturday Night* (28 March 1959): 9-11, 48.

[4] *Editors' note:* Hon. Raymond O'Hurley, Minister of Defence Production, House of Commons, *Debates*, 28 March 1960, 2541-43.

True there was waste, some avoidable, some not. The last site locations were finalized in July 1955, and half the line was ready for operation in January 1957 (in fact some of the Western stations in September 1956). The whole line was ready for service in mid-1957. With that kind of headlong dash to completion across a distance of 2800 miles, some waste was inevitable. The D.E.W. line, over a shorter distance, though with more sophisticated equipment, cost approximately $600 million, which was 70 percent above the early estimates for that project.

It is true also that relationships between the various agencies involved - the Management Contractor, R.C.A.F., Dept. of Defence Production, Defence Construction Ltd. and other Government groups - as well as the major construction contractors, were difficult and at times strained. Hard-driving, action oriented people do become abrasive under pressure. Mid-Canada had its share of such sometimes abrasive characters in all agencies. The pressure certainly was there, particularly on the Management Contractor, who, despite ambivalent and hazy designation of his role, was still looked to as responsible for coordinating and delivering the finished system in operating condition to the R.C.A.F. To a considerable extent difficulties in relationships stemmed from imbalance between delegated responsibility and authority to carry it out, to "too many cooks" in on every major decision; all pressing relentlessly on men who were working round the clock at top speed to accomplish a complicated and extremely urgent job.

Some of the frustration will undoubtedly show through this story, for I was personally in the middle of it from first to last, but Mid-Canada was much bigger than the sum of our frustrations. It was one of Canada's outstanding engineering achievements; it fulfilled its role in the Defence plan for the 1957-1964 period for which it was designed; and it established in the minds of the 10,000 people who at one time or another worked on the line, that life could be carried on quite satisfactorily 500 miles north of our present U.S. boundary-hugging Canadian civilization. It is in this light that the story should be interpreted.

My own first contact with "Project Tamarac" was a discussion with Air Force officers in Ottawa on December 30th of 1953, which A.J. Groleau (then Chief Engineer of Bell's Toll Area) and I attended. Air Commodore Hendrick, Chief of Telecommunications, and his people outlined the general purpose and content of a proposed detection and communication line of stations across Canada.

The plan was to use the doppler principle in detection of aircraft. The doppler effect, identified in the mid-nineteenth century by C.J. Doppler, a German physicist, is the change in frequency which occurs in a sound or electrical wave due to movement of the source of the wave in relation to the observer. The most frequently quoted example in everyday experience is the change in pitch (i.e. frequency) of a train whistle as the train approaches or recedes from the observer.

Shortly after the end of the Second World War, the Defence Research Board (D.R.B.), working with the R.C.A.F. and later McGill University, determined that aircraft could be detected with a high degree of accuracy using the doppler principle, and probably at a lower cost than with conventional radar sweep equipment. The proposed system acquired the name "McGill Fence." Early in 1951, Professor G.A. Woonton of McGill[5] discussed the idea with Washington officials, with the object of increasing the effectiveness of the North American radar network. D.R.B. continued its studies, made flight tests through 1952, and late that year made its report and recommendations on use of the system.

In February of 1953, the Canadian and American Governments asked the Canada-U.S. Military Study Group (M.S.G.) "to study those aspects of the North American defence system in general, and the early warning system in particular, which are of mutual concern to the two countries." Various scientific and operational studies ensued, and on October 8th the M.S.G. recommended to both Governments "that there be established at the earliest practicable date an Early Warning Line located generally along the 55th parallel between Alaska and Newfoundland."

Action was prompt. On November 3rd the Canadian Defence Committee of Cabinet directed that:

(a) An early warning line should be established along the 55th parallel of latitude;

(b) The Chiefs of Staff should instruct the Canadian section of the M.S.G. to complete the selection and specifications for equipment for the early warning line;

(c) The R.C.A.F. in consultation with the U.S.A.F. should carry out a detailed survey of the proposed early warning line and the sites along it;

(d) Canada should undertake the planning and construction of the early warning line, without prejudice to a later decision on the division of costs.

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[5] *Editors' note:* Professor Garnet A. Woonton (1907-1980) was a founding member and president of the Canadian Association of Physicists who became the director of McGill's Eaton Electronics Research Laboratory in 1950. Through most of his career, his research focused on magnetic resonance of gases, electron paramagnetic resonance, and the application of microwave techniques to physical measurements. "Garnet A. Woonton," *Physics Today* (Sept. 1980): 86.

By the end of the month the project was approved in principle. The R.C.A.F. was charged with overall responsibility to see this major project through to complete operation. Part of that responsibility was to establish clear operational requirements for the line. This took time and careful consideration, and overlapped considerably the more immediate and visible task of preparation for construction. The official "Operational Requirements" were promulgated early in 1955, and included provisions that the line should:

(1) Provide detection of moving objects in the air.

(2) Have an extremely high degree of reliability.

(3) Indicate whether the object is inbound or outbound.

(4) Be capable of indicating the point of penetration within a specified radius.

(5) Provide direct communication between the penetration reporter and the A.D.C.C. (Air Defence Control Centre).

(6) Have the capacity for transmitting Air Traffic Movements and Ground Observer Corps informatian.

(7) Give maximum possible immunity to E.C.M. [Electronic Counter Measures].

(8) Be economical in terms of construction and operation.

(9) Be in operation before January 1957.

The immediate and urgent R.C.A.F. responsibility was to investigate the logistic and construction problems inherent to the project, and to lay plans for full implementation. During December 1953 Mr. Howe indicated to Mr. Eadie, President of Bell Telephone Co., his intention to approach the major telephone systems early in January through the Trans Canada Telephone System, with a view to their undertaking the engineering and construction of this project. The alternatives in his view were that the R.C.A.F. organize to do the job themselves, or a Crown Company would have to be formed - i.e. the same alternatives that had faced the Government in planning to build "Pole Vault." In either case a substantial number of personnel would have to come from the telephone systems. It was indicated that Bell would be expected to play a major role. This would obviously interfere with Bell's activities in its own field by siphoning off experienced people. In the event, allocation of engineers and technicians to the Special Contract Department constituted ten percent of the Company's total resources in this category of personnel, and necessitated all engineering staff throughout the Bell Company going on scheduled overtime for most of 1955 and 1956.

But why the telephone companies? Why Bell? The big construction companies undoubtedly felt that the construction industry could mastermind the job, and many people in the Air Force, particularly on the construction side, the "Works and Bricks" group of wartime fame, felt that they were fully capable of implementing the project themselves. The rationale behind the choice of the telephone companies was outlined in a Government memorandum prepared some time later from which I quote:

> "It was realized that construction of a communication system of this magnitude demanded that the basic planning and systems engineering be of the highest order and excellence. As it was to be built across all provinces of Canada, it was obvious that advantage should be taken of the local knowledge in the various provinces.
>
> "After a great deal of study and consultation with the Armed Forces, industry, and experts in the communications field, it was established to the satisfaction of the Department of Defence Production that the employment of one company in the commercial communications field to manage the contract was the most efficient way to carry out a project of this magnitude and complexity. The techniques used to operate the system are almost entirely those of communications theory and practice. The major contribution to reliability rests with the ability of the communication system to carry the necessary warning data from each detection station to its appropriate sector station where after screening the combined intelligence is passed to Air Defence Command. The only companies in Canada considered to have the necessary capabilities were the various telephone companies and communcation divisions of the railway companies. Each of these organizations was analysed and with the exception of one they all lacked some requirement for one reason or another, either from a manpower, technical or timing standpoint.
>
> "The organization in Canada which most satisfactorily filled the requirement was the Trans Canada Telephone System. This system comprises all the major provincial and commercial telephone operating companies and was set up primarily to allow a smooth and efficiently reliable transcontinental system to be achieved. It is because of this that the Department of Defence Production considered the Trans Canada Telephone System the best organization to fill the requirement for coordinated systems engineering, planning, provincial know-how and the means to bring a large body of experienced communication people together.

> "A most important consideration was that the Bell Telephone Company, with its wealth of cornmunication and operating experience, its access to the Bell Telephone Laboratories, and its knowledge of industrial relations, was a member of the Trans Canada Telephone System, and acted as its project agent. The Bell Company was at the time constructing for the United States Air Force a tropospheric scatter radio relay system in the Newfoundland to Frobisher area for the Pinetree project. This was an undertaking somewhat similar to the Mid-Canada Line requirement in terms of remote terrain and climate but on a smaller scale."

This brings us back to the December 30th meeting in Ottawa. It was an exploratory session, at which the Air Force outlined the overall requirement for the proposed line, exposed their preliminary thinking as to organization for planning and implementation of the project, and invited our opinions.

The major items and problem areas identified were:

(1) Detection apparatus and associated display problems.

(2) Communication System (radio relay).

(3) Towers, buildings, and associated structures, including air strips at some locations.

(4) Power, with stations to be unattended for up to 30 days.

(5) Maintenance.

(6) Logistical support both in the construction and operational phases.

The Air Force basic objectives and sequence in planning appeared sound.

(1) Solution of design and engineering problems, and their cost evaluation before starting construction.

(2) Need for overall coordination and systems engineering of the whole project.

(3) Utilization of existing, prov en equipment and techniques as far as possible within the limits of the operational requirements.

(4) Need for continued close collaboration in the engineering phase between the engineering agency and the operational staff people.

(5) Expeditious action to permit meeting the desired operational date of January 1, 1957.

Views started to diverge when it came to possible forms of organization, particularly in the engineering phase. The Air Force proposed establishing a design and systems engineering group within the R.C.A.F., drawing individuals from industry as required to work alongside Service people. Specific engineering study contracts for parts of the project would then be let from this group to industry. Detailed engineering and construction presumably would be placed later in the hands of a prime contractor.

While recognizing the essentiality of extremely close liaison with the Air Force, particularly in meeting operational requirements, we felt that individuals borrowed from industry would carry only their own specific knowledge and competence, and that the Air Force would not tap industry's ability to furnish full engineering advice, drawing on particular knowledge from anywhere within a large company organization; in other words, they would not obtain the advantage of what might be called the technical infrastructure of a technology oriented company.

The more desirable alternative, in our opinion, was to appoint at the outset a prime contractor to take full responsibility for development, engineering and construction to meet the operational requirements of the Air Force. This was really the type of organization which we were using for Pole Vault, and we understood was being proposed for the D.E W. Line project by the Americans.

These discussions were preliminary, with no specific commitment on either side. However, as Bell representatives, with authority from Bell senior management, we indicated that Bell, in association with the other six members of the Trans Canada Telephone System, would be prepared to offer its services as prime contractor under such a general arrangement. A special group would be set apart to do the job with personnel drawn from the Trans Canada companies, as well as the electronic and construction industries. Sub contracting would be entered into to the fullest extent possible, but overall coordination would be the responsibility of the prime contractor.

Thus the telephone companies indicated their willingness to participate in the project if the Government so decided. The ball was now in the Government's court.

The winter of 1953-54 was an active one for the R.C.A.F. planners. An interdepartmental steering committee was formed in December to give overall policy direction to Government planning. Close study was given through this period to operational requirements, in consultation with the Americans, to ensure that the location and capability of the proposed line would be fully compatible with the continental early warning system. As already mentioned, these requirements were not formalized until early 1955, but many of the decisions affecting location, detection and communications needs were of necessity established by the operational people during the spring and summer of 1954, working with the new Systems Engineering Group.

Formation of this Systems Engineering Group (SEG) resulted from an R.C.A.F. decision that they must retain full responsibility for basic design of the system within the Air Force, with commensurate authority to monitor its implementation. This decision followed a recommendation of the Military Study Group in December 1953 that "the respective Air Forces jointly be given the task of developing the specifications and the selection of equipment for the Mid-Canada segment of the early warning system." By April 1954 SEG consisted of 30 people, including 10 senior engineers from industry in the electronics field. Other members were R.C.A.F. officers from the technical branches, plus several officers from U.S.A.F. who participated during the early planning phase. Initially SEG was under the direction of Group Captain G.M. Fawcett. He was succeeded in October 1954 by Group Captain E.C. Poole, who continued in charge throughout the project. A.F. Branscombe, a Bell Chief Engineer, was loaned to SEG as Chief Engineer of the Group.

Their initial role was to establish in broad outline the technical needs, physical dimensions and approximate cost of the project to fill the operational requirements, also the steps to be taken leading up to the implementation phase. The target date for this report was June 1, 1954. SEG made an interim submission in May. Based on this interim report, the Canadian Government on June 30th agreed that Canada should construct the aircraft warning line. The cost was estimated at $102 million. A final report in August was presented to the Canadian and American Governments, and approved in September 1954.

As part of this planning phase, the R.C.A.F. during the winter of 1953-54 investigated logistical problems in western Canada, including tractor train operation: and concluded that construction of the proposed line in the general area of the 55th parallel was physically practicable.

A more vital need was accurate maps of the territory through which the line was to be built. Since 1949, No. 408 Photo Squadron of the R.C.A.F. had mapped over two million square miles of the Canadian land mass, but precise maps were lacking for the area of the 55th parallel. Accordingly, in the Spring the squadron, flying their four-engine Lancasters, the famous World War II bombers, and assisted by civilian operators, commenced the mapping task. They completed nearly 8000 miles of aerial photography, comprising a forty mile wide strip from coast to coast. This involved 2600 hours of flying time, including Shoran survey work to lock the aerial photographs into the continental map. From these data, cartographers of the Canadian Army, using their resources for a full year, and assisted by the Photographic Survey Company for the western end of the line, produce accurate contour maps, one inch to the mile, for the complete strip of country across Canada. From these maps detailed study of possible doppler sites could proceed.

The Defence Research Board continued tests of doppler systems using test links in various Ontario locations, and working closely with SEG. After assessing four possible doppler systems, SEG recommended use of a single doppler line (called Mark II). Subsequent complications in detailed design of this equipment necessitated reverting to a system of two parallel lines (Mark I) as will be seen later. Aside from the doppler problem, SEG's report proposed broad plans for a detection line across Canada from Atlantic to Pacific, in the area of the 55^{th} parallel of latitude. It was to be served by a high quality radio relay communication system, providing lateral communicatjons from detection sites (25-30 miles apart) to main stations which were to be 350 to 400 miles apart. Rearward cornmunications from the line to Air Defence Control Centres and the continental defence network would be provided over circuits leased from the Common Carriers, except in the James Bay region where no commercial facilities existed, necessitating building a link southward to connect with the Common Carriers.

Following completion of their planning report, the Systems Engineering Group continued as the Design Authority throughout the project, developing the overall system specification, working with consultants and the Management Contractor on detailed plans, and monitoring the job from the viewpoint of the R.C.A.F. as the customer. Art Branscombe returned to Bell in May 1955, being replaced by Dr. Hans Von Baeyer. Many of the engineers from industry who had been loaned to SEG returned to their normal pursuits by the end of 1955.

A preliminary system specification for the line was issued by SEG in November 1954. This was necessarily incomplete because of the many unknowns, both technical and physical. Due to its extreme urgency, and unfortunately, the line to a considerable extent was planned in detail as it was being built. The final System Specification, covering all R.C.A.F. technical and physical requirements, was issued on June 29^{th}, 1956. By that time construction was approaching completion, so the specification was largely an after the fact record of what had been done rather than an advance statement of what was to be done.

Well, what had to be done? Initially the plan was to build the line right from coast to coast. Also, since there was concern about possible gaps in coverage of the East Coast by the Pinetree radar screen, it was proposed to extend a doppler or equivalent line of stations down the coast from Hopedale to Cape Race at the south-eastern tip of Newfoundland. Responsibility for this "gap filler" line was left to the Americans who continued with their own planning in that area. At the western end, it was decided after further study that the existing Pinetree radar chain which extended across the waist of British Columbia provided adequate coverage. The Mid-Canada Line as it was finally built, therefore, extended from Hopedale, one of the coastal Pinetree stations and a Pole Vault relay point on the Atlantic coast, to Dawson Creek, British Columbia, just west of the Alberta border. Eight

Section Control Stations (SCS), at intervals of about 400 miles, extended westward from Hopedale through Knob Lake, Great Whale River, Winisk, Bird, Cranberry Portage and Stoney Mountain to Dawson Creek. The seven sections between these main stations contained Doppler Detection Stations (DDS) at an average spacing of 30 miles (maximum 35 miles), sited to meet the combined requirements of doppler detection and microwave communications. These siting requirements resulted in a zig zag line of stations. Alternate stations were linked by doppler detection equipment to in effect form two doppler detection lines 3 to 6 miles apart. Doppler detection of aircraft extended in height from 200 ft. to 65,000 ft. All stations were interconnected by a microwave system carrying doppler intelligence, telemetry and voice communications laterally to SCS's and between SCS's. Capacity of the microwave system was 39 voice channels, plus a number of telegraph and telemetry circuits. In total there were 90 doppler stations. Each doppler station was connected directly to its two adjacent SCS's, and doppler signals from the DDS passed to both SCS's simultaneously, where they were recorded automatically, and interpreted by operating personnel.

In addition to the doppler system, three of the Section Control Stations – Knob Lake, Cranberry Pdrtage and Stoney Mountain – which were situated astride heavy air traffic routes were equipped with conventional surveillance radar, increasing the capability of the doppler line as regards identification.

Communications rearward from the Line for reporting, command and administration purposes, extended south from Knob Lake, Winisk, Cranberry Portage and Dawson Creek. Except for Winisk, these commumication facilities were leased from the Common Carriers. In the Hudson Bay area, with no commercial facilities available, the Mid-Canada project included a tropospheric scatter system linking Winisk and Great Whale River across James Bay and southward down the west side of James Bay, connecting with the Bell Telephone microwave system at Ramore. This necessitated tropo-scatter installations at five locations.

Direct communication with the DEW Line was to be available on the Atlantic side over the Pole Vault system, which would be in service before the operational date for Mid-Canada, while in the west ionospheric scatter links were set up to the DEW Line from Dawson Creek and Stoney Mountain. These links were the responsibility of the Americans, but the Mid-Canada Management contractor supervised the necessary construction at the two Mid-Canada sites. Ionospheric scatter operates on the same principle as tropospheric scatter, projecting a powerful signal beyond the horizon. The signal is reflected from the ionosphere in sufficient strength to be received by very large antennae at distances of 900 miles or more. At the stage of development extant in 1955, the system was only capable of providing three or four telegraph circuits.

In addition to the Mid-Canada Line proper, a test line of four doppler stations was built in the Ottawa Valley area. Certain construction and equipment installation was also required at three Line Clearance Airdromes in the west: Fort McMurray, Buffalo Narrows and Lac [la Ronge].

The doppler stations were designed for unattended operation, but included facilities to permit manning during the run in period and during future maintenance visits. Physically, a doppler station consisted of an equipment building, a survival hut, one and in some cases two towers, fuel tanks and a helicopter pad; the whole surrounded by metal fencing (which proved a poor deterrent to the black bears when they smelled meat). The equipment building (28 x 60 ft.) was mounted on concrete or creosoted wood posts, with heavy mill type flooring, and exterior walls and roof of prefabricated insulated metal panels. The building was divided into three areas. The equipment room contained doppler and microwave equipment, all in duplicate to minimize service interruption; a diesel room contained three 20 kilowatt diesels, each capable of carrying the full electric load of the station; the living area contained cooking, sleeping, water and toilet facilities for maintenance personnel. Where water was available on site, a normal water pressure system, flush toilet and septic tank was installed. Where a pressure system was impractical, a 200 gallon water tank was provided, and chemical toilets used. Heat recovery from diesel and electronic equipment was utilised, supplemented by oil space heaters in the living quarters.

Towers were all of the guyed type in the interests of logistics, and depending on topography, i.e. the line or sight path to the next station, varied in height from 50 to 350 feet. The doppler antenna had to be mounted at the top of the tower, usually with the microwave antenna further down on the same tower. However, in cases where microwave propagation required a very high tower, a separate tower for doppler was used. Since the nod and sway of the tower at its top could not exceed six inches, all guys had to be prestressed before installation and checked again after installation was completed. Each tower was designed to support its full load of antennae and associated equipment under a wind load of 120 miles per hour with two inches of radial ice.

The Section Control Stations were much more elaborate affairs. They were essentially fully equipped bases, and included all necessary operational and living facilities for a permanent staff of about 150 men. They were the key points in reception and initial interpretation of doppler signals from the Line, and for transmission of the significant intelligence to Air Force centres further south. They reported to four Air Defence Control Centres. The SCS was also the maintenance centre for all DDS's in its 400 mile section, with maintenance personnel dispatched to DDS's on a routine preventive maintenance basis and of course to clear troubles. The SCS was the supply depot for everything needed in its section, whether food, equipment spares, fuel supplies, construction materials, clothing, recreational equipment, etc., etc. – in other words it was designed to be completely self-sustained.

This required a fully equipped operational building, containing all essential equipment installed in duplicate as at the DDS's. Stores of equipment spares, food supplies, fuel, and all the rest, as well as personnel, had to be housed in buildings built to withstand the rugged climate of Canada's sub-Arctic.

Among the buildings in this miniature town were:

- Hangar (adequate for two and four engine planes at Great Whale River and Winisk, suitable for helicopters at other SCS's
- Quarters and Mess Building
- Food Storage Building
- Power and Heating Building
- Fire Hall (complete with fully equipped fire trucks)
- Operations Building
- Administration Building
- Drill and Recreation Hall
- Oil and paint stores Building
- M.T. Garage – 11 bays
- Laundry Building
- Sewage Disposal Plant
- Pump House

In addition there were small buildings to house HF radio, air-ground-air and beacon equipment, with which the line was fully equipped to meet emergencies. At Great Whale River and Winisk full length air strips were built, two at Great Whale and one at Winisk. At other SCS's helicopter pads were laid, and at some SCS's and DDS's temporary gravel strips for small aircraft during the construction phase. Water supply and storage tanks to keep it in, major oil tanks at the Hudson Bay sites, sewage and water piping systems, power and telephone distribution lines, roads throughout the camp etc. completed what amounted to a major air base. This obtained at seven of the SCS's. At Hopedale, the installation was in an already operating radar base, so the Mid-Canada construction needs were considerably less.

Chapter 8

Trans Canada is Chosen

Following the discussions between Mr. Howe and Mr. Eadie mentioned earlier, and the preliminary technical discussions in Ottawa on December 30th, the telephone companies assessed the problems involved and possible organization required in the event that they were asked to undetake the implementation of the Mid-Canada project. On January 13th of the new year the Bell Telephone Co. Executive Committee approved the Company's participation in the project, should the Government so desire and contractual arrangements be satisfactory. To quote a Bell memorandum: "For the first time … we have been approached by the Armed Services to sit in with them in the early stages of their planning. This we are doing, and we are sure benefits will accrue to both sides."

Shortly after this, a meeting of the Trans Canada management committee was held in Montreal. This committee included the senior operating head of each of the seven member companies, with Mr. Eadie, President of Bell, as Chairman. At that meeting Arnold Groleau and I outlined the Mid-Canada project as it had been explained to us in our discussions with the Air Force. The apparent reasons for the Government looking to the telephone companies to participate as the major contractor were explained. The committee agreed that T.C.T.S. should participate if the Government requested it, again assuming that satisfactory contractual arrangements would be forthcoming. All companies agreed to contribute personnel to the extent possible related to their own needs and resources.

So we now had authorization from our principals to deal with the Government on the Project. The Bell Telephone Company was to be the Project Agent for the Trans Canada Telephone System and the Bell Special Contract Department would do the work.

There ensued a pause of two months. We in Special Contract were fully occupied in getting Pole Vault plans, materials and logistics organized for the 1954 blitz on that project. The Air Force [was] busy with their planning and early logistics assessments for Mid-Canada. Their systems Engineering Group (SEG) was just getting started.

But ideas on possible organization for doing the Mid-Canada job were evolving in both the telephone companies and the Air Force. On April 6th, responding to a request from Bell senior management, I outlined some parameters for meeting the indicated Air Force requirements. In the light of subsequent events, it is interesting to quote from this memorandum:

> "Discussions with the Royal Canadian Air Force and the Department of Defence Production indicate this company may be asked to act as prime contractor for Project Tamarac. The contractual arrangements would probably be similar to those now in effect for the N.E.A.C. [Northeast Air Command] microwave and "Scatter" project.
>
> "The R.C.A.F. would be Design Authority. The prime contractor, in the initial phase, would work closely with the design study team now being formed in the R.C.A.F., would be responsible for all contacts with industry, and would have any detailed design or engineering work do as required by the Design Authority. In the second phase, with the operational and broad design requirements established, the Design Authority would approve detailed design work, but the prime contractor would have all such work done and submitted to the R.C.A.F. for design approval, as is now being done for the N.E.A.C. job. He would also be responsible for all detailed engineering, procurement of equipment, subcontracting of construction and installation, follow-up and supervision on the job until completion and acceptance for operational use."

As to organization, our recommendation was that an "Area" unit be established within Bell, separate from the Toll Area of which Special Contract was then a part, and that the Special Contract group be the nucleus of this organization. This unit would be expected to handle the Mid-Canada as well as the Pole Vault project, also any other major defence projects which might be undertaken.

On the Government side, on April 12th the Department of National Defence was stating its position to the Departnent of Defence Production:

> "From relevant correspondence concerning the Project known as "Mongoose" (formerly Tamarack) it appears that our departments have reached a mutual understanding regarding the responsibility for the project and the method of implementation. Generally these are taken to be-
>
> (a) that the RCAF must remain the design authority for the complete project and as such is responsible for: all plans, specifications, equipment selections, surveys to determine actual location and inspection of the following: equipment, construction, installation and testing.
>
> (b) that a Management Contractor be appointed as soon as possible to implement the project. In Phase I his appointment would permit familiarization with the project in the event that it proceeds to Phase II, and provide a

> channel with industry through which technical information may be obtained.
>
> "In the event that the project proceeds to Phase II it is considered that a specification (for the contractor's role) similar in concept to the NEAC Microwave contract would be acceptable, however, this should be the subject of a separate letter."

Hence on April 23rd a letter from the Department of Defence Production (DDP) to the Chairman of the Trans Canada Telephone System, requesting:

> "a general proposal from you for the handling of this project (Mongoose) if the Trans Canada Telephone System were selected as Management contractor.
>
> "We are currently planning on proceeding with this project in two phases. Phase I will include a technical study and report including an estimated cost for the complete undertaking. Phase II will involve the complete engineering, procurement, transportation, construction and installation of the system."

The Trans Canada reply on May 7th said:

> "The companies comprising the Trans Canada Telephone System would, therefore, be pleased to act as management or prime contractor for Project "Mongoose" should it be so decided. A special group would be formed to do this work. This group would be organized by and its operations co-ordinated with those of the present Special Contract Department of the Bell Telephone Company of Canada, thus making full use of the experience of that group in handling the North East Air Command communications project. The necessary personnel would be drawn from the member systems of Trans Canada, and from the electronics and construction industries as required. In this manner full advantage would be taken of specialized knowledge and experience both as to technical aspects of the job and local knowledge throughout the various provinces of Canada."

There followed a description of work to be covered in Phase I - i.e. siting, field surveys, liaison with RCAF as Design Authority, contact with industry for RCAF, and engineering assistance as required. Then this: "In the event that the project proceeds to Phase II, we would continue with the type of activity already outlined and, in addition, would be prepared at that time to proceed as required with detailed engineering, siting, construction and installation of the complete project." An estimate of $77,000 as the Management Contractor cost of Phase I was given, with the proposal that for Phase 2 the Trans Canada fee be fixed at 2½ percent of the total cost of the project "as estimated at the time it is decided to go ahead with it."

This proposal was reviewed by the Trans Canada management committee in June, and arrangements made to distribute the fee – 28% divided equally between the seven systems – i.e. 4% each, in recognition of their advice, assistance and know-how; the remaining 72% split in proportion to each system's contribution in personnel to the project management group. Symbolically, the proposal to go ahead with the contract and divide the fee as shown, was moved by A.M. Mackay of the Maritime Tel.& Tel. Co. and seconded by C.B. Diplock of B.C. Telephone – Trans Canada from sea to sea!

Finally on June 25th a letter of intent from DDP to Trans Canada, the significant paragraph being:

> "This Department intends placing a contract with the Trans Canada Telephone System in connection with what is known as Phase I of Project Mongoose, which phase includes a study by the Royal Canadian Air Force, Headquarters, Ottawa, (the Design Authority) for operational and technical requirements of the project, followed by a report. It is contemplated that Phase I will continue until September 1954. Under the proposed contract the Trans Canada Telephone System will co-operate fully with the Design Authority and will perform such work, including work of the types hereinafter set out, as is required by the Design Authority."

There followed a series of meetings between the newly-named Management Contractor and the RCAF. A July 5th session in Montreal brought the key technical and administrative people in Special Contract and the Air Force together for familiarization with the project, with the two organizations, and with the specific roles of the different people. Organization charts for both groups and brief job descriptions for key people in Special Contract were covered. Arrangements were made for monthly work status and financial reports to be issued by Special Contract.

It was proposed that a small co-ordinating group be formed, similar to that guiding the N.E.A.C. project, to include one senior member from each agency (Bell, RCAF, DRB, DDP) and to serve as a clearing point for matters of technical policy and decision. In the N.E.A.C. (Pole Vault) project this Policy Committee was very effective. For Mid-Canada, as time went on, more and more people attended the meetings until they were far too large for clear, prompt decisions, and became a forum for debate – at times acrimonious – and thus were not too useful in my view.

During the early phase, while systems design of the doppler and communications equipment was the concern of SEG, that group would report to Air Commodore Hendrick, Chief of Telecommunications.

For the construction phase, it was planned that SEG would report to Air Commodore Long, Chief of Construction Engineering. It was agreed that liaison between Special Contract and the RCAF should be established and made to work at all levels. The Air Force SEG was working towards a firm decision from Canadian and U.S. Air Force Headquarters on the type of line by Sept. 1st. (Final report was actually made August 27th). Hence discussions between Special Contract and SEG on all technical facets of the project were important.

A second meeting the next day in Ottawa brought Special Contract up to date on RCAF thinking as to type of doppler equipment, possible radar installations etc. Preliminary work done by the RCAF on power units, doppler equipment and antenna design with RCA was reviewed so that Special Contract could start to make some useful input, and take over the detailed engineering, coordinating and management role which was intended. It was agreed that there needed to be some broadening of the June 25th Letter of Intent so that no time would be lost in moving into the implementation phase, once overall approval of the SEG report, and decision to implement on the basis of the report, was made.

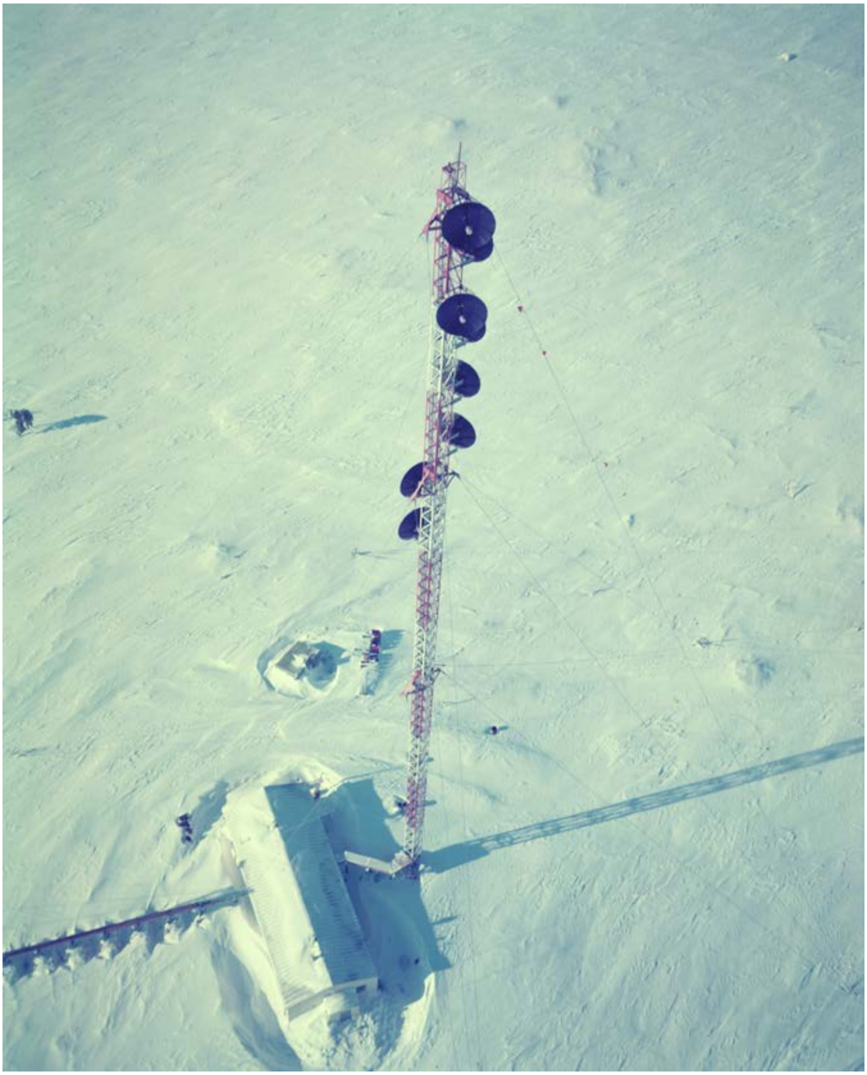
Anticipating approval somewhat, we proceeded to build up staff in Special Contract in order to meet the demands placed on us. Bear in mind that at this stage Pole Vault construction was at its peak. On September 2nd we asked DDP for a broadening of the June 25th authority, since we had already been asked by the RCAF to proceed with several activities which were not included in that authority.

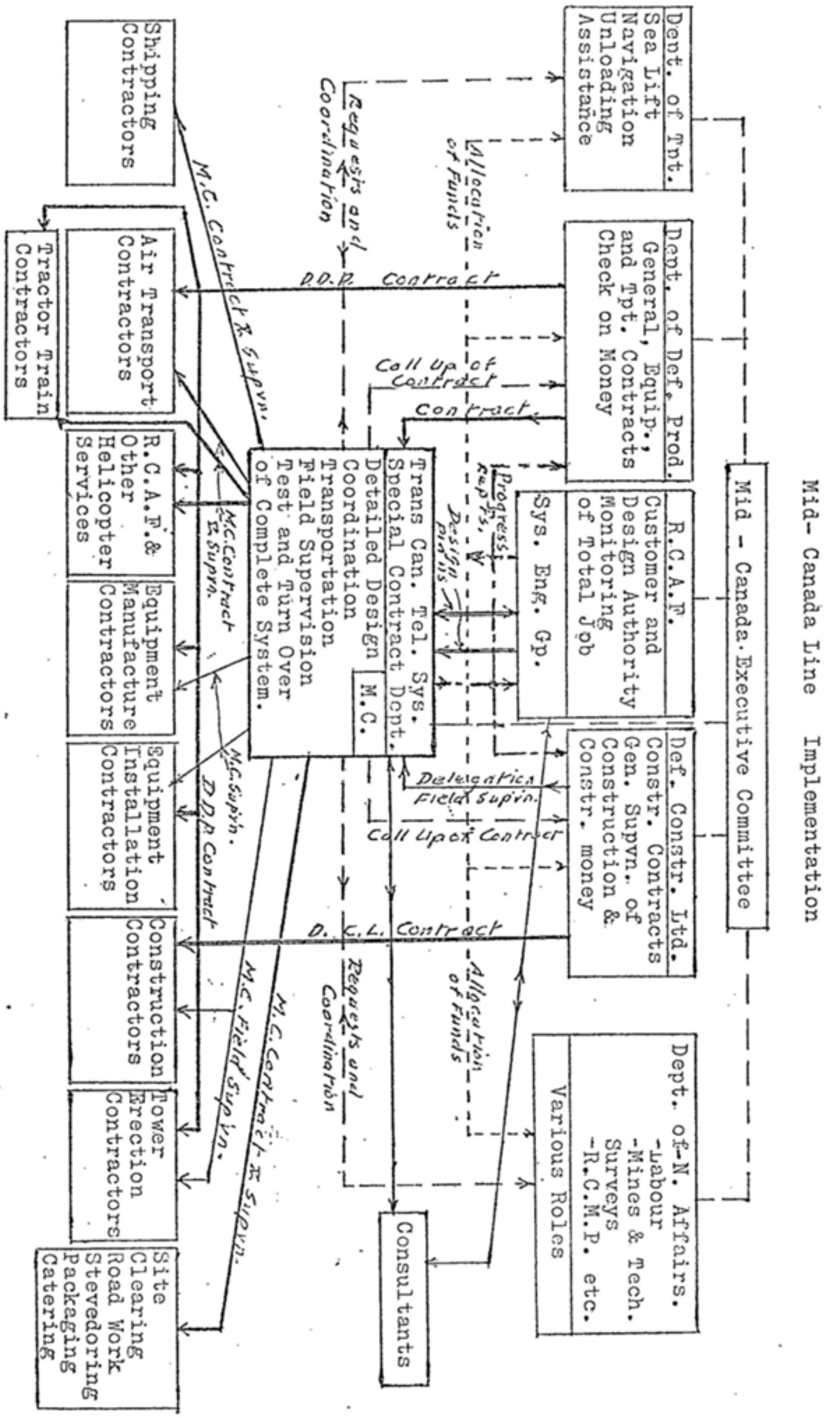
A week later DDP gave us authority to go ahead with the Test Line, one of the items requested by the RCAF, and increased our total spending authority to $427,000. Further authority to proceed with siting and limited construction at SCS's was tentatively authorized, and "if the project proceeds to Phase 2" DDP proposed to draw up a formal contract with the Trans Canada Telephone System. That "if" disturbed us. We pointed out that, on the understanding that Phase 2 was going ahead, we had started a staff build-up, which could not be delayed if the extremely tough schedule planned for Mid-Canada was to be met. We also, in our letter of Sept. 1st, as it turned out somewhat prophetically, said:

> "This brings up the whole question of the scope or authority to be granted the Management Contractor on this project. We would be very reluctant to see this authority handed down on a piece meal basis for individual parts of the project. Such a procedure will hamper us greatly in our overall planning and will inevitably result in delays and confusion.

> "We feel strongly that if we are to do the job of planning and implementation which is required to meet the target dates, it is essential that broad authority for all phases of the project should be forthcoming now."

DDP hastened to reassure us, indicating that the given authority of up to $427,000 need not be limited to test line work; and that they had been assured by the Department of National Defence that authorization to proceed with Phase 2 would be given as soon as possible.




Mid- Canada Line Implementation
Mid - Canada.Executive Committee
Dept. of Tpt.
Sea Lift
Navigation
Unloading
Assistance
Dept. of Def. Prod.
General, Equip.;
and Tpt. Contracts
Check on Money
R.C.A.F.
Customer and
Design Authority
Monitoring
of Total Job
Sys. Eng. Gp.
Def. Constr. Ltd.
Constr. Contracts
Gen. Supvn. of
Construction &
Constr. money
Dept. of N. Affairs.
-Labour
-Mines & Tech.
Surveys
-R.C.M.P. etc.
Various Roles
Trans Can. Tel. Sys.
Special Contract Dept.
Detailed Design
Coordination
Transportation
Field Supervision
Test and Turn Over
of Complete System.
M.C.
Consultants
Shipping Contractors
Air Transport Contractors
Tractor Train Contractors
R.C.A.F.& Other Helicopter Services
Equipment Manufacture Contractors
Equipment Installation Contractors
Construction Contractors
Tower Erection Contractors
Site Clearing
Road Work
Stevedoring
Packaging
Catering
Allocation of Funds
Requests and Coordination
D.D.P. Contract
Call Up of Contract
Contract
Progress Rep'ts.
Design Plans
Delegation Field Supvn.
Call Up of Contract
D.C.L. Contract
Allocation of Funds
Requests and Coordination
M.C. Contract & Supvn.
M.C. Contract & Supvn.
M.C. Supvn.
D.D.P. Contract
M.C. Field Supvn.
M.C. Contract & Supvn.

Chapter 9

Black Monday and After

From the inception of our discussions on the Mid-Canada Line, we in Special Contract, and in the Trans Canada Telephone System generally, had proceeded on the basis of being prime contractor, with full responsibility and authority to have the work done by ourselves or by sub-contractors to meet the design requirements of the RCAF; subject only to prior approval of major contracts by DDP. This corresponds to normal commercial practice, and was the basis used for Pole Vault and associated projects on which we were working. The arrangement worked well, authority was commensurate with responsibility, an essential feature for any job, and the results in terms of efficiency, cost and timing were proving eminently satisfactory to the United States Air Force, for whom the work was being done. Both the RCAF and DDP had indicated that this type of contractual arrangement would obtain for the Mid-Canada job.

During October, 1954, ten months after our first discussions and three months after the first DDP letter of intent, clouds started to appear in the Ottawa sky, and on Monday, November 1st, the deluge fell. This from the Deputy Minister of DDP:

> Discussions have been on the basis of a management contract, with the management contractor in full charge of the project. It is now contemplated that the Department of Defence Production and Defence Construction (1951) Limited should exercise procurement functions with regard to this contract. It would be appreciated if you would reconsider your proposals for the way in which the management contract would be handled in the light of this change in concept.
>
> I would point out that there is no change in the concept of employing a management contractor for the project but the new approach does affect the way in which the procurement of equipment, installation and construction will be handled.

The proposed division of functions and responsibilities out-lined with that letter was drastic, as far as we were concerned:

(a) The RCAF role as Design Authority remained as we had understood it.

(b) The Department of Defence Production would carry out its "normal procurement functions," in calling of tenders, negotiating and awarding contracts, supervising and expediting production. It would be responsible for placing engineering contracts, whether for the management contractor or the Government agencies; also for procurement of supplies, including fuel, barrack stores etc.; and it would place the major in-stallation contracts.

(c) Defence Construction (1951) Limited would arrange for construction of all buildings, roads, runways and other construction incidental to the project. DCL would be responsible for the supervision of all construction contracts placed by it.

(d) With all this, what was left for Trans Canada to do? The Trans Canada Telephone System was still to be primarily responsible for the supervision and coordination of the entire project. It was planned to include a clause in DDP contracts establishing this position of the management contractor. TCTS was to work closely with the Design Authority, providing them with engineering and consultant advice, technical and costing information, an implementation plan for the entire project, detailed plans and specifications to meet Systems requirements; to develop a master time schedule, carry out siting and other field surveys, coordinate reports; it would look after packing and transportation. In total, TCTS "will carry out the work required to turn over to the Government a complete and workable early warning line."

Well might Newt Culver, our Siting Engineer, call the day "Black Monday." We were astonished, and immediately objected strongly. In a memorandum, a copy of which was given to the RCAF, I outlined my fears to Bell senior management:

> In our opinion this concept is basically wrong. In attempting to operate under it the Management Contractor will not be able to choose his own subcontractors, he would have no control over their actions since he would not be a party to the contract, the time required for approval by DDP or DCL, by the Deputy Minister and by Treasury Board of each and every subcontract would inevitably result in time delays; the cost of the project would be higher and the amount of paper work greatly increased.
>
> In my opinion it is wishful thinking to consider that DDP and DCL would be satisfied simply to sign a contract with a sub-contractor who had been selected and with whom some terms had already been negotiated by the Management Contractor.... Thus we lose control of the quality of the job by losing the facility of picking

sub-contractors who we know are capable of satisfactory performance.

We have already had considerable difficulty in trying to discuss matters with one electronic manufacturer for the simple reason that we are not a party to his contract and have been plainly told so.

As an example of the benefit of direct control in the NEAC project: "Difficulties found in structural design of antennae were only corrected by the manufacturer at the insistence of our engineers. If the manufacturer's contract had been direct with DDP I am doubtful if he would have corrected these defects, with disastrous results to the whole project."

Coupled with this thought (timing) in our minds would be the necessity of keeping DDP and DCL completely integrated at all times with our detailed thinking as regards both design and procurement. This would represent a formidable task and would undoubtedly involve a very considerable amount of time and effort both on the part of the Management contractor and of the Government agencies concerned. The difficulty of securing technically competent people in these Government agencies to appreciate and act on this detailed planning is also a factor.

It is our understanding, confirmed many times by the Air Force, that the Mid-Canada Line is an urgent operational necessity and must be in service at the earliest possible date. Considerable effort was expended in trying to advance the date to January 1956. It was found that this was impossible but the Management Contractor has agreed to exert every effort to try and meet the overall service date of January 1957. It is our considered opinion that under the altered procedure now proposed it would be utterly impossible to meet this date, and that the overall completion would undoubtedly be delayed a year, and probably longer.

A contractor working in the field on a contract with DCL would be answerable only to DCL for his costs.

This control of costs is very real. Without it we feel that the overall expenditures on the project would be considerably greater than with the direct control inherent in the NEAC arrangement.

Finally the crux of the situation appears to us to be that the proposed arrangement divorces responsibility from authority. The Management Contractor cannot fulfill the responsibility of implementation and coordination of the whole project since he will not have authority over the people doing the job in the manufacturing, construction or installation field.

Over the next two months the problems stemming from the proposed division of responsibilities were discussed intensively between DDP and Bell, both at the technical and policy levels. This included a meeting between Mr. Eadie and Mr. Howe (Minister) and Mr. Golden (Deputy Minister) of Defence Production. Some modifications were made, chiefly affecting administration in the field, but the main thrust of the DDP proposals remained intact. By January 13th, 1955 agreement had been reached at senior level, with the intent that a formal contract would follow. Further minor modifications in understanding continued throughout the spring, and a Purchase Order from DDP was issued to Trans Canada on June 15th; or rather to the seven companies comprising Trans Canada, for the system per se is an association, not a corporate entity, so all seven members of the system signed the receipt of the Purchase Order, and later on the formal Contract.

This purchase order contained the contractual conditions as they had been established. However there continued to be throughout the project some backing and filling as to their interpretation. An amendment to the purchase order was issued later but the formal Contract was not actually completed and signed until August 1957, when the job had been finished.

The Toronto *Saturday Night* articles written in 1959 made much of this delay in a formal contract as a major cause of the confusion of command and frustration which persisted through the project. While the delay in a formal document was a contributing factor, the difficulties did not really stem from the delay, but from the contractual terms themselves, which were known in January 1955. As established then and later incorporated in the formal contract, the essential points were as follows:

(a) As Design Authority, the R.C.A.F. will produce the overall systems specification, and will monitor the project to ensure that the full intent of the specification is carried out and that progress scheduling will meet the completion date. The Design Authority will be responsible for a study and report on the operational and technical requirements of the project. It will draw on the Management contractor for information and advice. Close liaison will be maintained between the Management contractor and the R.C.A.F. on all design matters to ensure that the intent of the Design Authority is fully carried out.

(b) The Department of Defence Production will carry out its normal procurement functions in connection with this contract. This includes calling tenders where possible, negotiating and awarding contracts, supervising production, and such special expediting as is required to ensure satisfactory completion of contracts to meet delivery schedules. It will be responsible for placing certain engineering contracts, including the main management contract. Other types of contracts in this category include the employment of special engineers for the Design Authority or for Inspection Services of the Department of National Defence. The Department will be responsible for the procurement of equipment incidental to the operation of the project; will place the major installation contracts, and certain major transportation contracts. It will procure general supplies such as fuel, barrack stores, etc., required in the construction of the line.

Before contractual action is taken, the Management Contractor will be consulted in the preparation of source lists where his knowledge of available sources of equipment, materials and services would be of benefit. On receipt of tenders, he will assist the Department of Defence Production in their assessment, where his specialized knowledge would be useful.

It is agreed that, where applicable, a clause will be placed in contracts negotiated by the Department of Defence Production to the effect that the Management Contractor will act as agent of Her Majesty in respect of that contract, and will be responsible to the Department of Defence Production for such scheduling, expediting, verification of invoices and progress claims, marshalling and transporting of materials, components and equipment, as may be required.

(c) Defence Construction (1951) Limited will negotiate and award contracts for buildings and structures and for certain major transportation requirements, calling for tenders where necessary. It. has been agreed that the Management Contractor will be consulted with regard to the tender list where his experience and knowledge would be of benefit, and he will assist Defence Construction Limited in the assessment of tenders when received, where his specialized knowledge would be useful.

Defence Construction Limited will include with their contracts, either as a clause of the contract or a separate letter to the contractor, instructions that the Management Contractor shall be the agent for D.C.L. with respect to field supervision of the contract. This will cover complete direction of the job in the field both as to timing, quality of workmanship and overall co-ordination to meet design and all job requirements to the satisfaction of D.C.L. It will also include the verification of progress claims of the contractors and recommending them to D.C.L. for payment.

D.C.L. will employ a number of field representatives of their own who will be located at a few points along the Line and who will have access to all sites. These men will be of senior caliber and in effect will be the D.C.L. representatives who deal with the Management Contractor's field supervisors. They will deal in all matters with the Management Contractor's representatives and not with the general contractors on the job. All field changes in the project which involve an expenditure of money will be subject to their approval.

In addition, D.C.L. will organize a group in Ottawa to maintain direct liasion with their field representatives on the one hand and with the Management Contractor's staff on the other.

(d) The Trans Canada Telephone System, through its Project Agent, (i.e. Special Contract Department of the Bell Telephone Company of Canada) will carry out the duties mentioned above and will be responsible for the overall supervision, coordination and timing of the entire project. The Management Contractor will work closely with the Design Authority on organizing and planning; will provide engineering and consultant advice; technical reports; costing information and detailed drawings and specifications to meet the systems requirements established by the Design Authority. It will develop a master time schedule and will carry out siting and other field surveys on request of the Design Authority or as indicated by the requirements of the work. The Company will coordinate reports; arrange for special packing, storage and transportation of equipment, etc. to the sites; and arrange for tests of equipment, structures or systems, as required. The Company will turn over to the Government a complete and workable early warning Line in accordance with the overall design indicated by the Design Authority.

To carry out his engineering and coordinating function, the Management contractor will place contracts for the services of engineers, consultants, etc., for necessary engineering equipment and materials, and, where applicable, for transportation. Contracts so placed will be awarded as subcontracts of the management contract, using normal procedure of the Department of Defence Production, obtaining approval before commitment where necessary.

Two questions must be asked:

(1) Why did the Government insist on control of procurement?

(2) Why did the Telephone companies accept, and continue with the project?

Not being privy to the inner councils of Ottawa officialdom, I can only guess at the reasons for their change from the earlier approach of a clear-cut prime contract, with all other work on a sub-contract basis through the prime contractor, subject to prior approval of major items by DDP in accordance with their rules. The change must have been initiated, or at least endorsed, at the policy level in Government, for DDP continued to work with Bell as prime contractor for Pole Vault, to the satisfaction of both parties and of the United States Air Force who were paying the bill.

In my view there may have been three reasons for the change:

(a) Politically the Government wanted full credit as the direct contracting party to the companies concerned. Many were major firms, particularly in the construction industry, with substantial political clout, and I imagine many representations were made to Government political and civil service people for consideration in a project of this magnitude. The Government agencies were probably considered more open to a wide choice of contractors than Bell would be. In the equipment field, the fact that Bell purchased virtually all its telecommunications equipment from Northern Electric may well have influenced both the electronics manufacturers and Government towards DDP direction of contracts.

(b) From my observation, there is a much greater tendency in Canada than in the United States to consider that large projects, particularly if they have any Government connotation at all, should be implemented by Government or Government-owned agencies. Witness our many crown companies, Government-owned utilities etc. In my opinion our Government and civil service people, and perhaps the public generally, have much less faith than their opposite numbers in the U.S.A. in the capacity of private enterprise, and the desirability of giving private industry a free rein to do a job. In this case, this was despite Mr. Howe's expressed desire to have implementation of the project co-ordinated and pushed by the telephone companies.

(c) There may have been a question about the ability of Bell (as project agent for the Trans Canada Telephone System) to accomplish the task in hand without strong Government direction. Bell was perceived as expert in the telecommunications field, but not necessarily in construction or transportation. The fact that we were successfully handling the whole series of problems inherent in such a project in the case of Pole vault did not register fully.

From the Trans Canada side there were in my view two dominant reasons for agreeing to go ahead, even though we recognized the inherent difficulty in living with these contractual conditions:

(a) The feeling that the job was vital to the national interest, and, probably persuaded by Mr. Howe's initial approach, that the telephone companies might be the only nationwide private agency capable of its implementation. As in the case of Pole Vault, there was a strong element of duty as a Canadian corporate citizen.

(b) Pride. We were proud of what we were accomplishing in the North East Air Command project (Pole Vault) and were confident we could do the Mid-Canada job. In a broader field, Bell had recently completed the first major

> radio relay system in Canada (Buffalo-Toronto-Ottawa-Montreal) and along with its Trans Canada partners was busy planning the Trans Canada microwave system, which was built during the 1955-57 period, going into service early in 1958. Bell's own construction program for all types of installations was the largest continuous private industry construction program in Canada. So we were confident, proud to do the job, and ready to tackle it even under the very restrictive terms which the Government had laid down.

Many of the fears which we had expressed earlier materialized; some did not. Both DCL and DDP made a sincere effort to delegate field supervisory responsibility for their contracts to the Management Contractor, and to a considerable extent this worked. In the actual letting of contracts, we had difficulties as the job developed, particularly with DDP. They wished to maximize their procurement role, and for work which we as Management contractor were allowed to subcontract (under $10,000 or under $25,000 with DDP approval) they wanted contracts let in bulk so to speak from our Montreal headquarters. With a project spread across 2800 miles of wilderness it was essential that our field supervisors procure many things, especially transportation, as the exigencies of the local situation dictated. This they did with our blessing, in the interests of the urgency of the job, but with consequent problems with DDP. Interestingly, this DDP viewpoint was at complete variance with the Air Force, who felt we controlled things much too tightly from Montreal. DDP stationed people in Montreal for short periods to assist in liaison with us, but they were never given power of decision [and] had to refer everything back to Ottawa, so their help was limited.

There were delays, some inconsequential, some serious and expensive. These occurred both in getting monetary authority and in having contract negotiations completed for equipment, construction and transport. One interesting case was the Dorman diesels. Each Doppler station was to be equipped with three 20 kilowatt diesel engines as the power source. In August 1955, Special Contract, having written the requirement specification, requested DDP to let a contract for approximately 275 diesel units. We suggested about 15 possible suppliers. This being a large and important contract, DDP increased our list to about fifty suppliers and received 70 proposals in return. The process of narrowing down these proposals proceeded during the Fall, until two possible suppliers were left. Their engines were then tested in Government test beds, and Dorman of England was finally picked as the supplier - six months after our original request. It was now February. The units were too heavy for helicopter lift over long distances, so most of them had to go in to DDS's on the ground via snow road or tractor train during the winter of 1955-56, while the ground was frozen; otherwise the whole project could be delayed a year.

The Dorman Company were prompt in filling the order at the factory gate; but how to get delivery at DDS's before the Spring break-up? Finally the Executive Committee for Mid-Canada agreed with us that they must be air lifted to airports near the line. The lift was handled as a joint operation by Air Transport Command of the R.C.A.F. and Trans Canada Airlines (later Air Canada) who assigned some of their own and chartered other aircraft – mainly Superconstellations – to fly the machines to Great Whale River, Winisk and commercial airports close to other parts of the line. So, seven units to each constellation, some 135 diesels were airlifted from the United Kingdom, enough to provide for initial operation of the DDS's plus some spare. The units were then distributed from airports to DDS sites by tractor train or other surface transport before the Spring break-up, thereby enabling us to keep close to the schedule for the Project as a whole. The air lift charge per unit as I recollect was $2000, so the carefully assessed low bid factor was somewhat distorted!

There were other delays, none I think as spectacular as this one. To be fair, I should record that DCL and DDP were in general diligent in doing their job of contract negotiation. A difficult point was prompt payment of small contractors. The delaying factor was nearly always in securing Treasury approval of funds rather than slow payment of claims once funds were available. For whatever reason, we found it necessary many times to use Bell funds temporarily to keep these small contractors going. This problem was particularly prevalent early on, but persisted throughout the project.

In the construction contract field, the main problem was the chafing of the major contractors under Management Contractor guidance. Our field engineering checking and cost control was inclined to be emphatic and rigid, at least in the eyes of the general contractors. This was partly due to the type of individual we had in charge of that part of the operation; hard driving, knowledgeable men, dominating in a control situation, and disinclined to compromise. Partly also it was because we wanted to be sure that costs did not get out of hand, for the contracts were on a cost plus basis. On their part, the contractors felt that we did not make adequate use of their expertise in field management of the construction job, and they made their concerns known to DCL from time to time, which was natural. As against this, I should state that in my personal view, the quality of field management exhibited by the contractors' people in many cases left much to be desired. The smaller contractors were more "biddable" from our standpoint.

DCL tried to clear the air early in the game. The Eastern line major contractors having been selected in March and early April, 1955, Mr. Johnson, President of DCL, convened a meeting in Ottawa on May 17th. It was attended by the four major contractors for the Eastern end of the line, also by DDP, the Management Contractor, and of course DCL. Mr. Johnson laid down in some detail the proposed roles of the M.C. and the general contractors, amplifying and to some extent modifying the broad principles agreed upon earlier between the Government and ourselves. This meeting was held while we were still in the planning stage; the contractors had not yet moved into the field; so there was time to adjust attitudes and thinking.

The DCL philosophy was that the three agencies, DCL, M.C. and General Contractor, would carry out their normal functions. In this case DCL would act as the owner, the M.C. as coordinator of electronics with construction, and as resident engineer for DCL on the construction site, but would not be the job superintendent. The construction contractor would be responsible for carrying out construction in the normal manner, having normal relations with the owner and an engineer (the M.C.) who had full engineering supervision including cost control. The general contractor would be responsible for job management including purchasing, hiring, expediting, transporting, catering, etc. A number of special situations, including ship chartering, air transport along the line, marshalling areas, responsibility for camp operation, review of labour rates, were examined and the relative roles of the M.C. and general contractor delineated.

It was a good effort, and it bore fruit to a degree. We still had problems, but there was a greater understanding of each other's responsibilities in the field. DCL stationed a senior man at Special Contract headquarters in Montreal, which helped smooth out many tangles. I did, however, expect more from the construction industry in the way of high quality management than they demonstrated. They in their turn undoubtedly expected more elbow room as to field supervision than we gave them. Perhaps we were both wrong, but in any event we learned to live with each other and with an unsatisfactory type of contractual relationship. For despite all the desire to have "normal" relationships on the job, the fact of having a management cont ractor was not normal in the industry. As management contractor we had written large in our consciousness the first clause of our DDP purchase order, which also was the opening paragraph of the formal contract later on, namely:

> The Management Contractor shall be responsible for the completion of a workable system, ready for operation, to be known as the Mid-Canada Early Warning Line.... The Management Contractor shall use its best endeavours to complete the system on or before the first day of January, 1957, constructed and installed in accordance with plans and specifications approved by the R.C.A.F. Systems Engineering Group,--on condition that all contractors of the Department of Defence Production and Defence Construction (1951) Limited carry out their contracts in accordance with the terms and conditions thereof.

The operational need for the Mid-Canada Line was again emphasized in a message from the Chief of the Air Staff to the Chairman of the Mid-Canada Executive Committee in September 1955:

> I am well aware that this whole project is a very difficult logistic, technical and production one and that the target date is stringent. I would remind you, however, that the early warning provided by the Mid-Canada Line will enhance the capability of our defence forces in large measure and will thereby help reduce the great disparity between our forces and those air forces which could be directed against this continent in 1957. I should remind you further that the target date was advanced by one year as a result of the strong case made by the United States Chiefs of Staff and to which, after study, the Canadian Chiefs of Staff fully agreed. In consequence, the Canadian Government undertook to meet the requirement. It is a highly important requirement and therefore no effort must be spared to ensure that everything possible is done to achieve the target date which we have undertaken to meet.
>
> …I would appreciate your bringing these facts to the attention of the Executive committee and through them to the Management Contractor with the request that every possible effort be made to remove the bottle-necks and to achieve the promised dates of all seven sections completed by 1 January, 1957.

This was the main chance, our chief motivating force, as I am sure it was for the Government agencies involved.

Our biggest problem was one that we had not anticipated, and which, as it turned out, might have been present regardless of the terms of our contract. The problem was the Construction Engineering branch of the R.C.A.F. The Air Force, under the directive of the Cabinet Defence Committee, was charged with overall responsibility to see the project through to complete operation. The purchase orders and eventually the formal contract with the Trans Canada Telephone System stated that the R.C.A.F. was responsible for establishing the system specification, for approving all detailed plans and specifications, and for monitoring the work to ensure that it was carried out in accordance with the specifications to meet the operational requirements.

We had a normal owner-contractor relationship with the tele-communications branch of the Air Force through most of the project. There were a few rough spots, but not more than one would expect, given the urgency of the job, and the number of fingers in the implementation pie which the form of our management contract produced.

In the buildings and structures side of things, however, we ran into grief in two areas. We were to have detailed plans for all structures drawn up to meet Air Force requirements, using architects and consultants as required, the plans to be approved by the Air Force. Unfortunately it proved difficult to establish the Air Force requirements for the various buildings comprising the Section Control Stations, so much so that it delayed finalization of contractual arrangements with construction contractors. On their part, the Air Force found it very difficult to establish their requirements in detail under the agreed upon arrangement of working through the Management Contractor to the Architects and Consultants. They insisted that they must deal directly with these people. After considerable reassessment, for this tended to bypass us in an important responsibility, and abrogated almost completely our influence over building design, including economy of design, we agreed that the R.C.A.F. would deal directly with the architects and consultants on these detailed plans, keeping us fully informed so that we could reflect the status of the plans in our overall coordination and scheduling. Despite this direct R.C.A.F.-consultant contact, delays in availability of building plans persisted. It was well on into 1956 before the last of the building plans for Section Control Stations became available. The Air Force concern as to design was with the SCS's only. The Management Contractor continued to have design responsibility for the Doppler stations and for all towers.

The second and much longer lasting and difficult problem was in field supervision. The interpretation of the word "monitor" by the Construction Engineering group of the Air Force was that they must direct and drive the Management Contractor in every detail of the construction job, to suit their own ideas of how it should be done. Their ideas were generally very firm, but not always consistent. The approach seemed to be that the R.C.A.F. must coordinate the whole project, and be in charge of both planning and direction in complete detail. In reality, this group, based on their actions, wanted to use the Management Contractor simply as a provider of hired bodies, to do as directed by the Air Force. Their pressure on us, since their ideas of coordination and sequence of implementation frequently clashed with our own, tended to keep Special Contract off balance, and reduced our effectiveness. On the other hand, they felt that we did not tap the construction knowledge which the R.C.A.F. had. One rather senior individual told me in all seriousness that he knew more about construction than any man in Canada. He didn't; neither did I; but this attitude of aggressive dominance, which was also present to some degree in our own forces, did not make for easy relationships.

The relationship difficulties in this field construction area grew steadily to a peak in the middle of 1955 (that is in the first six to nine months of our joint efforts, and really before major construction activity got well started in the field). In a memorandum dated May 6th I was saying: "I think it must be stated that the construction branch of the Air Force in particular really does not want a management contractor." In point of fact, we offered on two occasions to withdraw from the project, since the Air Force and to a lesser extent the general contractors appeared anxious to "Gang their ain gait."[1]

At a meeting in Ottawa in June, the R.C.A.F., D.C.L., and D.D.P. all stressed to us their responsibility to exercise authority "in their normal roles"; that we were there to help them do the job, rather than to do it ourselves and report to them. This extreme and really impossible position would have meant that we could not have taken responsibility for timing or overall coordination of the project, for I think the Government people were finally realizing that authority must be commensurate with responsibility. In any event their approach reverted during the ensuing few months to confirming the responsibilities as spelled out in the January 1955 agreement. This was due partly to the fact that field construction was really getting ahead, and a happier atmosphere ensued. Late in the project, criticism of the M.C. increased again, this time chiefly due to cost overruns on construction, and we again had some relationship problems. As one of my associates put it, by that time we were like a duck swimming in a pond which was slowly freezing over, giving us less and less room to manoeuvre and get the job done. However before the pond froze over completely the Line was completed.

It is difficult even now, twenty years later, to assess this whole problem of relationships objectively. Certainly I feel that the Government would have been much better served if they had stayed with the original concept of a prime contractor, with the various component parts of the project sub-contracted through him, subject to D.D.P. approval – i.e. the plan carried through successfully for Pole Vault. I am also satisfied that under such a plan the overall cost of the project would have been less. However the fact remains that we accepted the revised contract, and it was up to us along with the Government agencies to make it work. We sincerely tried to do so, as I am sure did our associates in D.D.P., D.C.L. and the R.C.A.F. The personality conflicts between construction engineers in the Air Force and those in our own shop, the procurement problems, delays and other irritations probably loomed larger than warranted at the top of the organization, for it was there that they came for solution. This was particularly true of the Executive Committee, at which most of the frustrations were finally aired.

At times I felt that we could either drive the job intensively or be nice relaxed fellows to all concerned, but it was difficult to do both. We chose to drive the job

[1] Editor's note: Scottish phrase meaning "go one's own gate" or "take one's own path." *Scottish National Dictionary*, http://www.dsl.ac.uk/entry/snd/sndns1689.

and let the chips fall where they may. But the number of chips may have been unnecessarily large. At one time Bell people suggested that I should have a Public Relations man smoothing the way between ourselves and the Government agencies. Perhaps it would have been useful, although Bill Bell and Russ Cline did a good job in that area, and I tried myself to keep the wheels turning without too many squeaks.

In the field the project was being driven ahead through all these arguments by able, dedicated people in all agencies to meet the deadlines which had been set. There were hundreds of meetings between the Management Contractor and the other agencies at the engineering and management level, and literally thousands of personal contacts which proceeded constructively in the interests of getting the job done. It was by means of this steady constructive work that the project was carried through to completion.

Chapter 10

Organization and People

The basis of understanding with the Government, as expressed in discussions early in 1954, was that if the Trans Canada Telephone System was selected as Management Contractor for the Mid-Canada project, T.C.T.S. would draw on its knowledge and resources right across the country, but would name Bell as its Project Agent to interface with Government Departments. Bell would act through a separate group within the Company.

By April 1954 it was clear that Trans Canada would have a major role to play. So as of May 1st, the Special Contract Department was raised to the status of an "Area", and Mr. G.M. (George) Grant was appointed General Manager. George had many years service in Bell plus a distinguished Army career. From 1951 to 1954 he was on loan to the Department of Defence Production, first as Director of the Electronics Division, then as Coordinator of several divisions of D.D.P. including Electronics. He had been involved in much of the early negotiations and Government thinking on the Mid-Canada project, so was a natural to head the enlarged department.

In July R.A. (Russ) Cline was appointed Chief Engineer of Special Contract, heading up the complete Technical team, and shortly afterwards A.R. (Andy) Neilson became Personnel Supervisor, an important role, for we had to recruit not only from other Bell departments, but from communications, electronics, construction and transportation companies across Canada, in the U.S. and in Europe. For my part, I continued as Assistant General Manager reporting to Mr. Grant, with the rest of Special Contract reporting to me. This one to one relationship was temporary to permit Messrs. Grant and Cline to become familiar with the operations of the group. At that time we were working full bore on Pole Vault, and were just beginning to pick up the threads of Mid-Canada. Total staff had come quite a distance from its start of seven people in June 1953, and stood at about 150 as of July 1954.

In January 1955, the Bell Company expanded its own geographical organization into four Areas, Montreal, Toronto, Eastern and Western, while continuing with Toll Area and the Special Contract Department. George Grant was appointed General Manager of the new Toronto Area, and I moved into the General Manager's spot in Special Contract.

During the fall and winter of 1954-55 a steady build-up of staff continued, both for central headquarters and field work. With completion of the initial Pole Vault system in February, we were able to turn our attention and people more completely to Mid-Canada, although increasing the capacity of Pole Vault and building extensions at East Coast sites kept some of our forces occupied there through 1955 and most of 1956.

As Special Contract grew, most of the people dealing with transmission, equipment and overall planning came from Bell and other companies of Trans Canada, also the electronics manufacturers and Northern Electric. In the construction field we found some experienced engineers in Bell, chiefly from groups engineering outside plant (poles, cable, etc.) and key positions were filled by them. For the larger group of construction engineers for on site work we recruited through personnel placement companies, principally Racey McCallum in Montreal, who were experienced in identifying and screening engineering help for major construction projects.

As the ramifications of the project increased, the support staff – purchasing agents, expediters, draftsmen, contract negotiators, accounting and clerical personnel – grew with it. Most of the support staff came from Bell, a few from Northern Electric and elsewhere. With the exception of a few clerks at field locations, the support staff was located in Montreal, where we had taken over two floors of the old General Electric building on Beaver Hall Hill, after moving from the Salada Tea building on St. Lawrence Boulevard. By the end of 1954, total staff was about 200; by mid 1955--390, of which 250 were in the engineering department, and 140 in other groups.

By May 1955 the main outline of the R.C.A.F. Systems Specification had been established, and Art Branscombe moved back from S.E.G. to Bell as Assistant General Manager of Special Contract. But Chief Engineers were in great demand, so Art moved on to Toronto as Bell Chief Engineer in July. He was replaced by W.G. (Bill) Bell. Bill had succeeded me in the Department of Defence Production in Ottawa in November 1952, and served as Associate Director of Electronics for nearly two years. He was therefore familiar with Government procedure and mores, a fact which proved very useful as the job progressed. As Assistant General Manager, Bill took over responsibility for activites outside of engineering and personnel. Among other things, this included contractual negotiations, and planning and training for equipment installation and testing.

Installation and maintenance people, first as trainees, then moving into the field early in 1956, added to the breadth as well as the total numbers of the department. The staff continued to grow throuqh 1955 and the first half of 1956, reaching a peak of 1254 all hands in August of that year. Thereafter, with field construction, equipment installation and testing rapidly approaching completion (the first stations in the West were ready in September), Special Contract shrank quickly. By the end of the year it included just under 900 people, and by the Fall of 1957, when men who had supervised equipment installation and done the run-in testing had transferred to the continuing Mid-Canada maintenance group, Special Contract was down to 75 people, all of whom moved back to their more usual occupations in their home department or company by the end of 1957.

At the 1956 peak, make-up of the Special Contract staff was:

Bell Engineers	121
Retained engineers and technicians	245
Bell transport foremen and others associated with construction	170
Installation & maintenance, accounting and personnel	440
Clerical (female)	278
Total	1254

The retained engineers and technicians included people from our associates in the Trans Canada Telephone System, [and] also from Canadian Marconi, Northern Electric, Westinghouse, Canadian General Electric, Rogers Majestic, R.C.A., Canadian Aviation Electronics, Standard Telephones and Cables, and Racey McCallum. The installation and maintenance group were the people who had been trained in a special school in Montreal and were at this peak period located along the Line checking the work of the installation contractors, and making all necessary equipment and system run-in tests to ensure a workable network. More about them later.

The organization was functional, with responsibility and authority identified for each division as clearly as possible, and decision making delegated as far down the line as feasible, having regard to our overall responsibility to the Air Force and other Government agencies.

Russ Cline as Chief Engineer was in charge of the technical team. Five Division heads reported to him:

Siting Engineer	D.N. (Newt) Culver
Transmission Engineer	D.J. (Don) McDonald
Equipment Engineer	D.J. (Doug) Pepper
Buildings and Structures Engineer	C.E. (Cliff) Frost
Transport Advisor	J.L. (Joe) Hurley

The Siting Engineer carried responsibility for siting of Doppler stations (DDS) and, within the general area selected for Section Control Stations (SCS) the precise location most suitable for purposes of the Line. He worked with the R.C.A.F. Systems Engineering Group (SEG) as to basic system requirements, with the Transmission Engineer as to radio propagation criteria, and with the Buildings and Structures Engineer as to soil and other physical characteristics of selected locations. He was supported by a small staff, first in the office study of contour maps related to the desired route of the line, then in the field to check propagation paths and otherwise determine specifically the sites which met all criteria.

The Transmission Engineer was responsible for overall coordination of the detection and communications system to ensure meeting the electronic design requirements laid down by SEG. His analysis of system design included doppler and radar detection systems, communications systems laterally (microwave) and rearward (tropospheric scatter), air-ground-air systems, narrow band channels for doppler signals, alarm and supervisory control (i.e. telemetry). As part of his coordination role, he collaborated with the Siting Engineer on radio propagation criteria, also with the Equipment Engineer in setting up requirement specifications against which equipment orders could be placed.

As opposed to the normal situation in the Bell Company where most systems are standardized, the Transmission Engineer here had a wide variety of new and different requirements to fill. Also since it was important to utilize equipment of existing design as much as possible, analysis of many types and sources of equipment was necessary. In the final pattern of the network fifteen major and seventy smaller suppliers were used, with consequent need for extremely careful coordination to ensure an overall working system.

In this task, Don McDonald had reporting to him two district level engineers, Z.H. Krupski, later an Executive Vice President of Bell, and W.J. Inkster, later a Vice President of Bell-Northern Research; also a group of twenty to thirty more junior transmission engineers.

The Equipment Engineer, Doug Pepper, had responsibility for all equipments, from identification of requirements in collaboration with S.E.G. and the Transmission Engineer, through the writing of requirement specifications, placing requisitions on the Air Force for money authority and on D.D.P. for selection of suppliers. He then had to follow up with suppliers, and arrange for packing and transportation of equipment to marshalling areas, ready to move to Line locations for installation and test. Pepper's equipment status board, covering all equipments and all Line locations, covered a room wall of about eight by twenty feet. Keeping it updated and taking action to expedite laggards and plug gaps in procurement was a full time activity for several of his staff.

The variety of equipments was wide, including microwave radio-relay, point to point radio, radar, tropospheric and ionospheric scatter systems, radio beacons, air-ground-air systems, doppler detection and display equipment, carrier telephone and telegraph systems, test boards, telephone switchboards, fault alarm equipment, diesel power units and fire fighting equipment. By terms of our management contract, the Equipment Engineer, when calling up equipments on D.D.P., suggested suitable suppliers within our knowledge. When D.D.P. received bids from suppliers, the Equipment Engineer assisted in their analysis prior to D.D.P.'s final choice of supplier. In total, the Equipment Engineering group wrote some 520 detailed requirement and installation specifications, some for equipment entirely new in design and many for equipment put to new uses.

The complications of the equipment job can perhaps best be visualized by the fact that a list of spares for the Line comprised 180,000 items.

The Buildings and Structures Engineer, Cliff Frost, had undoubtedly the heaviest load in the Engineering Department. He was responsible for planning, in collaboration with the R.C.A.F., of all buildings and other structures associated with the project, and, by coordination and supervision of the general contractors, for their erection on site. This involved detailed study of design with the Air Force and with consultant specialists. Cliff continued to carry full responsibility for design of doppler stations and all towers throughout the project. In the case of SCS buildings, however, as mentioned earlier, there was a problem in establishing effective channels between the Air Force and the consultants via the Management Contractor, so in this area the R.C.A.F. dealt directly with the consultants, with the Buildings and Structures Engineer coordinating the resultant plans with on site construction, a most difficult role.

The general contractors were chosen by D.C.L., after consultation with the M.C. These contractors did the actual constrction, with field engineers of the Buildings and Structures Division having the authority of the "Engineer" on site, delegated by D.C.L. and covering overall supervision to ensure plans being followed and costs checked. The Buildings and Structures Engineer was also charged with logistic support of the line, a major job in itself, including fore-casting and securing sea and air transport, tractor train operation, establishment of marshalling areas, building of access roads, etc. Major contracts in this area of logistics were placed through D.D.P. and D.C.L., minor ones (under $25,000) directly, with D.D.P. approval.

In support of these activities, Frost had three district engineers at headquarters, to carry staff work on planning, construction proper and logistics. The field work was under the direction of zone construction engineers. Two, Jack Palframan and Harold Olafson covered the four western Section Control Stations and their associated Doppler Stations - i.e. Dawson Creek and Stoney Mountain under

Palframan, Cranberry Portage and Bird under Olafson. In the central zone, Max Narraway, having finished his assignment on Pole Vault, was in charge of Winisk and Great Whale, with their tributary Dopplers. Bill Martin was in charge of Knob Lake and the difficult air lift to DDS's across the Ungava Peninsula. Russ Parke, stationed at Goose Bay, looked after Hopedale plus associated Dopplers, along with his other assignments on Pole Vault extension.

Underpinning these zone engineers were senior engineers at each Section Control Station, with site engineers for doppler stations, transport foremen, etc., to make the whole operation work.

Joe Hurley, Transport Advisor, was an ex Air Commodore who served as advisor to the Chief Engineer and to the Buildings and Structures and Equipment divisions on major transport problems – sea lift, Air Transport Command assistance etc.

In addition to these five divisions, the Chief Engineer had a large clerical group, under the able direction of Miss Mary Murphy. Large, because the number of detailed plans, the formal submissions and reports to Government agencies, the documentation of contracts and accounts to comply with Government regulations, resulted in a lot of records. Much of this was classified as Secret, requiring special secure filing procedures, and all of it had to be kept track of. Twelve years after Mid-Canada was completed, I had a final visit to the records depository where all Mid-Canada files had been stored. There were forty steel cabinets full, each of four drawers! We certainly generated a lot of paper.

Outside of the Engineering Department, Andy Neilson, as Personnel Supervisor, was in charge of all normal, and some abnormal, personnel functions. In a rapidly growing group involving many types of required expertise, the recruiting, security clearance and posting to suitable jobs of people from across industry and across the country was a demanding activity. Attention to their personal concerns, many away from home for long periods, required tact and ability to cope with unusual situations. For example, there was an emergency call one day concerning the child of one of our employees who was working on the Line. The child had to have a serious operation and the doctors required the father's consent before they would operate. The wife knew her husband worked for us, but he had not told her where he was going – apparently deliberately to escape conjugal problems. Getting that consent, while keeping both husband and wife in line, was a bit tricky. There were other cases, all needing good personnel handling to keep the whole operation moving satisfactorily from the human standpoint. Neilson was assisted in his task by Ken Hosley and a number of more junior but experienced personnel people from Bell.

Bill Bell, as assistant General Manager, played a major role in negotiations with Government agencies and others, and in supervising the whole program of training people and securing installation contractors, leading to full installation, line-up and test of the completed detection and communication system. He also had reporting to him Gordon Dewar who dealt with formal contracts and the whole accounting procedure. On the Mid-Canada Project alone, Gordon Dewar issued more than 12,000 purchase orders, from ship charters to consulting services.

As General Manager, I had complete authority from Bell senior management and the Board of Directors to enter into sub-contracts, and to carry out the project, subject of course to the provisions of our contractual relationships with the Government. In turn, the Department heads and each Division head (Transmission Engineer, Buildings and Structures Engineer, Equipment Engineer, etc.) was fully responsible for all activities within his own Division. If something went wrong, he had the answer in his own organization.

To keep the whole operation in tune, we held regular staff meetings, kept the lines of communication short, and tried to make sure that decisions were made promptly and clearly. The senior people were constantly on the job and available. Everyone was overloaded with work, but was expected to run his own show under tough conditions. One or two people did weaken and stumble under the pressure, but in total we remained a very healthy group. In fact through 1955 and 1956 absenteeism and lost time due to illness was the lowest in the Bell Company.

What were they like, this group of people, gathered from many occupations and many locations? First an overall comment. They were without question the most dedicated and loyal group of people it has been my privilege to be associated with. Frustrated they were at times, both with the complications of our Government relationships and with the infinite number of detailed things that can and do go wrong in a project of this size. But they worked their hearts out. Working hours were long in the field; they were even longer at headquarters. Yet with the tremendous work-load there was little internal friction – some, for we were all very human – and there was a continuous and tremendous effort to get the job done. This was coupled with a loyalty to me personally such as I have seldom experienced.

It had some of the characteristics of wartime camaraderie. Each of the Christmases – 1954, 55, 56, 57 – the whole group, or as many as were in reach of Montreal, gathered for a Christmas party. These were memorable events, usually held in the old Queens Hotel. At one of them, I was presented with an electric lamp. The lamp was a simple one; the unusual feature was that the parchment shade was covered with the signatures of all the female staff – and there were nearly three hundred of them! At the end of the project we sent out service certificates to the 1900 people who had served in Special Contract. I see some of the people from time to time, and to many of them, I think, Special Contract was a high point in their career.

Comment on individuals is always difficult, and of problematical benefit. Russ Cline: a capable, take-charge engineer, brought up in Missouri and to a degree following that state's reputation for having to be shown. He probed deeply before accepting solutions. His experience was princiaplly in equipment engineering, both in Bell and previous assignments in commercial radio broadcasting. His knowledge of transmission was also substantial, and his approach to construction and to management generally one of level-headed common sense. It was Russ who finally pinned down the basic reason for the difficulties with Mark 2 doppler, forcing the decision to revert to Mark 1 for Mid-Canada.

Bill Bell: a mature, thoughtful man, with long and successful management experience in Bell supplemented, as I have pointed out, by two years in the complicated and somewhat hectic atmosphere of D.D.P. Bill's down to earth judgment and knowledge were of great help to myself and to the whole group.

Andy Neilson: bright, efficient, with long experience in commercial and personnel work in the Bell organization. His solid, objective approach to the sometimes delicate and difficult job of handling peculiar people like engineers and others in our own and the Government shop; his capable direction of recruiting to meet a wide variety of requirements, plus coping with the many problems inherent to such a diverse group, were outstanding and helped keep the whole operation on even keel.

Gordon Dewar: highly intelligent, hardworking, with well balanced judgment, loyalty and a strong sense of humour, sometimes sardonic, but always helping to keep our sense of proportion by being able to laugh at ourselves. His efforts in contract negotiations and keeping the really cqmplicated accounting and reporting straight were thorough and competent. He drove some accounting types round the bend at times by pointing out that there were only ten digits in our numerical system, so it surely should be possible to present them simply and understandably.

Newt Culver's stay in Special Contract was shorter than some of the others, since his assignment of siting D.D.S. and details of S.C.S. locations of necessity had to be completed early in the game. Newt took early and effective action and cleared up the siting chore efficiently and expeditiously. His background was transmission engineering over a substantial part of his Bell service, which also included work on the wartime Newfoundland cable project which Bell had completed for the U.S. military forces.

Don McDonald: quiet, thoughtful, cautious, and one of Bell's – and Canada's – best telecommunication transmission engineers. Don checked and double-checked every angle; yet had the deep knowledge and breadth of vision to encompass the welding of the many requirements and types of equipment involved in the Mid-Canada Line into a cohesive, reliable working system.

Doug Pepper: an equipment engineer of many years standing. Almost painfully quiet, no small talk, but very thorough in his analysis of equipment needs and in following through the complicated procedure for procurement which our D.D.P. contract necessitated. Doug had firm opinions, and his depth of knowledge resulted usually in his being able to follow them, sometimes contrary to views of his associates in the Air Force and D.D.P. One D.D.P. comment was that he sat quietly through meetings with Government people, then did what he had made up his mind to do all along. Doug was a radio ham of some repute, as were also Russ Cline and several of the other engineers, a circumstance which facilitated our having radio communications with the far flung centres of our activity from Frobisher to Dawson Creek during the course of field operations.

Cliff Frost did not sit quietly through meetings with Government or contractors' people. Articulate, voluble at times, and sure of his own wide knowledge of construction, civil and structural engineering, Cliff thrust ahead with his eye on the main chance – getting the construction job done well and on time. In doing that, a few toes got trodden on and relationships bruised. But his planning of the multifarious details of the construction job was thoroughly competent and sound. He carried his people along with him, educating them along the way, and for himself lived, ate and dreamt construction and logistics for the five years of Special Contract's life. I know of no one, either in our own organization or the Government agencies, who contributed more of themselves and of sheer hard work to the project.

The Special Contract organization had to understand and work through an elaborate network of Government agencies, contractors and procedures to get the job done. Included with this chapter is a chart showing these contacts. The complications are obvious from a look at this document, particularly when it is realized that the R.C.A.F., D.D.P. and D.C.L., under the contractual arrangements with us, were entitled to, and did, look over our shoulder in all our dealings with contractors and in running the job. Relationships with the Department of Transport were less complicated because pretty well confined to the one area of sea lift. Northern Affairs, Labour etc. came into the picture only occasionally. However on one occasion we ran into difficulty by paying Indians [First Nations men] the minimum Canadian wage; – the Government had been paying them on a lower scale! In another case, rather amusingly, one Government agency owed another one some money connected with the project. Apparently the only feasible way to straighten this out was for Bell to receive the money from one agency and pay it to the other!

Finally, riding herd over the whole elaborate project was the Mid-Canada Executive Committee. This committee was formed in November 1954, succeeding the Steering Committee which had been established a year earlier. On the committee sat representatives of all the Deputy Ministers involved in the project, plus a Management Contractor representative, myself. Total membership varied through the project, reaching I think, a maximum of fourteen at one point. The Executive Committee was what its name implies. It dealt with overall problems of implementation, received progress reports from the Management Contractor and other agencies, and tried to cope with the many emergencies and differences of opinion which occurred during the nearly three years of its existence. Seventeen meetings were held in Ottawa, plus five to ten special sessions at various points on the Line. With Mid-Canada in operation in August 1957, the Committee disbanded. Max Hendrick, Air Commodore Chief of Telecommunications, later Air Vice Marshal and Air Member for Technical Services, was chairman of the Committee. It was not an easy job, but he handled it with tact and good humour, so that differences got talked out and the project implementation momentum sustained to meet as nearly as possible the target date.

Chapter 11

Into the Wilderness

One has only to fly north from any of our major Canadian cities to realize how thin the development of this country is. The Southern Ontario peninsula is thickly settled, and in the west the extension of the Great Plains into Alberta and Saskatchewan has resulted in substantial development almost to the 55th parallel. But for most of the 3500 miles from coast to coast the concentration of development and population is within 150 miles of the United States border. The Fathers of Confederation chose the name "Dominion" of Canada, following the Biblical injunction that "His Dominion shall stretch from sea to sea, and from the rivers to the ends of the Earth." Stretch from sea to sea it does, both in geography and rather spottily in population. But north beyond the great rivers, while the geography is there, the development, except for the mines and now oil exploration, is not.

To fly across this "great lone land" is to realize its immensity and its loneliness. On a flight from Fairbanks, Alaska to Cambridge Bay on Victoria Island, I was struck by the fact that we had gone through five time zones, and from Cambridge Bay south to Churchill on Hudson Bay in winter is an 800 mile flight over a flat white snowscape; no trees, no mountains, nothing – except a very occasional small herd of caribou.

Canadian ignorance of the Northland is still profound. As Pierre [Berton] pointed out in *The Mysterious North*:

> It wasn't until 1948 that we were finally able to answer - in the affirmative - a question that had been asked in the north for three centuries: does Hudson Bay freeze solidly in the centre? And we still have only a smattering of knowledge about the one great natural phenomenon common to the entire land: permafrost. The problem of permanently frozen ground affects almost every enterprise contemplated in the north, yet the very name was not coined until 1943. Until a very few years ago, the only map of Canada showing the limits of permafrost was published in Russia.

We have learned a lot more about the north country in the last twenty years, but in the mid-1950's our knowledge was pretty meagre.

The Mid-Canada Line, though primarily a defence project, made a 500-mile leap northward in initial development throughout most of its length of 2800 miles. Even then we were less than half way into Canada's northern heritage – the Arctic coast is 1000 miles further north. However, the fact that at the peak of activity some 5500 people were working on the Line, and probably 10,000 individuals spent some time on it, means to me that the project made a very real contribution to broadening our grip, as Canadians, on our own geography.

The Line ran through three broad areas of geography and topography. Dawson Creek, the western terminus, is at the eastern edge of the Rocky Mountains, and looks to the east along the broad valley of the Peace River. As a teenager, I recall the desire of farmers from Ontario and Quebec to move out to the broad plains and rolling country of the Peace River, where hay and other crops were reputed to grow to fabulous height, and farming was a good life. It is good land, and well settled; the climate severe at times, but tempered by the Chinooks, and with no permafrost, as witness the tree line, which extends right up to the Arctic coast following the Mackenzie valley.

Eastward from the valley of the Peace, the Line plunges into the northern bush, the primeval forest which extends east above the Great Plains. This rolling, wooded country, interspersed with lakes, extends through northern Alberta, across Saskatchewan, and half way across northern Manitoba. Muskeg is prevalent at many points even with substantial tree cover, but as the trees thin out the muskeg takes over completely. North and east of the Great Plains lies the huge horseshoe of the Laurentian Shield, with Hudson Bay in the centre. But to the west and south of Hudson Bay, it is a bald plateau, with thousands of square miles of muskeg – a quaking mass of yellow-green sickly looking vegetation, held in that state by underlying impervious clay and rock. Without special load-bearing vehicles, overland transportation of any materiel in this area can only be done during the winter when the ground is frozen. Even then, much of it is what is called "hot muskeg" where at temperatures above -20 degrees Fahrenheit the ooze bubbles up through the ice and snow, with resultant complications to transportation.

At various places in this muskeg country there are eskers and lateral moraines, gravel and stone deposits left by the retreating ice cap of another age. In places these run for miles, looking [to] all the world like an abandoned railway embankment. They proved very useful in siting some of the doppler stations, and providing for a few temporary air strips which we were able to set up during the construction phase of the project. The muskeg extends right to the shore of Hudson Bay, and south to the foot of James Bay at Moosenee.

The eastern sweep of the Laurentian Shield is much more rugged. The whole Ungava region of northern Quebec and Labrador is a series of mountainous ridges, 1000 to 2500 feet high, and running generally in a north to south direction. It is much more attractive country than west of the Bay, but transportation on the ground is, if anything, more difficult. Fortunately, the whole area is laced with lakes, thousands of them, making air transport the obvious solution to logistics.

A word about climate. At the same latitude, it is much colder in the east than in the west. If a January mean temperature line of -10 degrees F. is drawn across the country, it starts in mid Alaska, runs steadily southeast to the middle of James Bay, then due east to the Atlantic coast. In other words, the winter climate at James Bay is as severe as in Alaska, 800 miles farther north. The tree line and permafrost line follow the temperature; thus our problems with permafrost on Mid-Canada were in the Hudson Bay area; but not elsewhere.

Much of the bad weather for Eastern Canada seems to be manufactured in Hudson Bay, so we had plenty of problems both with shipping and air travel. In winter, the temperature frequently dropped to 40, 50 and 60 degrees below zero Fahrenheit, and east of the Bay we were in a particularly heavy snow belt. But the most serious climatic problem, from the standpoint of transportation and construction was the Fall freeze-up which took two months and the spring break-up which took about six weeks. This meant that from about mid-October to mid-December, and again from about May 1st to mid-June, much of ground transportation and all fixed wing transport based on the lakes, came to a full stop. Hudson Strait opens up on July 25th in a good year, but sometimes not until early August. It closes in with ice in late September. In the southern part of Hudson Bay itself, the open season is about four months. Across the Ungava peninsula in most years there is only one month without frost – August.

This then was the country, the wilderness, across which the Mid-Canada Line was to be built. During the fall and winter of 1954-55 all efforts were bent on getting ready to start field construction as early in 1955 as weather would permit.

In the winter of 1953-54 the R.C.A.F. had carried out field trips in the west to determine what logistic problems might be encountered in this part of the proposed line. Both reconnaissance by air and forays in tractors and snowmobiles were made. The R.C.A.F. concluded, as we did later, that both ground and air access was quite feasible.

Starting in October 1954, looking for immediate field action, a combined R.C.A.F.-Management Contractor team set out to establish in the field the approximate site locations in this area. Planning was still on the basis of the Mark II doppler equipment, with 40 mile spacing between sites. A preliminary reconnaissance was made early in the month by two small groups in fixed wing aircraft, one taking off from Ft. William and examining the territory from Winisk through to Grande Prairie, the other scanning from Hopedale in the east to Great Whale River. Then starting in mid-October, and concentrating in the west, where it was felt more immediate progress could be made, a larger field party, using a flight of three U.S.A.F. helicopters, worked east and west from Flin Flon, exploring the possibilities of various sites in more detail.

It immediately became apparent that initial access to sites in this heavily wooded country would require special procedures. One possibility was to land on the nearest lake by float plane, then hike through the bush to the proposed site – a difficult and time-consuming operation. The alterative was to lower people from a hovering helicopter directly above the site, then have them clear enough space for a helicopter to land. After some hesitation due to the very real safety hazard involved, this method was tested and finally adopted; Newt Culver, the siting engineer, being the first Bell employee to be lowered and picked up by this method.

Along with this examination of possible specific sites, a number of marshalling areas were set up at focal points. Building materials were shipped to these locations, with the intent of distributing from them to the designated sites, from Lesser Slave to Bird, a distance of over 900 miles, or one third the total length of the Line. This would have provided a great running start to 1955 construction over this distance, but unfortunately Mark II doppler was found wanting. By February we had pretty well concludad that we would have to revert to Mark I, with consequent different spacing between stations. The final decision was not made on Mark I until May, so materials had to be held at the marshalling areas until field siting was completed in the summer of 1955.

As part of this 1954 abortive blitz, several thousand yards of gravel were hauled up the Hudson Bay Railway and piled at Amery for future use. With the changed siting spacing to 30 and 60 miles and other problems, it was found impossible to use most of this stockpile. The unused gravel became somewhat of a political liability for us, and required frequent explanation to the local Member of Parliament by our Zone Engineer.

In the muskeg country, where summer access on the ground would be next to impossible, advance provision for the summer siting teams was made during the winter of 1954-55, with caches of fuel for helicopters and small accommodation huts for the crews, all distributed by tractor train at 30 mile intervals from Ilford through to Winisk. In addition these tractor trains carried G.P. hut sections, gasoline, oil, and construction materials to establish the advance camp at Winisk itself. Tractors from the train, plus some contractors' equipment were left at Winisk to permit starting work on the camp site as early as possible in the Spring.

This operation proved to be extremely difficult and hazardous, and cost the lives of two people. The tractor was guided on its route by a helicopter. When some distance along the route the helicopter crashed, killing both the pilot and observer. Another "chopper" took over and the train continued its trek to the east; but again the Grim Reaper had exacted his toll. I never knew the names of the men who were killed; they were employed by the tractor train operator.

The spring break-up caught the train in the muskeg country south of Hudson Bay, and it was found impossible to continue to Winisk over the planned inland route. So the train made a dash for the shore ice of the Bay, which was still firm and thick, and got to Winisk safely.

East of Great Whale River across Ungava, the plethora of lakes enabled us to set up lakehead camps close to 22 of the 25 indicated doppler sites. Most of this work was done from Knob Lake. Bell people moved into the area in the late fall of 1954. After as a first step starting construction of base camps at Knob Lake, one for Bell and transient people, the other for the general contractor, they concentrated during the winter on establishing the lakehead camps. Fixed wing ski-equipped aircraft flew building materials and sufficient fuel to store a small cache at each lakehead site. A small building, storage area and landing strip on the lake were then set up. These lakehead poinfs were thus made ready for the large shipments of fuel oil, aviation gas, building materials etc. which were scheduled for the summer of 1955.

As an ongoing operation these lakehead sites were to be supplied from the SCS by amphibious aircraft (mainly Cansos) onto the lakes in summer, and by ski-equipped or ski-wheel equipped air-craft to ice landing strips on the lakes in winter. From there helicopters would lift materials to the hilltop doppler sites. For a few sites tractors and sleds could also be used. This lakehead marshalling point operation really got into high gear through the winter, so much so that we had paid out $800,000 of Bell money to small contractors and bush line pilots, and for materials generally, before D.D.P. approval caught up with us.

What about the main sites, the Section Control Stations? These had to be 350 to 400 miles apart, on or above the 55^{th} parallel, and accessible by surface or sea transport, to cope with the heavy movement of material and personnel during the construction period; also to enable them to be efficient centres of supply and distribution when the line went into operation.

Hopedale on the Atlantic coast was the eastern anchor of the line and therefore fixed. It is accessible by sea. The much lower construction requirement as compared with the other S.C.S.'s, while it didn't decrease the inherent difficulties in off-loading the ships, did reduce greatly the total amount of material which had to go in this way. Across the Ungava Peninsula, the main, in fact the only point accessible by rail and by major aircraft was Knob Lake, site of the Iron Ore company mining operations. Knob Lake is roughly 300 miles from Hopedale and somewhat more than 400 miles from the shore of Hudson Bay, so was the only available choice.

In the Hudson Bay region, two main stations were required. There was already a settlement of Indians [First Nations] and Eskimo [Inuit] at Great Whale River; really two settlements for the two groups would have very little to do with each other.

Great Whale River was established as a settlement in the mid 18th century by the Hudson's Bay Company, and a Hudson's Bay trading post and factor were still there; also an Anglican mission. For the eastern side of Hudson Bay has been the Missionary territory of the Anglican church, and the west side that of the Roman Catholic persuasion for many years. Great Whale is accessible by sea, and the topography was suitable for building a full size air strip as a main point of entry to the area. On the western side of the Bay, near the mouth of the Winisk River, there was a small native village, also an original Hudson's Bay Co. post. The shoreline is so flat that over the years the tiny settlement has been wiped out three times by the Bay ice driven by northern winds. However, right at the river mouth the land surface, as opposed to the surrounding muskeg, looked suitable for building the station and an air strip.

Moving west, the next 350 mile hop meant somewhere along the Hudson Bay Railway, for of roads there were none. Ilford, Gillam and Bird were considered, and Bird selected as a reasonably good location, with access to Churchill as well as to the south by rail, and river connection to York Factory on the Bay. Cranberry Portage was the next main point, with good rail and road access to The Pas fifty miles to the south.

The Northern Alberta Railway runs from Edmonton north through Lac LaBiche, scene of one of Chief Ringing Cloud's raids in the Riel rebellion of 1885, and continues on to waterways. Waterways geographically is about half way between Cranberry Portage and the British Columbia border, and McMurray airport is close by. So a nearby hill, called Stoney Mountain – it isn't much of a mountain, nor is it particularly stony – was selected as a good S.C.S. site. Finally Dawson Creek, just west of the B.C.-Alberta border, on the main rail and road line from Grande Prairie and the south, and only a few miles from Ft. St. John airport, was a logical western terminus for the Line.

To pick the general location of the S.C.S. was one thing; to get in on the ground, do a detailed survey and select the precise site, enabling land acquisition, foundation design and start of construction was quite another. First off the mark by a wide margin was Great Whale River. In the Fall of 1954, No.2 Construction and Maintenance Unit of the R.C.A.F. Air Material Command moved into Great Whale. Earth moving and other heavy equipment was brough in on a Department of Transport ship, other gear by plane. They built a 5000 foot air strip north to south, graded and ready for surfacing in the spring of 1955. They also erected construction camp buildings, using G.P. (general purpose) Canadian Army huts. These are prefabricated wood frame sectionalized buildings units, which go together rapidly, and were a tremendous help at Great Whale and a number of other main sites.

The job the Air Force did at Great Whale was excellent, and enabled the general contractor (Fraser Brace) and our own people to get an early start on survey and construction work in the 1955 season. An engineering survey party was on site in mid April, and completed testing soil etc. for the site plan and establishing metes and bounds shortly afterwards. At Hopedale, the precise location of the S.C.S. building and towers within the U.S.A.F. air base was established early in the new year. For the other main sites, however, winter blocked any work on the ground. We had discussions with the Iron Ore Company as to a suitable location for the R.C.A.F. station at Knob Lake. But it was not until May 26th, when snow was still above my knees at Knob Lake, that the R.C.A.F., the Iron Ore Company and ourselves agreed on one of the three specific sites which had been suggested.

At Winisk, a reconnaissance by helicopter over the proposed site was made in the late Fall of 1954. This plus aerial photographs enabled us to prepare a preliminary site plan. The site consisted of a gravel and sand plateau at the mouth of the river, really two converging eskers. One was used for the S.C.S. proper with the buildings strung out somewhat to conform to the shape of the esker; the other for the air strip, which was built during 1955 by the general contractor (Carter Co.).

A report as of April 15th said that the exact site at Bird had just been selected, and that a field party would go in as soon as snow would permit. At Cranberry Portage a preliminary choice of the site had been made but it was subject to check after the five to eight feet of snow cover had gone down somewhat! Neither at Stoney Mountain nor Dawson Creek had we been able to pinpoint the exact S.C.S. site due to snow conditions. When the survey team finally did get onto Stoney Mountain, they picked the exact spot for the station, only to find that the Army cartographers, who had done a tremendous job of mapping the route of the Line, had not caught up with Stoney Mountain. However, the data was soon forthcoming and the boys finally knew where they were located in space.

Dawson Creek site, once the snow had gone, was quickly located by the side of the road, not far from the town, so it proved to be the closest to "civilization" of all the main sites. None of these four western sites were precisely located on the ground, however, until well on in May.

The key to doppler site location and to equipment requirements was transmission systems engineering. From mid-1954 on Don McDonald and his engineers worked closely with the Air Force Systems Engineering Group and from time to time with Bell Laboratories to fully interpret the operational requirements and to develop the technical means to fill them.

Don's people also worked with Newt Culver's siting engineers to ensure that propagation criteria for (a) doppler and (b) microwave were met. For months desks and tables were covered with contour maps, aerial photographs and point to point contour profiles between sites, covering the whole 2800 mile route of the line. The contour maps were assembled in strips. On these trial site locations were picked which appeared to meet transmission requirements, and which also seemed suitable to support buildings and towers. Straight lines connecting these sites identified the intervening topography, and contours crossing the line were plotted to produce a contour profile between the stations. These profiles were then related to transmission criteria to determine tower heights and the resultant propagation loss was calculated. If it was too high, other site selections were made and the whole process repeated.

When this trial and error process had been completed for the whole route, and the Siting Engineer was satisfied he had selected the best locations on paper, he submitted a full report to the Siting Committee, consisting of himself, the Transmission Engineer, the Buildings and Structures Engineer, and the Chief Engineer as chairman. Site selections were then sent to the Air Force S.E.G. for Design Authority approval.

But there was a problem. It was that a decision had not yet been made as between use of Mark 2 and Mark 1 doppler equipment. S.E.G. after considerable study, had opted for the more advanced Mark 2 system being developed by R.C.A. This system was designed to give indication of aircraft direction as well as penetration with a single line of doppler stations at 40 mile spacing. The alternative Mark 1 equipment-required two parallel lines at 60 mile spacing to give direction. Mark 2 looked considerably more attractive from a cost standpoint. However, R.C.A. was having real problems in detailed design of the Mark 2 unit. A test link was set up out of Montreal to evaluate both systems, and intensive study was given to the problem by Bell, S.E.G. and D.R.B. along with R.C.A. By February it had been pretty well concluded that we would have to go with Mark 1; but until a firm decision could be made, map siting had to be done for both 40 and 60 mile spacing.

The siting engineers had their office studies completed by mid March, but it was not until May that a final decision was made, in favour of the Mark 1 doppler system. This meant 60 mile doppler spacing in two parallel lines. The parallel line effect was secured by a single zig-zag line of stations 30 miles apart, with dopplers connected so as in effect to provide two lines, three to six miles apart, at 60 mile spacing. Once the decision was made, the siting teams were ready to move into the field.

Outside of the doppler and associated siting problems the transmission and equipment engineers, with reference to S.E.G. as required, spent the winter identifying specific equipment requirements for each system forming part of the overall network – microwave, doppler, air-ground-air radio, fault alarm, tropospheric scatter etc. – for each doppler and main station along the line depending on that station's function. With detailed needs identified, the various commercially available equipments were analyzed to establish the degree to which they met the design criteria. A number of situations came to light where there was no fully compcitible commercial equipment, so modifications involving new technological development were required.

The equipment engineers were then in a position to start writing requirements specifications and placing requisitions on D.D.P. for specific equipments in specific quantities, two years maintenance spares being included in all cases. They also advised the R.C.A.F. of the approximate money requirement so that adequate funding could be channeled to D.D.P.

As part of the preparation for construction, the Equipment Engineer made arrangements for temporary radio communications along the line. This included:

(a) Equipment at Great Whale River for use during the air lift of materials into that location during the early months of 1955.

(b) Arrangements through the Manitoba Telephone System for radio communications to all marshalling areas and for tractor train operations during the winter from Lesser Slave Lake to James Bay.

(c) Preliminary discussions with the Department of Transport and R.C.A.F. leading to a complete radio communications network across the line during the construction phase. Implementation of this later in 1955, plus leased teletype circuits from key points back to Montreal, meant that we had good communications to virtually all parts of the project, including tractor trains, throughout the job.

As regards building plans, the relatively simple doppler buildings were designed jointly between Bell buildings and structures engineers and the R.C.A.F. in the Fall of 1954. Design of foundations for both buildings and towers plus site plans for these stations had of course to wait for specific site location on the ground. The S.C.S. plans were another story. Each site except Hopedale included a substantial number of buildings, from a large hangar to small radio transmitter building, plus towers, sewage disposal plants, municipal services, etc. As outlined elsewhere, these plans involved a lot of co-ordination and difficulty, leading to the R.C.A.F. taking over the prime responsibility for producing them, working directly with the consultants. Preliminary plans started to appear early in 1955. By mid April design work on many of the items – e.g. oil tanks, heating plant, sewage disposal, water supply, aircraft hangars, airstrips – was under way, less of course site plans and foundation details which had to await site surveys.

Difficulties in obtaining final S.C.S. plans persisted for some time and it really was not until well into 1956 that they could be said to be essentially complete. This made construction difficult but was almost inevitable considering the telescoped time scale of the whole project, the foundation problems and the fact that the whole Line concept was new and untried.

In February 1955 steps were initiated to choose the general contractors. Early in our discussions with the Air Force, in August 1954 in fact, we had stressed the obvious importance of getting ahead with construction at the Section Control Stations as early as possible, since each of these main stations was going to be a major construction project in itself. Realistically, however, detailed or even sketch plans for these sites were non-existent at that point. Since great emphasis was being placed on early action in the field along the doppler route, it was decided to push forward with the doppler siting and transportation of materials to those sites, with results as I have outined.

By January it was agreed that we must start pushing the Section Control Station program if we were to maximize progress in the 1955 season. A useful amount of design data from the R.C.A.F. became available in February. It was not enough to permit site layouts nor to produce adequate plans for assessment by a contractor. However, more data continued to come to hand, the result of work both within the R.C.A.F. and by the consulting firms – namely Giffels and Vallet; Abra Balharrie and Shore; B.R.Perry; Tasse and Saurault. It then became possible to gauge the approximate size of the jobs, select the general contractors, present the job picture to them and get them started.

In accordance with our arrangements with Defence Construction Ltd., we provided them in February with a list of contractors with whom the various companies of the Trans Canada Telephone System had had satisfactory experience and who in our view would be possible candidates for the S.C.S. contracts. It had been agreed that there should be a separate general contractor for each S.C.S. The question of contractors for the doppler sites was left in abeyance for the moment, but shortly afterwards it was concluded, and logically, that each of the S.C.S. contractors would be responsible for D.D.S.'s on either side of the main site, halfway to the next S.C.S.

D.C.L. narrowed our list and added a few names of their own. Finally after further discussions, D.C.L. selected and negotiated contracts with four firms to cover the Eastern end of the line. This was done by sometime in April, as I recall, with selection of the western contractors shortly after. The full list of general contractors was as follows:

Firm	S.C.S.	Number of D.D.S. Sites
Deschamps & Belanger	Hopedale	5
H.J. O'Connell Ltd.	Knob Lake	12
Fraser Brace Engineering Co. Ltd.	Great Whale River	11
Carter Construction Co.	Winisk	14
Claydon Construction Co.	Bird	12
W.C. Wells Construction Ltd.	Cranberry Portage	13
Mannix Ltd.	Stoney Mountain	10
General Construction Co.	Dawson Creek	13

In addition, two other major contractors were picked for specialized work:

Hill Clark Francis Co. Ltd.	Tropo-Scatter Sites
E. Crain Co.	Ottawa Test Line (4 doppler sites)

Because of the incomplete nature of plans initially and the anticipated problems of transportation and climate, the contracts were negotiated on a cost plus fixed fee basis. Later in the project, when the full scope of the plans and construction problems had materialized, the fee was adjusted by D.C.L. where this was considered equitable.

Special Contract people started to work with the contractors as soon as they were chosen. We had to shift gears from the dominant job direction role we held in the Pole Vault project as prime contractor, to the more indirect coordinating, advisory, and engineering supervisory role required by the Mid-Canada contract. We had problems in making the adjustment as I have outlined elsewhere, and I suppose were not completely successful; but if love did not reign universally, the [adrenaline] flowed in full spate in energetic pursuit of success by all concerned. Because of the late spring in the north country, problems of precise site locations and scarcity of plans, it was June and in some cases July before the contractors were on site, setting up camp, getting in materials and starting preliminary construction work.

A specific requirement of our management contract was that we prepare a complete implementation plan for the project. Up to the end of 1954 we had been planning the job on a Division by Division basis – i.e. Transmission, Buildings and Structures including transportation, Equipment, [and] Siting. In the drive to get the project launched, not too much of this planning had been committed to paper. By mid-February, however, our Government friends were feeling the need for a written document, outlining in some detail where we were going, and how all parts of the project were to be implemented. The thought was that against this detailed plan regular progress reports would be made on an itemized basis to ensure that schedules were being met, and that there were no gaps in procurement or on site activities.

The implementation plan was prepared, and copies issued to all concerned on April 15th. It was a fairly comprehensive document of some 85 pages, and included the following:

(a) Management Contractor overall organization and responsibilities; the total concept and configuration of the Line; and our general plan of implementation.

(b) Siting - the proposed methods and procedures for carrying it out.

(c) Buildings, structures and transportation, including surveying and site planning, structural design, transportation planning and construction planning, at both S.C.S.'s and doppler locations.

(d) Transmission engineering; its role, requirements for this project and proposed procedures.

(e) Equipment engineering and installation; the complete sequence proposed from identification of technical requirements through assessment of available equipment types and manufacturers, requirement specifications, procurement, follow up, installation and test.

(f) Training of necessary personnel to supervise installation and do run-in testing of the individual installations and the complete system.

(g) Contracts and accounting procedures.

(h) Personnel policies and procedures.

As with many such documents, its most important benefit was to consolidate the thinking of the people who prepared it. The item of most immediate use was the transportation plan, particularly for the 1955 season. Copies of this were sent to D.D.P., amplified where necessary, as a comprehensive outline of our needs for sea transport into Hudson Bay, major air transport, etc.

It quickly became apparent that the implementation plan which we had prepared was not what the Air Force had in mind, as to its format and perhaps also its content. What I think they were looking for was a much more detailed document, with chapter and verse for every site, building, tower, etc. against which actual progress for each item could be plotted. Such a report would have been voluminous, taken a very substantial amount of senior peoples' time and at that stage of inadequate knowledge of details of the job, would have been out of date almost as soon as it had been written. It may be both possible and necessary to do this kind of meticulous checking at top level for some types of project. Not this one; it was too far flung, too fluid, with many emergencies which had to be solved locally every day.

We had several meetings with the R.C.A.F. to review the implementation plan, but interest on their part then seemed to die – I presume because the report was not what they really wanted – and to my knowledge it was never referred to again by them. Our own people continued their planning on a division basis, coordinated by Russ Cline and myself. As to status reports, we presented our first overall project schedule to the Steering Committee (predecessor of the Executive Committee) in August 1954. We also arranged to provide reports and schedule charts quarterly, including an updated view of costs. Supplementing this were my own reports at each meeting of the Executive Committee and at innumerable meetings to review particular parts of the job.

On a division basis, we did prepare as the job developed, and kept up to date, site by site schedules showing timing of construction, equipment delivery and installation for each of the 102 sites plus line clearance airdromes, test lines and marshalling areas. In the same manner, schedules were set up for site by site tower and antenna erection. The nearest approach to a completely detailed schedule and follow-up on a project wide basis was Doug Pepper's wall chart of all equipments, showing forecast requirements, deliveries and actual performance for every piece of electronic equipment for every site on the Line.

So passed the winter. It was a busy one: busy on the one hand with the final drive to completion of Pole Vault; on the other complicated by the sand in the gears which we and the Government people were feeling in trying to operate efficiently and with urgency on the Mid-Canada project under a very unusual and complicated contractual arrangement. But by Spring we were prepared to move into the field in force. We had to make as many yards as we could in the 1955 season if we were to have any hope of meeting the January 1, 1957 service date.

Chapter 12

Siting

"Is the winch line secure? Then lower away." These or similar words started the site clearing operation at a score of doppler locations in the woods of northern Manitoba, Saskatchewan and Alberta, and at many sites across the muskeg barrens of Ontario. Lowered by winch line from the hovering helicopter, the axemen were first on the site in the bush country. Complete with axes, saws, survival rations, sleeping bags, etc., they cut a few trees and fastened a discarded parachute to the stumps to mark the location, then cleared enough space for a helicopter to land - land gingerly so as not to be caught in the stumps or surrounding branches. The wind was also an important factor, for the helicopters of that day had problems in winds of more than 12 miles per hour.

The survey party came in next, by helicopter, and the detailed survey was on; to check topography and subsoil conditions, stake out the full area required for the doppler station, and establish metes and bounds for purposes of registration and ownership of land by the R.C.A.F.

The office job of site location on maps had been completed early in the spring. So when the final decision was made in May to use the Mark I doppler system, the siting crews were ready to go. Two teams were organized, each including men from the Siting Engineer's staff, the Buildings and Structures Division, and the R.C.A.F. Systems Engineering Group. The eastern team was supported by No. 108 R.C.A.F. Communication Flight of helicopters, and the western team by a flight of United States Air Force helicopters, loaned for the occasion. A few commercially operated helicopters helped out. Arrival of the U.S.A.F. helicopters was a very impressive operation. Three C-130 U.S.A.F. Hercules aircraft landed at Grande Prairie, and disgorged six S-51 helicopters, complete with spare parts, ground and air crews. The Bell people were duly impressed.

The siting teams moved into the field early in June, and in less than two months essentially finished the field siting job – but not without hazard. A near tragedy occurred east of Ft. McMurray, when a helicopter hovering just a few feet above the surface of the lake was checking the barometer. As the machine took off again, and in the nose down position, the rotor blades struck the water and the helicopter flopped into the lake. Fortunately the water was shallow and the crew got to shore safely. When they didn't return to base, another helicopter followed their flight path until dark; but it was not until early morning that a fixed wing aircraft spotted the crew. A helicopter picked them up, except for two hardy but foolish souls who had elected to walk out to the railway. They finally made it through dense bush and across many steams, and were picked up, exhausted, by a train.

All doppler siting work was completed by July 27th, with the exception of a few doubtful locations requiring more detailed propagation checks. It was a notable achievement considering the nature of the country, and the many problems of sheer survival, supplies, helicopter maintenance; etc.

The siting team flew each leg of the route as plotted on the maps and aerial photographs. When they arrived at a map site, they checked its suitability on the ground. In the bush country and parts of Ungava the procedure was much as described above. For the muskeg area the search was for solid ground as close as possible to the theoretical site. In some cases the helicopter could not land, necessitating all men and materials for surveying being lowered from the hovering "chopper." At other points they could land, but only with extreme caution, testing out various patches of caribou moss until one was found that was sufficiently firm to support the helicopter for a short period. To quote "Sky Watch on 55", a movie of the Mid-Canada project made by Crawley Films:

> There is a carpet of caribou moss all through this country, maybe two or three feet deep. Make a soft landing pad --- (but hazardous). It's very wet here because there's no drainage through the permafrost. The moss is a semi-fungus which gets its nourishment from traces of mineral dust and carbon dioxide in the air. The individual lichens may be several hundred years old. As the branches grow, the lower part decays to form a spongy acid soil with little value.
>
> Foundation for a tower site would be difficult and expensive here. The siting crew will move on just a little farther to search for a rock outcrop.[1]

With the map sites or more suitable locations close to the map reference points located, the next job was to check the transmission path between them. This was done by using two helicopters leapfrogging each other. One remained at site A, hovering at calculated tower height, while the second machine flew to and took up a hovering position at site B, again at calculated tower height. Clear line of sight could then be established by beaming a light between the two helicopters. This process was repeated right across the line. More detailed electronic propagation checks were made in a few doubtful cases in the fall, but with the exception of two sites, which

[1] *Editors' note:* Crawley films for Bell Canada, "Sky Watch on 55" (33 min.) is available online at https://www.youtube.com/watch?v=eDQRvdot_W0. Last accessed 18 February 2019.

were moved slightly to optimize the propagation path, the locations picked on the ground and basically derived from the map studies were confirmed. It was a tribute to the thoroughness of the siting teams and, as importantly, to the precision of the Army maps and the Air Force photography.

Siting considerations were not confined exclusively to electronic propagation and topography. Throughout the operation there was consultation with geologists, weather experts, forestry men, and even the Canadian Wild Life Service. For example, we pulled proposed sites several miles south from the shore of Hudson Bay west of Winisk to avoid the most heavily travelled flyways and nesting areas of ducks and Canada geese.

The survey crews followed close on the heels of the siting teams, taking on the average two days to do the necessary work at each doppler site. These crews included Buildings and Structures Division people plus Provincial land surveyors. Results of their survey in terms of topographical description, metes and bounds, were then forwarded to the Department of Transport and to the R.C.A.F. for land procurement action, and to the Buildings and Structures Engineer in Montreal for design of tower and building foundations and production of site plans. In the case of doppler stations the general site lay-out was pretty well standard, though precise location of the tower and building could vary depending on the sub soil conditions.

Soil conditions at sites across the line ranged from clay beds 100 feet deep to muskeg, permafrost, shale rock and solid granite. So foundation design for towers and tower anchors particularly required careful individual assessment for each site. Foundation plans and specifications for all towers were produced through the remainder of 1955 and into early 1956 by the Buildings and Structures division and by B. R. Perry Co., who were our consulting engineers in this area.

An important key to expeditious siting and surveying was the helicopter, which was just coming into its own as an essential transportation tool. This may be the right place to record – and pay tribute to – the role of the R.C.A.F. 108 Communication Flight, the first unit in the R.C.A.F. to be equipped exclusively with rotary wing aircraft.[2]

[2] Much of what follows is taken from Flying Officer French's articles on the Mid Canada Line in *Roundel*, the R.C.A.F. magazine. *Editors' note:* Flying Officer S.G. French, "The Mid-Canada Line," *The Roundel* [three parts], vol. 10, no.3 (April 1958): 2-5, 31, no.4 (May 1958): 10-15; and no.5 (June-July 1958): 12-18, reprinted in *Northern Skytrails: Perspectives on the Royal Canadian Air Force in the Arctic from the Pages of* The Roundel*, 1949-65,* eds. Richard Goette and P. Whitney Lackenbauer, Documents on Canadian Arctic Sovereignty and Security (DCASS) No. 10 (Calgary

108 Communication Flight was formed on June 1, 1954, under command of Squadron Leader R.T. Heaslip, the most experienced helicopter pilot in the R.C.A.F. at the time. S/L Heaslip continued in command of the Flight through the Mid-Canada operation. R.C.A.F. station Bagotville was selected initially as the base of operations; arrangements for maintenance of the aircraft were made, and twelve helicopters were ordered: six Sikorskys and six Piaseckis (which we nicknamed the flying banana).

Pending delivery of the new aircraft, six Piaseckis from Search and Rescue units were borrowed for training purposes. Training was carried out by the R.C.A.F. at the Light Aircraft School at Rivers, Manitoba, and by Okanagan Helicopter Co. in Vancouver. By the end of 1954 the Flight was finding its "air legs." A number of mercy flights were performed, airlifting sick or injured people from the northern bush to hospital. The first was in March of 1955, when a lighthouse keeper who had suffered a heart attack was airlifted from Anticosti Island to the hospital at Havre St. Pierre, Quebec. Five mercy flights were made to Molson Stadium in Montreal, landing just 200 yards from the emergency receiving room of the Montreal Neurological Institute. 108 Flight also assisted briefly in fighting forest fires, carrying fire fighters to inaccessible locations.

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and Waterloo: Centre for Military, Strategic and Security Studies/Centre on Foreign Policy and Federalism/Arctic Institute of North America, 2017), docs. 6-1 to 6-4, pages 211-231.

Flight training included lift loads in all types of weather, cross country flights, hovering techniques, and all the other procedures anticipated for the Mid-Canada operation. Late in May the operations base was moved to Knob Lake and, from early June on, 108 Flight was up to its collective neck in siting and survey operations. Then, and for eighteen months thereafter, the job was lifting material, equipment, and men from bases and marshalling areas to doppler sites, mainly atop the hills of Quebec and Labrador.

The helicopters needed routine maintenance, but occasionally developed more serious mechanical trouble. During the siting and survey work west of Hudson Bay, a major breakdown occurred at Winisk, when a routine inspection disclosed metal in the oil filter. A new engine was flown to Winisk in a Canso (the airstrip was not yet built, hence the amphibian). A ground crew flew in from Moosonee in an Otter, and the helicopter was back in service in two days.

Through 1956, 108 Flight operated out of many points on the line, but mainly Winisk, Knob Lake and Great Whale River. For a time the work load exceeded the Flight's capacity, and several Navy (R.C.N.) helicopters were used temporarily as well as commercially operated machines. Once in the fall of 1956, a rather bizarre series of incidents brought some notoriety. Helicopter No. 9639 had been out of service for two months at a doppler site after crashing on its side. As I remember it there were two helicopter crashes that day, this one in the east, another in western Canada. Fortunately no one was hurt. I was in Washington that day, talking to the U.S.A.F. about Pole Vault expansion when I got the news - a bad day all round. However, in October No. 9639 was repaired temporarily and flown to Knob Lake, whence it took off for Rockcliffe. Following a series of adventures involving the damaged machine having to convoy the helicopter which was supposed to convoy it, Rockcliffe was eventually reached. From there an unsuccessful attempt to fly the machine to Arnprior for permanent repairs resulted in a decision to tow it for the 40 miles involved. Picture the good citizens of the Ottawa Valley rubbing their eyes on seeing a modern helicopter proceeding down Highway 17 hauled by a mule, with a dapper Air Force officer as mule-skinner!

From June 1955 to the end of August 1956 the Flight logged 10,500 flying hours in support of the project. Activity from that time through the spring of 1957, when construction was essentially completed, must have added another 4000 to 5000 hours to the total. The six R.C.N. helicopters flew several thousand hours and transported 1700 tons of material. 108 Flight was a most useful and cooperative group as were also the Navy and civilian pilots. It is pleasant to record the fact that Squadron Leader Heaslip, 108 Flight Commanding Officer, was awarded the McKee trophy for his outstanding performance on the Mid-Canada project.

CHAPTER 13

THE 1955 SEASON - CONSTRUCTION STARTS

Transportation and construction as related to building the Mid-Canada Line are so intertwined, so interdependent, that their stories are really one story from initial planning to final completion of the job. Along with this interdependence was the fact that work on all sections of the line, all 2800 miles of it, had to proceed simultaneously if we were to come anywhere near the target service date of January 1, 1957. The site surveys were completed at the end of July 1955 so, except for advance work on establishing marshalling areas, lakehead and other material distributing points, and the air-strip at Great Whale, we had seventeen months to the deadline.

Hence the organization: eight separate contractors, one for each section control station and contiguous dopplers, all in the field at the same time, all requiring transport of material to their section, all needing detailed plans simultaneously so construction could commence. Hence also the Management Contractor field organization, with five zone engineers, plus site engineers at main sites and, as necessary at dopplers, plus an extensive transport organization to get materials distributed to the right place and hopefully at the right time. Erection of towers and installation of electronic equipment were also divided among groups of contractors - six in the case of tower erection, two to install antennae, and six for equipment installation - all in order to shorten the time interval for each phase of the project.

This massive effort in parallel rather than in series, to use electrical terms, meant many people in the field: camps of 400 to 500 men, sometimes more, at each main site and a total of about 5500 people on the Line at the peak of the construction period. Something in the order of 10,000 men worked on the Line for some part of the project. In turn, camp accommodation and supplies, food, transport to and from sites, personnel difficulties, all the multifarious problems that are a function of the size of the work force, were present in major quantities. The penalty for this blitzkrieg approach to the job was high cost, increasing as detailed plans and construction difficulties unfolded.

Coordination of this hydra-headed monster was the job of the Management Contractor, backed up, supervised, and prodded by the R.C.A.F., D.D.P., D.C.L. and other Government agencies. Back of our field organization (who coordinated transportation and supervised on site construction from an engineering standpoint) was the headquarters staff, involved in planning, systems and detailed engineering, procurement, expediting and supervising the overall effort.

Through the winter of 1954-55 we had moved camp construction and other materials up to certain marshalling areas and from there along the Line. The Mark 2-Mark 1 doppler question delayed this action in the west, but in the east we were able to get well ahead with the establishment of lakehead distribution sites along the route across Ungava. Climate and transport are the keys to construction in the north, and we tried to lay our plans so as to minimize the adverse effects of both. we had several basic objectives in transport planning:

(a) Transport was a means to an end, not an end in itself. Thus a series of relatively small movements of material as required on site was often preferable to building up large quantities for a major sea or air lift. In particular, lateral movement along the line was essentially in the same category as a truck or taxi service on a normal job. Aircraft had to move when wanted rather than when they had a full load. Unfortunately this tended to increase transportation costs, and was a cause of some concern to D.D.P. who preferred less frequent, well orchestrated bulk shipments.

(b) The closer we could get to year round access to all sites the more smoothly and economically transportation of material and manpower to, and construction on, site would go.

(c) The nature of the topography across Quebec and Labrador meant that we had to use helicopters there. Helicopters and helicopter pilots were in short supply, so from Hudson Bay west we tried to maximize surface transport capabilities right to the sites.

Canada's railways run east and west, with few feeders to the north. Generally these feeders are light traffic lines. The first step in transportation planning was to establish marshalling areas at the end of steel, or on major roads as close to the action as possible. In the west this was comparatively easy. Three of the Section Control Stations - Dawson Creek, Cranberry Portage and Bird - were on rail lines and Stoney Mountain only eighteen miles from the railway at Waterways. In addition to rail access from the continental network in the south, Bird was accessible by rail from Churchill on Hudson Bay, permitting this route to be used during the short (2 months) shipping season. In addition to these main points, marshalling areas were set up at places like Slave Lake, Anzac, Meadow Lake, The Pas and Gillam on the railway; and at Lac Laronge and Fort Black on major roads. Most of these points were within a hundred miles of the Line, thus keeping down the overall effort required to get material and people on site.

In the central and eastern part of the country the situation was entirely different. The closest railhead giving access to Hudson Bay from the south is Moosonee, at the extreme southern end of James Bay, and 300 miles from the Line. Timmins and Val D'Or are 200 miles further south. The eastern region was even worse off, for the one railway running out of Knob Lake, in addition to being a private railway and therefore used at the owner's sufferance, terminates on the Gulf of St. Lawrence, with no rail connection to the continental network.

Moosonee, Val D'Or, Timmins and Montreal were the main marshalling areas for the eastern half of the country. For the whole project seventeen marshalling areas were established, the heaviest material movement being through Montreal, which handled 40,000 tons.

Back to the west: There the marshalling areas usually consisted of a Quonset or Butler type building of adequate size to shelter substantial quantities of supplies: a dirt floor, with a cubby-hole of an office for the foreman in charge to keep his records. Sufficient ground space was rented for outside storage and movement of materiel. In at least one case, Waterways, which was the off-loading point for Stoney Mountain and contiguous doppler stations, arrangements were made for the railway to build a siding (at Mid-Canada expense, of course).

As a further step, in the more fully developed country of western Saskatchewan and Alberta it was found that existing secondary roads could be extended through the bush to many of the doppler sites. During the summer and fall of 1955 some 200 miles of bush roads were built and made passable for both winter and summer traffic. Most of this work was done by Indians [First Nations men], hired from local native groups, and working under direction of Bell transport foremen. They did a good job, worked well. There were some problems, however, when it came to paying them. In accordance with Federal labour legislation, we proposed to pay the Indians the standard minimum wage, only to find that the Government apparently had a lower scale of their own which they wanted us to use. However, equal pay for equal work won out, and the Indians were paid the standard minimum wage.

One amusing sidelight on these directly accessible sites. A year later I landed by helicopter at a doppler site, accompanied by a group of newspaper reporters who were being given a conducted tour of the Line. The site had been cleared from the solid bush and the newsmen were duly impressed by the resident engineer's tales of bears raiding the food supplies and trying to claw down the temporary shelter - until there was a honk from a motor horn, and a taxi drove up to the gate of the station, having come up the road from the nearest town! The illusion of rugged frontier living was shattered; civilization in this area at least was not so far away after all.

Forward of these western marshalling areas: in addition to trucks over bush roads, many forms of transportation were used. In winter tractor trains were the order of the day – sometimes a tractor pulling one or two sleds, frequently a long train of "wanigans" as they were called. A number of local contractors, with many years experience in tractor train operation and a complete knowledge of the country and the problems presented by it, made this a fairly smooth operation. In summer from places like Slave Lake and Fort Black transhipment was made from railway or truck convoy to barges, boats, even canoes, muskeg tractors and float planes. In some instances portages were made from one barge to another through the lake system.

Full advantage was taken of the lakes with which this western area is dotted to establish lakehead distribution points close to the sites. Float planes onto the lakes in summer, ski-equipped planes onto ploughed ice strips on the lake surface in winter – all were an essential part of the transportation network. Where no other method was possible, the final lift to the site was made by helicopter. Some of the lakehead distribution points were on large lakes where there was lots of room for landing and take-off in summer, and for good long ice strips in winter. In a few cases the lakes were small but still usable. I recall coming in to one such location in a float plane where it had been necessary to clear the trees back from the shore line at both ends of the lake to permit landing and take-off without brushing the tree tops.

In the muskeg country of northeastern Manitoba and south of Hudson Bay, all heavy materials had to move to sites by tractor train during the winter season. In summer, muskeg tractors (principally the Bombardier swamp buggy or tractor) were used, supplemented by helicopter lifts where necessary. These Bombardier units had wide rubber tracks (about 24-inches wide) which distributed a load of a ton as one pound per square inch at the ground. Thus they could travel over muskeg and swampy ground with reasonable facility. They were rugged and useful. Several other types of vehicle were tried, one mounted on tremendous soft air-filled rubber tires; but, as developed up to that time, the Bombardier unit served our purpose best. I would suppose that modern hovercraft techniques might be useful in a similar situation now; but in the mid-fifties these had not been developed adequately.

In an earlier chapter I mentioned eskers in this muskeg country. At four or five points where these were close to or actually at a doppler site, they were utilized to provide temporary year round air strips which were of course very useful. In one case a soft spot developed in the middle of the runway, probably due to a small stream under the esker. Coming in to this strip in a two-engine Grumann Goose, Russ Cline and I were a bit startled when the plane, rolling to a stop, suddenly nosed over with the tip of one wing and the propeller into the runway surface. Fortunately the plane was moving slowly, so no one was hurt, not even the plane.

Such was the transportation plan in the west. A typical shipment of heavy material might be tower steel. It would start from the source at Central Bridge Co. in Windsor, Ontario, where a Bell Expediter organized shipments; by rail, say, to Meadow Lake, Saskatchewan, then by truck to Fort Black, barge through the Pinehouse and Peter Pond lake network to a lakehead distribution point, and finally by helicopter to a doppler site on the line; three transhipment points and eight separate handlings. Where there was a road into the site, however, there would be only one transhipment point, from rail to truck, with much less handling and consequent savings in time and money.

Travel over these bush roads to the sites was not exactly beer and skittles. During the summer of 1955, a truck loaded with building materials for a doppler site left Dawson Creek but broke a wheel half-way to its destination, and 100 miles from Watson Lake, the nearest town. A spare wheel had to be flown 300 miles from the base to Watson Lake, then by truck to the scene of the breakdown. Result - 7 days delay and twenty men idle at the doppler site.

The overall result of transport arrangements in the west was that for the westernmost 500 miles access to sites was close to our year round objective; for northern Manitoba good access, but subject to fall freeze-up and spring break-up delays; south of Hudson Bay dependent on tractor train in winter, supplemented year round by fixed wing aircraft to temporary air strips, and by helicopters. The main result of pushing the transport network close to the scene of action was that general contractors were able to get started on construction expeditiously, and to carry through without major interruption due to transport. The final outcome, as will be seen later, was completion to operational readiness several months ahead of schedule in this area.

The general contractors – i.e. General Construction Co. at Dawson Creek, Mannix Ltd. at Stoney Mountain, Wells Construction Ltd. at Cranberry Portage, and Claydon Construction Co. at Bird – moved into the field in June and early July, setting up camp and getting organized. Snow conditions had held up detailed site surveys at the main sites, the doppler sites were not completely fixed as to location until the end of July, and building plans for the main sites were slow coming out. So it was early fall before site construction could really start.

During the fall the contractors made good progress with the doppler sites, particularly those directly accessible by road. In the bush country, the first step was to clear the site of trees and underbrush to get working space, space for a helicopter landing pad, and to provide fire protection. This was quite a cutting job in itself, since a clearing of about 500 feet in each direction was required. Then followed three crews; the first laid foundations, very heavy deep set ones for the towers and tower anchors; concrete or creosoted wood posts for the building. A second crew erected the doppler building and the survival hut. These survival huts were prefabricated of plywood and equipped with a heater, bedding and cooking facilities. A third crew completed insulation and interior painting preparatory to equipment installation. This concentrated attack on the dopplers produced twelve sites at the western end of the line essentially completed as regards outside construction by the close-in of winter, whereas we had not expected them to be built until the summer of 1956. All of this effort, particularly in the bush, was despite the jet propelled mosquitoes of a northern summer, which raise welts even on tough skin, and the bull-dog flies which seem to take a bite right out of the victim.

At the main sites, conditions at Dawson Creek, Cranberry Portage, and to some degree at Bird, were fairly normal. Once plans were in hand, construction proceeded steadily and without undue problems. Dawson Creek station was just outside the town, with the rail terminus nearby. Water and sewer connection was made to the town system, and the sub-soil conditions were good for normal foundation treatment. Cranberry Portage, directly accessible by road and railway, with dry sandy soil also permitted standard foundation construction and presented few problems. Bird is on the Hudson Bay Railway, so transport of materiel from the south, and at times from Churchill, was generally satisfactory. Movement of personnel was more difficult due to train schedules, but by and large, construction was not unduly difficult.

Availability of medical attention was important. Dawson Creek forces had access to the town's facilities. At Cranberry Portage the camp included a first aid centre, with doctors paying monthly visits. Access to the Flin Flon hospital, 25 miles away, was available in emergencies. At Bird, which was more isolated, we had a five-bed hospital in camp, with complete facilities and a full-time doctor to attend to camp personnel.

For a time there was a personnel problem of a different sort at Bird. A nearby Indian settlement[1] contained a few young ladies who were inclined to follow the oldest profession in the world. Construction crews being a cross-section of the general populace, there was some fraternization. The situation grew difficult and the contractor finally declared the Indian encampment off-limits to people on the Mid-Canada site.

The really difficult site of these four western locations was Stoney Mountain. A permanent access road had to be built from the railroad siding at Waterways, eighteen miles to the site on top of the hill. The route was through very difficult country, a mixture of bush, muskeg, swamp and beaver dams. The muskeg cover and trees had to be removed and disposed of, [and] the combination of swamps and beavers coped with. It developed into a battle of engineers: the site construction engineers on one side and those shrewd natural engineers, the beavers, on the other. Beaver dams were built, destroyed and rebuilt, flooding the road route in places until the beavers apparently decided to let the crazy white men have their way and abandoned the fight.

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[1] *Editors' note:* The First Nation settlement nearby is the Fox Lake Cree Nation. See Manitoba Historical Soceity, "Historic Sites of Manitoba: RCAF Station Bird (Fox Lake Cree Nation)," http://www.mhs.mb.ca/docs/sites/birdstation.shtml.

Another problem was securing right of way permission for the road. The route crossed part of an Indian reservation, and the Department of Indian Affairs was concerned as to how the local Indians [First Nations people] would react to giving the necessary clearance. However, the site engineer played practical politics [by] hir[ing] the Indian chief as foreman and his braves as crew to help build the road. The necessary right of way permits were signed without a hitch, and the Indian road crew worked happily and well.[2]

Road access was not the only problem. The whole top of the hill on which the site was located was covered with from two to four feet of rubbery muskeg. This had to be completely removed before construction could start. A complete water pumping and purification plant was required to treat water piped from a lake two miles away. A sewage disposal plant was also necessary. This site was the southern terminus for an ionospheric scatter link to the D.E.W. line, thus necessitating large antenna structures and associated buildings. Since it also included a surveillance radar installation, Stoney Mountain was one of the largest sites on the line.

The site was in an exposed position related to the surrounding territory, and was subject to high wind and storms. On one visit late in 1956 I arrived the day after a severe ice storm. The ionospheric scatter antennae were in a state of partial collapse. The doppler tower, which was heavy steel and well anchored was undamaged, but a light weight radio antenna was doubled in two as a result of ice and wind. All in all [it was] a tough site. But the Mannix Company (though we had problems with several of their supervisory people) were experienced contractors, and through the fall of 1955 and on into the winter the job started to take shape.

Potable drinking water was a problem at some of the western doppler sites, and became increasingly difficult to secure as the route proceeded east to Hudson Bay. At some locations it was necessary to haul water in drums on stone boats or sledges from shallow lakes or brackish ponds a mile or two – sometimes more – from the site. When treated the water smelled and tasted like chlorine. In the area south of Hudson Bay the boys even called on a local celebrity with a divining rod for help in locating water. I'm told that in one or two cases this actually succeeded.

In mid-October 1955 Russ Cline and I made an inspection trip across the Line, one of a number during the course of the project. As it happens I kept my trip notes for the western half of the Line. These give, I think, a better sense of what was going on in this area and of the problems being met than any hindsight recollections of

[2] *Editors' note:* Fort McMurray #468 First Nation is a Cree and Chipewyan Treaty 8 nation in northeast Alberta. It has three reserves (176, 176A, and 176B) near Anzac, Alberta, on Gregoire Lake approximately 50 km southeast of Fort McMurray.

mine from this distance in time. The trip extended from the 16th to the 19th of October. Here are the notes. As will be seen, progress was being made at the main sites as well as at the dopplers.

Dawson Creek (General Construction Co.)

(1) Sewers complete
Water pipes approaching 50%.
Site roads 95% completed, 3 inches more surfacing to be added in spring. Helicopter pad 50% completed.
Fencing underway, complete next week.

Rather ridiculously we had to employ qualified steel erectors to put up steel fences in B.C. to conform to union rules. As soon as we struck the Alberta border, where there was no such rule, general labourers took over this job.

(2) Quarters building sheeted in; plumbing and insulation being completed; floor slab next.
Administration building - insulated; partitions under way. Supplies building - sheeted in; piping under way.
Garage - foundations in; steelox erection starting.
Power plant - Foundation walls in.
Operations Bldg. - foundation in.
Mess - concrete forms 80% complete.
Hangar) Not started - no plans. Plans not complete for power
Fire Hall) plant, operations building or mess.

(3) 4000 pound concrete being obtained from mix called for in specification.

(4) Criticism of consultants regarding interpretation of plans - slow and vague answers.

(5) Doppler sites cleared (13 stations).

Helicopter pads levelled in some cases. Materials on most sites; more gravel required; 110 feet of plastic clay in one location; - foundation? Several need winter transport due to muskeg. Roads into about nine sites, 1½ to 24 miles long. Construction sequence of two teams, 10 to 12 men each, after clearing. One team does concrete work, the second puts up building.

(6) General Construction has 175 men working now; 250 more on call.

Stoney Mountain (Mannix Construction Co.)

(1) Have complete plans for five buildings only, plus preliminary plans for operations building (based on steelox). Need complete Ops. bldg. plans plus all others, including Western Electric Co. plans for Ionospheric Scatter, since

all materials must move up to site this winter. Temporary road unusable for two months next spring.

(2) Grading complete on 2 miles of permanent road, right of way cleared on another 5-6 miles, with construction trail to site. Trail will be O.K. when frozen for winter transport only. Finished permanent road next season.

Good superintendent and crew on road job, including Indians [First Nations men] who number up to 40 and are working well under their Chief as foreman. Estimated cost of road (18 miles) is $500,000.

(3) Concern about running of building job. Project manager and superintendent seem weak in organization and administration. Poor follow up on material deliveries; not enough sense of urgency. Plumbing and heating contractor not impressive. Important to tighten up and meet schedules.

(4) Railway siding at Anzac (Waterways) not yet in - cook house in the way. Good gravel pit two miles from site on road. camp almost ready for occupancy.

(5) Doppler stations (10)
6 sites now accessible by road or barge and road, with material delivered to most of these.
4 sites will have winter access by tractor train.

(6) Mannix has approximately 140 men employed now.

All told in two western sections 13 of 24 doppler sites are now ready for construction (some started) and two more sites ready shortly.

Cranberry Portage (Wells Construction Co.)

(1) Administration building - foundation poured.
Quarters - foundation poured; sub surface plumbing in.
Supplies building - Steel erected and foundation back filled.
Garage - poured and 50% back filled.
Inflammable stores - foundation poured.
Operations building - forms in.
Combined mess) Laid out and partly excavated. Need
Diesel bldg.) detailed plans.

(2) Consultants (Underwood and McLelland) feeding plans to R.C.A.F. and site simultaneously for both Cranberry and Bird.

(3) Sand base good; aggregate available.
Water supply piping in as far as pump house.
Sewer piping in transit.
Site roads - hold off until landscaping checked; complete in 1956.

Fencing requirements being checked.

(4) Guards on site at night.

(5) Doppler stations (13)
Road or barge and road access to nine sites.
Remainder by muskeg tractor and/or tractor train. Patricia Co. (tractor train) has been working with us, willing to sub contract.
Building complete or nearly so on three sites.

Bird (Claydon Construction Co.)

(1) Administration building - excavated.
Quarters - foundation poured.
Supplies bldg. - foundation poured.
Garage - foundation footings poured.
Inflammable stores - laid out.

(2) Plans not yet available for remaining buildings.
Assistance needed on delivery of steel for operations, quarters, and power buildings (Dominion Bridge).

(3) Need plans for water and sewer systems.

(4) Claydon suggests we check Armco material for dopplers before moving to sites.

(5) Question of isolation pay for some doppler sites.
Plumbers and steamfitters get this on their Union agreement.
Approval for rotation every three months?
Claydon stresses safety factors on tractor trains; caboose for personnel, etc.
Possible future difficulty in hiring all personnel to medical standards.
Rental of three trailers for married quarters? 125 men on site now; probably 250 next spring.

(6) Doppler sites (12)
5 sites west of Bird accessible by barge and road; several out of Ilford or Gillam, using Muskeg tractors.
Building started at one site, material going in at others.
7 sites east of Bird are a tractor train operation during coming winter. Patricia Co. a possibility as operator.

(7) Story on Lamb aircraft damaged at Winisk evacuation (last fall).
Claim delay on our part resulted in ice damage and subsequent crack up.
Lamb flying a lot for Management Contractor.

Chapter 14

1955 The Eastern End

Thousands of oil drums, literally acres of them, were piled on the Montreal dock, waiting to be loaded on board ship for the 500 mile trip to Sept Iles, the jumping off place for Knob Lake. It was the spring of 1955 and vitally important to get supplies of aviation gasoline and fuel oil into Knob Lake, and from there to lakehead distribution points which had been established during the winter. So on board the drums went, and on to Sept Iles, the first of many thousands of drums to be shipped to and along the 55th parallel, all neatly stencilled with "Trans Canada Telephone System."

From Sept Iles the drums went by rail over the newly-completed Quebec, North Shore and Labrador Railway of the Iron Ore Company to Knob Lake, where they were stacked preparatory to movement to the lake-heads. How to get them there? Well, the Canso aircraft (PBY to the Americans) was basically designed for wartime anti-submarine patrol. To ensure being able to remain on patrol for long periods it was equipped with extra large wing fuel tanks. So Canso wing tanks were filled from the drums at Knob Lake, and the empty drums lashed down in the body of the plane. [When they] arrived at the lakehead distribution point the process was reversed. The drums were unloaded on to a raft moored off shore, and the fuel pumped into the drums. Then the raft was winched ashore and the filled drums stacked for future lift by helicopter to the hilltop doppler site.

Building the rafts, and particularly keeping them in place, was not easy. The smooth rock surface of some of the lake beds offered little grip for anchors. In a high wind an aircraft would drift away, dragging the buoy, anchor and raft with it. When that happened the plane motor was started up, and the plane used as a tug to drag the raft and all its gear back into place.

This process for getting aviation gas and fuel oil to the doppler sites was obviously an expensive one, but unavoidable. It involved four transhipment points - Montreal, Sept Iles, Knob Lake, and a lakehead distribution point - and twelve separate handlings. The delivered cost per gallon was something to shudder at. A few months later we were able to improve the economics somewhat. In view of the large quantities of gasoline and oil which the project would require, the Imperial Oil Company agreed to establish a storage depot at Knob Lake; so getting the supply into Knob Lake from the south became their concern. Overnight the price of gasoline at Knob Lake dropped from $1 per gallon to 50 cents.

Most of the other construction materials and bulk supplies, however, had perforce to continue to use the ship-rail route from Montreal. A large warehouse was rented close to the Montreal dock for storage preparatory to shipment: construction materiel came from many points, and sources of electronic equipment ranged from Manchester, England to Los Angeles. Regular shipping lines were used as much as possible, but it was necessary to also charter ships from time to time for this movement. In emergencies and when the winter freeze-up of the St. Lawrence made ships impossible, Quebecair was used; at times the R.C.A.F. took over with their Dakotas and C-119 cargo carrying aircraft. Personnel moved into and out of Knob Lake by air, normally on scheduled commercial flights of Quebecair.

All movement of materials and men east and west across the Quebec-Labrador area of the Line had to be by air. Knob Lake was the control point. The direction and handling of this movement is a saga in itself. When Management Contract people arrived on the scene in the fall of 1954 they found the newly-built Iron Ore Company airstrip already in operation. The Company, who were most cooperative throughout the project, agreed to our using the strip, with the Management Contractor maintaining it and the Department of Transport providing a flight advisory service. Knob Lake was probably the only airstrip in the world surfaced with iron ore! Unfortunately the shale which came with it was sharp and caused a number of tire blowouts on incoming aircraft.

Nine airline companies, normally competitors, sat down with a representative of the Air Industries and Transport Association to co-ordinate their efforts on the airlift. This group set up a joint stores and maintenance operation, and with Department of Transport approval prepared a common operating manual for their crews. The air-craft were all radio-equipped, and both Knob Lake and the lakehead sites were equipped with radio beacons. The Management contractor furnished weather reports, loaded and dispatched the aircraft. The pilot, however, had the last word as to how much weight he would carry and whether the weather was good enough to fly or not.

These flights out of Knob Lake were all chartered aircraft (except for the R.C.A.F. and Navy of course). Throughout the project we stuck to a policy of chartering and paying on the basis of time used. The alternative of basing payment on ton miles moved was used to some degree for the D.E.W. line and some other projects. In the opinion of our people, and I fully supported it, this tended to leave the way open for pilots to take chances both as to weather and over-loading. Proof of the pudding, though not solely due to this decision, is that despite short hours of daylight, storms, and intensely cold weather, 11,000 tons of materials and equipment, plus scores of personnel, were lifted out of Knob Lake without one serious accident. Great credit for this performance is due the civilian pilots, the Air Industries and Transport Association, and the R.C.A.F., as well as our own people.

One accident almost happened on an evening when I was in Knob Lake. It was the start of the news reporter tour mentioned earlier. The newsmen had been sitting around the lounge, getting the atmosphere of the project, and exclaiming over two very large grey trout which one of them had caught in a half hour's fishing in Squaw Lake adjacent to the site. Suddenly the door opened and a bundled up figure staggered in. He was an airline pilot, and against the advice of the airport controller he had decided to take off for a lakehead site. The weather was murky, he misjudged his distance, and [he] ran his plane off the end of the runway into the mud. The plane wasn't damaged, but it would take quite a winch pull to get it out. The pilot was shaken up but unhurt. Where else could things happen and the participants bring the news to the reporters rather than the other way round?

Flying conditions were anything but easy, particularly in winter, which meant October to May. The Knob Lake runway was lighted at night, as were some of the ice strips at lakehead sites. But wind and snow made things difficult. In the words of one civilian helicopter pilot, "The weather is the worst I've ever seen. We get it from the Arctic, Hudson Bay and the Atlantic. We don't fly in winds much over 40 to 45 miles per hour. We've had winds of 90 miles per hour sometimes." The annual snowfall at Knob Lake is 133 inches – eleven feet, and not much of it melts during the winter. In point of fact, extra heavy roof sections had to be used for buildings in this area to take the snow load. Temperature ranges down to -44 degrees Fahrenheit at times. No wonder special clothing was needed. Coats and trousers of nylon impregnated with neoprene and quilted over heavy wool – so-called "thermo wear" – and other similar clothing was supplied to outside workers; in some cases R.C.A.F. arctic flight outfits with flight boots were used. outdoor workers frequently carried naptha hand warmers.

As the tempo of the job increased, air traffic to and from Knob Lake grew sharply. By the winter of 1955-56 up to 200 aircraft per day were landing or taking off during the daylight hours. Many planes had to circle for some time until the runway was clear.

Setting up and operating the lakehead distribution points was a two season proposition. Their initial establishment close to the doppler sites, with fuel caches and accommodation buildings, had been done the previous winter (1954-55). Now it was time for the major summer airlift. To ensure safety, the lakes at all 22 distribution points were charted to show underwater shoals and reefs. These were marked with buoys and maps were prepared for the pilot's use. As we have seen, the major aircraft for the summer run was the Canso. At the time there were some 14 of these in commercial use in Canada. At peak activity, 12 of them were employed on the Mid-Canada project. Smaller float planes such as Otters, Beavers, Gruman Goose, Norsemen, even Pipers and Cessnas were used for lighter loads and for personnel.

[In the] meantime construction had started in earnest at Knob Lake. Foundations were difficult. The geological formation is such that the grain of the rock is about at a 45 degree angle. The result was that blasting for footings, sewer lines, poles, etc. tore great wide holes, necessitating extensive back fill and presenting problems in getting firm bed rock for foundations of towers and anchors. The cold weather added complications. In this area, heat had to be applied in the concrete pouring process for nine months of the year. In some instances, here and elsewhere on the Line, huge tents had to be thrown up over the site of the pouring. Temperature was thus controlled so that the concrete would pour and set evenly. Knob Lake installation included a surveillance radar which made for a larger project, but water and sewer connection was established to the town of Schefferville's system, thus simplifying those arrangements.

Organization of the supervisory team at Knob Lake was typical of the various sections of the Line. Bill Martin was Bell construction engineer responsible for Management Contractor functions. He had a staff of site engineers, at the main site and dopplers, transport foremen and others to assist in supervising the operation. The general contractor, in this case H.J. O'Connell Co., was responsible for the construction, the work force being directed by a job superintendent. On site also were an engineer from D.C.L. and a representative of Cost Inspection and Audit of the Treasury Department to assist Bell in its work, and ensure that Government requirements were met. Finally there was the commanding Officer of the R.C.A.F. helicopter flight, and a representative of the Air Industries and Transport Association of Canada. In the words of Bill Martin, "This team is working together at Knob Lake to complete the job assigned to us by the scheduled date."

With detailed plans becoming more fully available, the pace of construction activity was increasing steadily when, just as cold weather set in, fire broke out. Escaping cooking gas blazed, and fire swept through the construction camp, destroying most of it. Fortunately there were no casualties, but with minimal or no shelter in cold weather, most of the labour force had to be evacuated by air.

The Air Force and Army came to the rescue. Materials for more G.P. huts were flown in along with other necessary items. Between Bell and the general contractor the camp was rebuilt, and construction got going again. But a valuable month or more had been lost. Fire is an ever present hazard in the north. We experienced about 80 small flare-ups during the whole project, nearly all caused by careless smokers. Fortunately with the exception of this one at Knob Lake only minor damage was done. With the Line completed a fire did occur in one of the dopplers in the west, with some damage to the interior of the station. The attendant made use of the survival hut for his own safety, and repairs to the main building were quickly completed.

By late September of 1955, the summer airlift to the lakeheads was complete, and the two months pause for freeze-up took over. An early heavy snowfall formed a blanket on the lakes which slowed freezing and made it difficult to form the ice landing strips. Ingenuity was called for. Small ski-equipped planes were taxied back and forth to pack the snow, reducing its insulating properties and aiding ice formation underneath. Bombardier tractors were flown in to assist in the operation, and in a few cases, Caterpillar tractors were taken apart, flown to lakeheads and reassembled. By January several feet of ice underlay the strips, and large ski-equipped and ski-wheel aircraft were in full operation between Knob Lake and the lakeheads.

So the winter lift was on, with DC3's, DC4's and other heavy planes ferrying a steady stream of construction materials and supplies to the lakeheads – all the necessary gear to get on with construction of the doppler stations. In a few instances during the winter deep freeze, the Dakotas and C119's of the R.C.A.F. delivered heavy materials direct to ice strips on the larger lakes. Ice had to be four or five feet thick for this to be safe. The Dakotas were equipped with ski-wheel landing gear for year round operation, and were also fitted with Jato units for assisted take-offs from the shorter lakehead ice strips. I recall a senior Air Force officer being very concerned on learning that two C119 aircraft were resting on one ice strip. However the ice was very thick and the planes were safe. The transport of diesel engines which had been airlifted from the United Kingdom was part of this movement of heavy material. Many of the ice strips were lighted so that after dark flights could be made, and as already mentioned electronic beacons were installed to guide the aircraft to the strips.

As doppler construction got under way, the helicopter operation went into high gear, lifting materials from the lakeheads – sometimes direct from Knob Lake – to the doppler sites on top of the hills. To facilitate handling and keep helicopter loads within their lifting capability, individual material sections for the dopplers in this area were limited to thirteen by five feet in dimension and 1500 pounds in weight. For the same reason lightweight cast magnesium sections were used for doppler building floors. There were, however, some off-setting factors. Most of the hill sites proved to be solid granite knolls, requiring extensive drilling and blasting for tower and building foundations. In most cases aggregate for making concrete was not available on the site, so had to be flown in by plane and helicopter.

The helicopters were fitted with external cargo slings to pick up loads without landing. In order to do this, they carried full fuel loads, which limited the payload of the Sikorsky H-19 to 1200 pounds and that of the larger Piasecki machine to 3600 pounds. These limits still permitted them to carry very substantial items, even for the Sikorski short lifts of the diesel engines to the hill-top sites. The helicopters could range up to 300 miles from their base, though the vast majority of their lifts was over short distances. Depositing loads on the small landing pads of the doppler sites was an exercise in precision flying which demanded great skill, particularly if there was a wind – and there usually was.

One circumstance which puzzled and distressed us until we found the reason for it was the occasional disappearance of materials and equipment when en route between a lakehead site or Knob Lake and a doppler hilltop location. The reason turned out to be the problem of operating a helicopter in a high wind. With a substantial load slung below the machine, the pilot had trouble manoeuvering in a wind of anything over twelve miles per hour. In the interests of safety, he had strict instructions from his R.C.A.F. superior officers that when trouble developed due to wind – or other cause – he was to cut the sling and dump the load. On one occasion a pilot in difficulty dumped a reel of cable [which] struck the top of a mountain, broke apart, and the cable unrolled right down the face of the hill. The directive was sensible, but unfortunately at times the pilots omitted reporting the loss to the Management Contractor, so supplies sent to the field disappeared from the pipeline without explanation. The mystery was finally cleared up, and duplicate supplies sent out.

The whirly birds were also called on for emergency action in case of accident or illness. One such flight, in which an injured workman was carried from a doppler detection site to hospital in Knob Lake, took two full days because of bad weather. Several stops had to be made for refuelling, and once the helicopter perched on a hill-top for hours waiting for low hanging clouds to clear. Flying time in the whole two days was only 6½ hours.

At the peak of the airlift activity, which was concentrated in this eastern section but extended in lesser volume right across the Line, about fifty chartered fixed wing aircraft were in use on the whole project. Of helicopters, 108 R.C.A.F. Flight had twenty-five on the job at the peak. They were assisted by six Royal Canadian Navy helicopters (four at Knob Lake, two at Great Whale) and by six U.S.A.F. machines and six civilian-operated helicopters.

By midwinter of 1955-56 construction was in full spate at Knob Lake, material movement to the dopplers was well along, and doppler construction was starting.

Chapter 15

1955 The Bay

Hudson Bay. That great salt water sea extending deep into northeastern Canada. 850 miles from Hudson Strait to the southern tip of James Bay, 650 miles from east to west at its greatest width, the bay has an area of close to 500,000 square miles, five times that of the whole Great Lakes system. Canada's four Maritime provinces would fit into it comfortably, with lots of room to spare. A shallow storm-tossed sea in the all too brief summer; a solid mass of tortured ice in the long winter; home of polar bears and ravens. Scattered settlements of Eskimo [Inuit] in the north, Cree Indians [First Nations] in the south, with a few outposts of the white man, built for trade, whether fur or wheat, or for military purposes. These continue a precarious existence which adds to the loneliness – or perhaps more accurately the lonely grandeur – of the whole scene.

Many explorers and just plain wanderers have probed Canada's eastern Arctic over the years. Viking bands were probably the first, in the tenth and eleventh centuries. Lief Ericson landed at L'Anse aux Meadows in northern Newfoundland about the year 1000. Others roamed along the coast of what is now Baffinland [Baffin Island], which was known in the Middle Ages as the source of polar bears and hunting falcons. Emphasis in the 16th and 17th century – even to some extent up to the 20th – was on the search for a Northwest Passage to the fabled riches of the Orient. [Martin] Frobisher, [John] Davis, [Henry] Hudson, and [Thomas] James were all on that quest but found no Passage. In 1602 [George] Weymouth sailed into Hudson Strait but did not enter the Bay. In 1610 Henry Hudson sailed through the strait and down the Bay to its southern extremity at the foot of what was later known as James Bay. The search for the Passage continued after Hudson's tragic end, in the belief that China lay just beyond this sea – people like [Robert] Bylot and [William] Baffin, who penetrated farther into Lancaster Sound than anyone up to the twentieth century; [as well as] Jens Munk, [Luke] Foxe, and [John] Knight – all probed, explored, and came away defeated in their quest.

In the second half of the 17th century fur trading became the lode star. [Pierre-Esprit] Radisson and [Médard des Groseilliers], those intrepid coureurs-de-bois, having with herculean exertion reached the Bay over-land from the south, conceived the idea that entrance from the northeast by sea would be a lot easier. Their idea rejected by France, they sought sponsorship in Charles II's England. The result: formation of "The Governor and Company of Adventurers Trading into Hudson's Bay" in 1670. Initially granted rights over most of what constitutes today's northern and western Canada, the company established forts and trading posts around the

Bay and inland. In 1690 Henry Kelsey, a Hudson's Bay Company factor, penetrated inland from York Factory as far as the plains of Saskatchewan. In 1717 a fort was erected at Churchill as protection from the French, who naturally did not take kindly to this British invasion of what they regarded as their private trading preserve.

And so [followed] the years of conflict between the Hudson's Bay Company and the French traders, then with the Northwest Company from Montreal, ending finally with absorption of the Norwesters into the Hudson's Bay company in 1821. Then [came] a long lull until the opening up in this century of grain shipments out of Churchill, backed by the Hudson Bay Railway. Finally [came] our own invasion of these historic and at times inhospitable waters to build a warning line against modern day threats to Canada and the continent.

The Bay was vitally important to the Mid-Canada project, both from the standpoint of continental defence – the essential purpose of the Line – and because of the major difficulties in implementation foreseen due to difficulty of access and climate. What is virtually an open sea approach from the north into the middle of the continent made the detection line particularly important in this region. To counter low flying aircraft, doppler coverage right down to water level was specified. As to construction problems, the combination of an extremely short shipping season, difficult unloading conditions, long winters, permafrost, and costly air transport, made for slower progress and higher costs than elsewhere on the Line.

Physically the Bay area included two of the seven major S.C.S.'s and 25 of 90 Doppler stations, so it constituted about 28 percent of the total line in terms of operations. Added to this, however, was the tropospheric scatter system across and down the west side of James Bay, major airstrips at Great Whale and Winisk, extensive sea lift and tractor train operations, and many other unusual and expensive situations. In fact, though equipment and tower costs were of course proportionate to the number of stations, this other work plus the complications of access and implementation meant that closer to 40 percent of the total cost of the project was incurred in the Bay area.

Our transport plan for the 1955 summer season, as laid down in the April 1955 Implementation Plan and sent to D.D.P. at that time, included the following proposed arrangements:

(1) Shipment through Hudson Strait to be used for the vast majority of material, with off-loading at Great Whale River, Winisk, Severn, Bear Island, Cape Jones, and Lake River. Approximate total tonnage moving into the Bay during the 1955 season was estimated at 10,000 tons. It was planned to use a series of smaller ships - from 500 to 2000 tons burden, rather than a few larger vessels.

Lack of docking facilities and shallow water would necessitate off-loading by lighter at Bay locations, and we requested that the Department of Transport provide twelve self propelled barges to handle dry cargo and, by means of removable tanks, fuel oil and aviation gasoline also. Barges of about 16 foot width and 40 foot over-all length and of shallow draft, powered by two 40 h.p. diesel units were suggested. The provision of adequate lightering gear and the organization of the lightering operation to meet the requirements of the job was very much in the area of D.O.T. expertise, and we looked to them for help, which was forthcoming readily throughout the project.

(2) Supplementing shipment via the straits was the proposed use of small coastal vessels out of Moosonee, chartered from the Hudson's Bay Co. and from residents of Moosonee, for transport from that railhead to Bay sites and between sites. Ahout 1000 tons of material was expected to follow this route.

(3) The airstrip built during the winter of 1954-55 at Great Whale River, plus a strip at Winisk and a second one at Great Whale to be built by the contractors during 1955, were to be used to supplement shipment of material by sea, and of course for movement of personnel.

(4) With the onset of winter, tractor train operation into Winisk and the west Bay Dopplers, working out of Moosonee in the south and Amery or Gillam in the west, was a possibility. Winter movement into Great Whale would have to be confined to air transport.

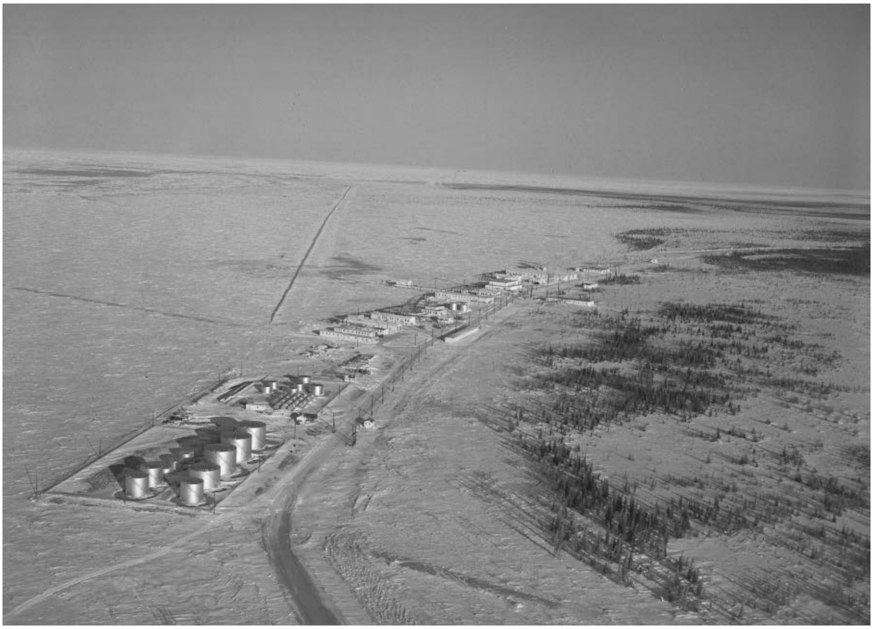
The first job of the general contractors - Fraser Brace at Great Whale River, and Carter Construction at Winisk - was to build camp facilities. At Great Whale that task was well on the way, thanks to the efforts of the Air Force C.M.U. and the Management Contractor during the spring. The camp accommodation was expanded by means of tents and additional G.P. huts to handle 400 construction personnel. A Management Contractor transient camp was also established. It was planned, as at all S.C.S.'s, to concentrate on erection of the permanent barracks buildings early in the game and to use them if necessary for some of the construction personnel so as to avoid unduly large construction camps.

At Winisk materials for camp construction had been brought in during the winter, [as well as] some heavy tractors for work on the air strip which was urgently required. Minor amounts of material started to move out of Moosonee in June, for James Bay is open a month earlier and closes in a month or more later than Hudson Strait. Zone headquarters had been established at Moosonee, and Max Narraway, as zone engineer, operated out of there, though of necessity he spent a lot of his time at Winisk and Great Whale. Since Moosonee was the nearest railhead to the Line in this area, and in order to maximize use of all possible transportation media, we established an extensive marshalling yard and camp there to facilitate distribution of material and manpower. Men were flown from Moosonee to sites in float planes (there was no air strip at Moosonee) Later on Moosonee became the base for tractor train operations into Winisk, and was a very active community during the months of that safari.

For two years the question "When can we ship through Hudson Strait?" plagued everyone responsible for transport and construction in the Bay area. In 1955 the "all clear" at Hudson Strait in the last week of July was the real blast-off for the season. The first chartered ships, laden with dry cargo, also fuel oil in drums, and carrying lighters for unloading, came through the straits and down to Great Whale River and Winisk. At Great Whale, small boats or barges of 50 to 100 tons could come in to the dock; but all larger ships, which meant all coming through the straits, due to the shallow water had to stand off two to four miles from shore and lighter their cargo.

The Department of Transport, General Contractor and Management Contractor people set to with a will, aided by the ships' crews. In a calm sea the lightering operation proceeded with reasonable dispatch. The barges, some self-propelled, some "dumb" (i.e. towed), were brought to the beach at the mouth of the river, the cargo unloaded by crane to trucks, and the material trucked to the nearby storage area. At this early stage fuel oil, gasoline, etc. was of necessity shipped and stored in drums. By the next year, tank farms were erected at Great Whale and Winisk. When the weather was rough, and the Bay is subject to storms, lightering became virtually impossible, with both ships and barges rolling violently in the waves. However, persistence, manpower and time resulted in some 12,000 tons of construction equipment, building materials, fuel oil, aviation gas and diesel fuel being unloaded at Great Whale during the 1955 shipping season of two months. Small amounts of material were also unloaded at a few doppler sites which were close to the shore line between Great Whale and Cape Jones.

At Winisk the problem of unloading was much more difficult. The southwestern section of Hudson Bay is very shallow, and off Winisk there are shoals and sand bars in all the wrong places. At low tide the muddy, rock-littered bottom is exposed for what seems a mile out to sea. As a result ships of 2000 tons had to anchor eight to ten miles out and lighter their cargo ashore. High tide clearance over the shoals was only sufficient for small barges, so it was a long process for any one ship, with consequent heavy use of manpower, and high demurrage charges for the ships. Add to this the hazards of transferring cargo from ship to these small barges in rough weather – ships anchored ten miles at sea incurred the full force of the storms – and a picture of the difficulties of sea transport into this location, [as well as] into Bear Island, Lake River, and other points on this southwestern coast of the Bay starts to materialize.



In all, only 1900 tons of essential material was unloaded at Winisk during the 1955 shipping season. This included fuel, construction equipment and building materials, wooden piles, concrete and steel. An additional 2800 tons was unloaded at Churchill, and shipped by rail, air or boat along the shore, to its destination on the Line.

Thus the total sea lift into Hudson Bay in 1955, counting smaller tonnages shipped through Moosonee, was about 18,000 tons. It greatly exceeded our earlier estimate, and was adequate to meet the current needs of Great Whale. For Winisk, however, greater volume was needed, emphasizing the urgency of a major winter tractor train operation.

Our estimate of lightering barges required was also too meagre, both in number of units and in necessary variety. The early ships coming into the Bay carried their own barges. Others were provided by the Department of Transport, either by purchase charged to the Mid-Canada project or borrowed from other agencies. For example, arrangements were made to borrow some 14 landing craft from the United States Navy. These were located at Newport News and had to be shipped by rail to Moosonee. With dimensions of 56 feet by 14 feet and a 9-foot draft, loading them securely on flat cars was rather tricky. However, they were loaded on their sides and sent on their way. Prior to shipment it was necessary to check all tunnels and some of the sharp curves on the south to north railways, particularly from Cochrane to Moosonee, to ensure their safe arrival at Moosonee and not as a casualty of a low tunnel or bounced off a sharp curve. They did arrive safely and were used extensively throughout the project. By the 1956 shipping season we had gone farther afield. At the peak of the 1956 season we had operating in the Bay two heavy L.C.T. landing craft of 600-tons capacity, acquired in the United Kingdom and towed across the Atlantic; 14 L.C.M. landing craft of 35-tons capacity; 10 seven-ton barges, four pontoon barges of 85-tons capacity; and two tugs for towing "dumb" barges ranging in capacity from 50 to 500 tons — quite a substantial stevedoring fleet.

The sea lift extended from late July to the end of September, so it was late summer before there was sufficient materials and equipment on hand for major construction to get into full gear. The concentration at both Great Whale and Winisk was to complete an air strip and get building foundations in or at least started before winter set in. At Great Whale the air strip built by the Air Force was in use. It paralleled the Bay shore line in a north-south direction, was 5000 feet 1ong with 1000 foot overshoots, and was surfaced with a mixture of local clay and sand which proved to be very effective. The second strip 5700 feet long but with no overshoots, was to extent in an east-west direction, roughly parallel to the river. The combination of the two strips would provide better conditions for landing and take-off in the variable winds of the region, and substantially increase the capacity of the airport - something which would be needed at the peak of activity in 1956. Work on this second strip started early in the summer, since heavy earth-moving equipment was available from the earlier C.M.U. effort. By late fall the strip was usable.

As to site construction proper, early access of the survey team to the site had permitted foundation design to go forward promptly. Consequently foundation work started in late summer, and by the onset of winter the foundations for ten buildings had been poured, ready for erection of the building superstructures during the winter of 1955-56. So progress through 1955 at Great Whale River was visible and good. The concentration was on the Section Control Station. Materials were moved out to lakeheads close to doppler sites to the east, as was being done out of Knob Lake, and some materials were put ashore at doppler sites west of Great Whale along the shore of the Bay. But construction at the doppler sites plus the more extensive operations required at Bear Island and Cape Jones were left for the new year.

Word of the white man's activities at Great Whale River had spread up and down the coast, bringing a straggle of Eskimo [Inuit] from the north and Indians [First Nations] from the south to the site, looking for employment. Some of these people were in dire straits by the time they reached the site. Two Eskimo walked 350 miles across country from Fort Chimo, an unbelievable trek, to get jobs at Great Whale. Another party was found starving in the bush, trying to reach the site. In all about sixty Eskimo were employed at Great Whale. They worked at stevedoring, concrete forming and pouring, and general construction tasks. They

proved to be willing and cheerful workers, and quite adept at acquiring mechanical skills. Driving a truck or other activities requiring good comprehension and coordination were quickly learned. For the most part the Natives [Indigenous people] worked under Bell or general contractor foremen, really on a follow the leader basis, since many if not most of them spoke neither French nor English. In fact camp notices written in English, French, Inuit and Cree were quite an attraction to visiting newsmen later in the project.

The money the Natives earned was, of course, outside their normal knowledge altogether; though in more recent years the popularity of Eskimo carvings has undoubtedly made them more aware of the white man's money values. They spent the money on exotic things at times, dealing through the everpresent Hudson Bay store. Expensive field glasses and watches were not unusual purchases, and quite a number of the children – who almost invariably were rosy-cheeked, merry, likeable youngsters – were given expensive bicycles by generous parents. On one occasion an Eskimo [Inuk] came to one of the Bell people wanting to buy a chocolate bar. In return for the bar he pulled a roll of bills from his pocket which when counted totalled fourteen hundred dollars. I'm sure his successors are much less naive now.

We had one interesting character who had at some previous time murdered another Native and had served a prison sentence as a result. He was a short, harmless-looking individual who, as his history got around, shrewdly decided to cash in on his notoriety. Thereafter he charged fifty cents every time anyone wanted to take his picture. Since there were quite a few transient visitors to the base, he made a fair profit.

The Natives were subject to a number of illnesses, though generally not those of the white man. On one of my visits a Native girl was very ill with something the doctor could not diagnose, but which apparently had been caught from the dogs. These animals, though often attractive in appearance, were invariably filthy, especially in summer, and we were warned never to touch them. A ten-bed hospital with a full-time doctor and a staff of four was established at Great Whale as part of the camp facilities. It was available to everyone on the site, including the Eskimo [Inuit] and Indian [First Nations] villages.

The Indians, though considerably more dour than the Eskimo and not as quick to take to things mechanical, were nonetheless a substantial source of labour. Except for one old man. He refused to abandon the ways of his fathers, and regularly set out in his canoe to fish for his dinner. The abandonment of their normal activity of foraging for their food by Indians and Eskimo employed on the Line had two rather unusual results from our standpoint. First we found that their normal diet was not adequate for them to put in a full day's work, so we fed them a mid-day dinner and occasionally a second or third meal. The second problem was that with the man of the family working on construction rather than hunting and fishing, food for the family had to be bought. Where? At the [Hudson's] Bay [Company] store of course. So we found ourselves arranging the purchase of meat and other staples in Montreal, shipping it by air to Great Whale River to be deposited in the [Hudson's] Bay store for sale to the natives.

Commercial enterprise intruded in a number of ways. The [Hudson's] Bay people acquired a selection of T-shirts, pennants, belts, etc., suitably labelled as souvenirs of Great Whale River or the Mid-Canada Line. It was intriguing to turn them over and find in small print "Made in Japan."

Weather was an ever-present problem at Great Whale, as at many other points on the Line. Severe cold with lots of snow in winter, heavy fog both summer and winter. Fog was particularly bad for air transport. Dense fog from the Bay seldom cleared before 11 a.m. and valuable time and money was lost when aircraft had to be diverted to other points, or could not come in at all. I recall one occasion when it took us two days to get into Great Whale in an Air Force C-119. We flew the 700 miles from Montreal one morning, circled the Great Whale airport for close to two hours, then had to return to Montreal. The next morning we set out again, and this time when we reached Great Whale the airport was clear and we were able to land.

At Winisk the general contractor, Carter Construction, started from a point well behind his opposite number at Great Whale. He had no airstrip, and essentially no camp though he had the makings of one. Using the G.P. hut sections brought in by tractor train during the winter the camp was built, again supplementing the G.P.

huts with tents. Tractors from the winter's activities were utilized to start the urgent job of building the air strip on one of the two eskers of the site. This effort was pursued during the fall, as more equipment and materials came in by sea, to the point that the air strip was ready for use late in the year. The surface was fine sand, and as there was nearly always a wind, dust blowing across the runway plagued the pilots and cut down on visibility. Consequently there were problems with aircraft stationed at this base, in that the dust sifted into delicate mechanisms, keeping the repair crews busy.

The buildings comprising the site were to be located in a line along the esker, but the essential initial problem was foundations in permafrost. For Winisk, Lake River, Bear Island, and a number of intermediate doppler sites were in the permafrost area. In such areas permafrost, or permanently frozen ground, extends from a few inches below the surface to depths measured in hundreds of feet. Left undisturbed, permafrost makes an excellent bearing surface for a structure. There are two problem areas: the "active layer" of soil between the permafrost line and the surface, which freezes and thaws in the normal manner causing expansion and contraction; and the permafrost itself which must not be disturbed by heat conduction from foundations or other penetrating materials if a secure bearing surface is to be obtained.

One of the successful solutions used by the R.C.A.F. and others in the north has been pile foundations, using steel pipe capped with wood in some cases and timber piles in others. In the case of Winisk 30-foot cedar wood piles were driven hard into the permafrost. The piles were then capped with concrete, permitting them to carry the reinforced concrete beams forming the foundation load without conducting heat to the permafrost. A clear space of at least two feet was left between the ground and the bottom of the floor slab. Special Q panel flooring was used, covered with alternate layers of tar, paper and cork before the concrete floor slab was poured. In the case of poles for power and telephone line distribution, a wooden pile was driven into the permafrost and cut off two to three feet above the surface. Then the utility pole was strapped to the protruding pile.

By the time winter set in, piles for six buildings had been driven and capped, preparatory to winter erection of the buildings. A very substantial amount of effort was used in the off-loading operations here due to the extreme difficulties caused by shallow water, shoals and bad conditions generally. Winisk was unquestionably the most difficult main site on the Line, and probably the least desirable from the standpoint of personnel on site. Except for the small mission north of the river, the camp was isolated from outside contact, particularly until the air strip was completed; there was no influx of Eskimo [Inuit] or Indians [First Nations], and the surrounding territory consisted of miles and miles of dreary and treacherous muskeg. Despite all this, the food was good; likewise, from my observation, [was] the morale. I saw some very active soccer being played from time to time, and fishing expeditions were organized occasionally. Later on there was some strain in relationships between supervisory staff of the general contractor and the Management Contractor, due essentially to pressure to get the job finished. But for the present everyone was driving ahead to the best of his ability and progress was being made, though slowly.

So 1955 came to a close. Very substantial progress in construction had been made in the west, good progress in the east and at Great Whale River, [but] slower progress at Winisk for the reasons I have outlined. On the whole we felt we had a grip on the job. Everyone was busy, and the earlier carping criticism between agencies had died down. In September and October Russ Cline and I held a series of full discussions with all the general contractors on the general status and conduct of the project, with what we felt was distinct benefit in the way of mutual understanding.

On November 23rd Mr. Eadie was able to report to Mr. Howe:

> Our current view of the construction situation in the field and of the headquarters planning is that it should be possible to meet the construction schedules. Work is well ahead, particularly at the far western end of the Line, with some dividends accruing in the way of on site construction of the smaller stations (D.D.S.) this fall and winter in place of next summer as had previously been expected. Work is now advancing rapidly on all of the main Section Control Stations and the big push on the smaller intermediate stations in the central and eastern portion of the Line will come next summer.

During the second half of 1955 several changes took place in the R.C.A.F. senior staff involved in the Mid-Canada project. In mid year Max Hendrick, Air Commodore and Chief of Telecommunications, was promoted to Air Vice Marshal and Air Member for Technical Services (including telecommunications). A/V/M Hendrick continued as Chairman of the Mid-Canada Executive Committee, where his overall good judgment was a stabilizing influence. Max was replaced as Chief of Telecommunications by Air Commodore Annis; however Group Captain Poole remained as full time head of the Systems Engineering Group, so continued to be our senior contact for design requirements.

Towards the end of the year Air Commodore Long was posted overseas, and replaced by Air Commodore Whiting as Chief of Construction Engineering. Dick Whiting proved to be an able officer and a sound engineer, of good judgment.

The appointment which really affected us most as Management contractor was that of Frank Bradley as senior civilian construction engineer for the Air Force. He had come to the Air Force well recommended by the Rolls Royce Company of the

United Kingdom. Apparently qualified in both architecture and engineering, his advent seemed at first to be a distinct step forward in helpful coordination and relationship between the Air Force and the Management Contractor, and I am sure this is what the Air Force intended and hoped. Later, however, his attitude changed sharply and, in my view, contributed to some of the controversy and strained relationships which surfaced again towards the end of the project.

Chapter 16

Tractor Trains, Air Lifts, and Snow

> The trail blazing tractor train of the biggest Northland transportation project ever undertaken chugged safely across the Albany River today and headed north toward Attawapiskat on the next leg of its journey to cape Henrietta Maria.
>
> It had covered more than 100 miles in the two days since leaving Moosonee, and had traversed about a third of the largest swamp in eastern Canada.
>
> The fight to get it to Cape Henrietta Maria, still more than 200 miles from here - Attawapiskat is approximately half way - already had the ear marks of a Northland epic.

Thus Don Delaplante's report to the Toronto *Globe and Mail* on January 23rd, 1956, from Fort Albany, on the bleak wintry coast of James Bay. Tractor trains had been used during the previous winter (1954-55) in the west to get camp material and supply caches into prospective doppler station locations, particularly in the muskeg area from Gillam on the Hudson Bay Railway east to Winisk. During this current winter tractor trains would operate into about 15 of the 41 doppler sites west of Bird, with a number of experienced operators such as Heglin, Patricia, Lindau and Johnson, and others doing the work on a sub-contract basis from the Management Contractor. Most of these tractor train runs were less than 50 miles in length.

The main problem this winter, however, was to get badly needed construction materials into Winisk and to the 12 sites between Bird and Winisk plus six sites east of Winisk. All of these were in muskeg country, thus dictating surface transport when the ground was frozen. The necessity of getting the heavy diesel units into such sites during this winter was mentioned in an earlier chapter. Much depended on this winter operation if we were going to come close to our overall schedule for the Line. Most importantly, we had only been able to off load 1900 tons of material at Winisk during the summer, plus another 2800 tons via Churchill. This was not nearly enough to get on with, and the job was hurting. It was planned, therefore, to mount major tractor train operations from Gillam east to Winisk to provide for the doppler stations in that area, with some material going into Winisk; also, and this was the main effort, from Moosonee north to Cape Henrietta Maria and Winisk. The first train swung out of Moosonee on January 20th, several weeks later than had been hoped due to mild weather. Operations out of Gillam started on February

12th. Both projects continued through the winter. In total 2000 tons of materials and supplies were moved out of Gillam over the 400 miles to Winisk. From Moosonee 9000 tons of material, the equivalent of 300 loaded railway freight cars, was moved 300 miles to cape Henrietta plus another 100 miles into Winisk, constituting a record tractor train operation for Canada up to that time.

Writing of the madmen who chose the overland route from Edmonton to the Yukon during the gold rush of 1898, Harwood Steele in *Policing the Arctic* records:

> Perhaps the most bird-witted scheme was that evolved by the "I Will" Steam Sleigh Company of Chicago---They built a train of four cabooses or cars, the motive power of which was steam. All Edmonton was assembled----scores of Indians squatted around and stared like gargoyles.
>
> "Let her go!"
>
> There was a vast creaking, a shudder as if the caverns of the deep were opened, and the wheels turned- and turned - and turned, and with each turn buried the macnine deeper in the earth, there to remain till the day Kenneth MacLeod bought the marine boilers and engine for his saw mill. Those stampeders who did not die of scurvy, hardships, starvation or accident, and who returned via Edmonton used the cabooses for shelter while they wrote home for money.[1]

Bird-witter of 1898, the tractor train proved a godsend to us in 1955 and 1956.

The contractor for the operation out of Gillam was the Patricia Transportation Company, and for the larger job out of Moosonee, Alex Hennessey of Hudson Bay Forwarding Ltd.

Four trains, each consisting of 6 to 8 sledges or "wanigans" hauled by a heavy tractor, together made up a "catswing" perhaps 1000 feet long and carrying 200 tons of supplies at a top speed of three miles an hour. Six swings ran day and night on the Moosonee-Cape Henrietta run for the next three months. The men worked 12 hours a day, seven days a week by special permission of the Department of Labour. Altogether Hudson Bay Forwarding used 34 tractors, 350 sets of sleighs, 15 waggons, and numerous muskeg buggies.

[1] *Editors' note*: Harwood Elmes Robert Steele, *Policing the Arctic: The Story of the Conquest of the Arctic by the Royal Canadian (formerly North-West) Mounted Police* (London: Jarrolds, 1936).

In addition to the pay load (five to seven tons per sled), each swing carried 4000 gallons of gasoline for the round trip, a sleeping caboose, and a cooking caboose. Each train had a crew of four – two drivers and two brakemen – working in shifts, six hours on, six hours off. Drivers were paid $550 to $675 a month plus board and Arctic clothing. Cooks got $500 a month – good money in those days.

As a safeguard in case the ice coat above the muskeg collapsed, the tractors were not provided with cabs, so the driver could jump clear without impediment. All cabooses had two escape hatches built into their roofs for the same purpose. Crossing the shore ice of James Bay, the trains kept 1000 feet apart in case of break-through. Each tractor travelled with a steel towing cable attached to its draw bar in case it broke through. Then the second tractor could haul it from the muskeg or lake.

The stove in the cooking caboose had a fence around it to keep the pots from slipping off in rough spots. Meat was kept in a box on the roof so no indoor refrigeration was needed. On this energy-burning job, pie was served four times a day and steak for dinrier every night.

The trail breaking swings were shepherded from the air by bush plane or helicopter. From a few hundred feet up, the pilot could see difficulties which were out of the driver's line of vision. A complete radio hook-up linked each swing with the aircraft and with the marshalling yard at Moosonee.

Each swing carried red sea marker dye for use on the snow in case of distress. The dye cannot be blown away by the wind, and even if snowdrifts obliterate the road, the dye works its way up through the snow.

Train operators like weather of 20 or 30 degrees below zero Fahrenheit to keep the ice hard enough to stand the pounding of the tractors. Ahead of the trains went experienced tractor crews testing the ice by drilling holes in it. A depth of 17 to 25 inches was needed to support the trains. Behind these men came crews of Indians [First Nations labourers] cutting brush and putting in bridges. Altogether some 150 bridges had to be built, ranging from six feet to 200 feet long.

It is interesting to note that in the Attawapiskat region the man in charge of preparing the road was Brother Charpentier of the Oblate Order of Mary Immaculate (O.M.I.), directing the efforts of 30 Cree Indians.

Perhaps the feel of this operation can best be further quote from Don Delaplante's article. He was a keen observer on the first swing out of Moosonee:

> Our swing of four trains left Moosonee on Friday night and all was clear sailing until one o'clock Saturday afternoon; the four big diesel tractors and their sleighs piled up mile after mile during the night and the morning.

We passed through a land of majestic desolation, where trees hundreds of years old grew to a height of only three feet on little ridges between the huge floating muskeg along the west side of James Bay.

Then 60 miles out, swing boss Alf Elliott put the leading machine across a barren, treeless plain. The bottom beneath the road began to tremble. He unhooked the sleighs, (and attached them to) his cable, which is 400 feet long.

The second tractor broke through the frost but struggled out. The crews of all four stood by as the third also bucked its way over.

Alex Hennessey … walked the steaming broken ground and signalled that the final unit was over. Then all the parka-clad drivers and brakeman grabbed the cable leading back to the sleighs. They were like fishermen hauling in a net as they strove to steer the first sleigh. Fred Jett, the driver, threw in his winch and the sleighs came across on their bellies.

Suddenly five miles farther along, a sleigh slipped over when its left runners broke through the frost and sank to a depth of four feet. A ten ton tank of diesel oil was tossed on its side but the chains holding it to the sleigh held….

The sleigh that turned over was directly in front of the caboose which held the cookery. The front runner of the cookery was three feet from the gaping hole and the cookery itself had acquired a pronounced tilt….

A tractor was inched slowly into the muskeg beside the road. A chain was slung around the tank. With shovels and by hand the crews removed the slabs of broken ground from about the runners and the tank. This took some time…. Presently, the winch of the big cat started to turn and the tank began to lift. The sunken runners cane with the tank, which fell exactly into its old position on the bunks of the sleigh.

The cook's caboose was unnooked and then was edged around the hole. Away we went again with no damage done. But the ground was boggy and the going slow. At two more places the entire train moved ahead by winch.

Hennessey was travelling ahead of the train, alternating from snowmobile to helicopter, to inspect the work of a gang of Indians cutting brush and putting in bridges. As darkness fell he found them

> bridging a 60 foot river, and he didn't like the look of the job. The logs weren't anchored properly on the banks, he thought.
>
> He ordered a tractor with the gang to try the bridge. The end of the bridge collapsed. He ordered the Indians to come back after supper at their camp.
>
> Next Hennessey wanted to inspect the bridging of the Albany, now 15 miles ahead. The Albany is a mile wide where the train was due to cross. The river is shallow except for about 200 feet of the main channel. Tests made by trader Bill Anderson show the ice varies in depth from 17 inches to 25. Anderson, supervising a gang of 30 Indians, had reinforced a 200 foot stretch with poles. He covered them with snow and made ice by pumping water out of the river.
>
> We got back to the fallen bridge in snowy darkness, an hour before midnight. The far end was still down in the water, now thinly coated with ice again. The Indians hadn't come back to work, maybe because they hadn't understood Hennessey's order. Across the frozen stillness we could hear the faint roar of the tractors' motors, now perhaps eight miles away.
>
> Hennessey held the accelerator of the snowmobile to the floor all the way to the Indians' camp, where he routed them out of bed mercilessly. The sight of those awakened Cree trappers, rebuilding the bridge in the light of the headlights of the snowmobile, snow falling on their shoulders, their breath steaming in the air, racing to beat the train, was almost unforgettable. Upriver from the spot were some of the few good spruce in the entire barren tract. The Crees rushed in and cut down more than 25 trees in total darkness.
>
> For three hours, as the noise of the train boomed louder, and its lights grew from a dim halo on the horizon to a bright glare, the Crees worked like slaves, cutting, skinning, hewing the logs to size, running to help one another hoist them into position. Their axe work was phenomenally swift and accurate. They finished the job as Alf Elliott's lead tractor thundered to the bank, and watched with glowing eyes as he put a big cat across and began to winch across the sleighs. Hennessey had the face of a tyrant when they started to work, but now he grinned happily. They grinned back at him, white teeth gleaming. It was 2.30 in the morning."

[It was] a rough passage for the pioneer swing, who were really making the road as they went. Following trains had an easier time, though the dangers of break-through and mechanical damage to the tractors were always present. The road gradually became all beaten down, frozen deep, and less hazardous. So much so that towards the end of the operation, one of my more innovative Air Force friends suggested a trip over it by motor car by the Chief of the Air staff and Mr. Eadie, I presume in the interests of public relations. The trip did not come off, but it is fair to say that the whole operation, both out of Moosonee and Gillam, was a success. As indicated earlier, 9000 tons of badly needed material was transported from Moosonee and 2000 tons from Gillam, to Winisk and its tributary doppler stations, thus permitting the general contractor to get on with the job.

Supplementing the tractor train operation, urgently needed material as well as food and personnel were transported by air, mostly from Val d'Or and Timmins, into Great Whale and Winisk in chartered aircraft. Over the winter and early spring this movement amounted to over 3000 tons.

In the west material and supplies continued to move to the Line by rail, truck and tractor train, plus air lift to lakehead ice strips and helicopter to the final site location where this was necessary. Construction carried on at the doppler sites and good progress was made, to the point that locally designed interior fittings, cup-boards, etc. for the living area of the dopplers were fabricated and installed before the official layouts were available from headquarters. At the Section Control Stations, building continued at a rapid pace, despite the cold weather and the snow.

Snow conditions were heavy at Dawson Creek, Cranberry Portage and Bird, and were worse at Stoney Mountain due to the wind. Much of the snow was powder fine. An unoccupied building would fill almost completely with snow sifted through a fine crack in a door jamb or window. Ventilators had to be kept tightly shut during the winter to prevent entry and packing of snow. The cold was really cold. One wintry morning on a western trip I boarded our aircraft, which had stood out all night, to find that the temperature inside the cabin was 40 degrees below zero, Fahrenheit! The joys of winter travel!

The impact of a large construction project on small communities like Cranberry Portage or Moosonee is substantial. At Cranberry Portage the village increased in size, with the families of some of the workers moving there temporarily. A curling rink was built with the aid of volunteers from the Wells Construction Co. and from Bell, and through the winter the easterners were well and truly introduced to the roarin' game of western Canada. The Manitoba Telephone System established an exchange to provide adequate telephone service, and additional school accommodation was required for the 170 children of the town.

In The Pas, zone headquarters for the Cranberry and Bird area, the men of the Line participated in many of the community activities of the town, including the well known Trappers Festival. For one festival parade, Bell people built a float in their off hours, a float which turned out to be quite a hit.

In Moosonee, the substantial camp and supply base, the activities generated by the big tractor train operation, and later on the servicing of the Line in its operational phase, had a marked impact on the town. Writing in *The Family Herald* in January 1957, a year after the tractor train blitz, Adelaide Leitch said:

> There is a dealer in furs, a small 'Malamute Cafe', and a long dusty road that leads to the Moosonee station. Twice a day, weather balloons carry aloft their delicate instruments, and the chart of their flight followed on the radar screen is part of a system that forecasts Canada's weather.
>
> When … the … established residents of the old Moosonee stride off down town to shop in 'The Bay', the slicked up little modern successor to the old trading post, they rub shoulders today with the men of the telepnone installations and the cat trains, the engineers and specialists and government men, and even a few tourists….
>
> The real character of Moosonee today, however, depends on your viewpoint. There are mixed opinions as the McGill Fence makes changes in the quiet routine of Moosonee and Moose Factory. There is the reaction of the southern Canadian going north, like the portly gentleman who stayed briefly at the Log Lodge last summer.
>
> 'Why did you come to Moosonee?' they asked him. He looked thoughtful for a moment. 'Well you see' he said 'I guess I always wanted to see the places we've read about in our history books in school. I wanted to see them before there were hot dog stands all over the place.'
>
> But then there was the minister from up the shore who spent an uncomfortable day or two in town and departed with an audible sigh of relief. He 'couldn't wait to get back to the peace and quiet of Attawapiskat.'

Construction pressed ahead at both Winisk and Great Whale River, with more material at hand and detailed plans gradually becoming available. Outside work was impossible on some days due to extreme cold or severe storms. For the most part, however, the men carried on, though obviously less efficiently than in the summer season. Many of the workers here and elsewhere took time off over Christmas to return home, the net effect being that from mid December to mid January job progress was minimal. By April, however, most plans were available and a substantial number of buildings at both sites were sheeted in, with inside finishing started. Great Whale, with better soil and general conditions, kept its lead ahead of Winisk, though the latter was making substantial progress.

In the east the movement of material to the dopplers by fixed wing aircraft and helicopter continued through the winter. The Knob Lake airport was frantically busy, as were the lakehead sites, while construction crews tackled the foundations and buildings at the doppler locations on the hilltops. Anchored in reinforced concrete set for the most part in excavations blasted out of the granite hills, the towers took shape, with the doppler buildings and survival huts close by. There were many rough and strenuous trips by fixed wing aircraft and helicopter during that winter. To the credit of the whole team, Air Force and civilian pilots, Department of Transport and Air Industries and Transport men, Bell transport forces and the rest, there were no serious accidents. Material and supplies moved out as required and the dopplers started to materialize.

At Knob Lake itself construction progressed without serious delay during the winter, except for the tremendous snowfall which at times meant tunnelling a passage between buildings, rather than shovelling an open path. But by spring the whole site was well on the way, with the expectation that equipment installation could start in the late spring or early summer.

We haven't talked about Hopedale, but Russ Parke, the zone engineer, was pushing construction of the relatively simple installation there, plus the five dopplers which were part of his responsibility. In addition to supervising the work of the general contractor, Deschamps and Belanger, at these sites, Russ was also in charge of the follow-up construction work at Pole Vault sites on the coast which the U.S. Air Force had asked us to do, so he was a busy engineer.

Chapter 17

V.I.P.s and Springtime

The Mid-Canada Line was part of the overall defence of North America, as planned jointly by United States and Canadian military strategists. It will be recalled that the Canadian Cabinet decision to build the line was based on recommendations of the joint Canada-U.S. Military Study Group, and on the more detailed proposals of the R.C.A.F., expressed through the August 1954 report of its Systems Engineering Group in which U.S. Air Force officers participated. While this Systems Engineering Group had prime responsibility for having the Line built, other military groups in Canada (e.g. Air Defence Command) and in the U.S. (Norad) were vitally interested from the standpoint of overall strategy and future operational use. At the international policy level, the Permanent Joint Board on Defence (P.J.B.D.) was involved in Mid-Canada as being an integral part of continental defence, along with the D.E.W. Line in the far north.

Early in April 1956, members of the P.J.B.D., along with other senior people of the Canadian and United States governments made an inspection trip to the Mid-Canada and D.E.W. lines. They spent the best part of two days at Great Whale River, saw both the main site and nearby dopplers, and were briefed on the status of the whole project. From Great Whale they flew north to the D.E.W. line for a similar briefing there.

It was a very interesting - and interested - group. Included among others in the party were:

Mr. C.E. Wilson, Secretary of Defense, U.S.A.

Mr. Donald Quarles, Civilian advisor to the U.S. Defense Dept., previously an officer of the Bell System.

Gen. Earle E. Partridge, Commanding General NORAD.

Mr. R.D. Stuart, U.S. Ambassador to Canada.

Mr. C.D. Howe, Minister of Defence Production, Canada.

Mr. Ralph E. Campney, Minister of National Defence, Canada.

Mr. Jean Lesage, Minister of Northern Affairs, Canada, later Premier of Quebec.

Gen. A.G.L. MacNaughton, Senior Canadian member, P.J.B.D.

A/V/M L.E. Wray, Air Officer Commanding Air Defence Command, Canada.

Most of the senior people flew direct from Washington and Ottawa to Great Whale River. The rest of the Canadian party flew from Ottawa via Montreal to the site. As a diversion on the trip north, we flew over Churchill Falls and the Hamilton River valley, the Churchill Falls project then being in its early phase. It turned out that General MacNaughton had been one of the engineers in the survey party who first traversed the Falls area in pre-World War I days. So we circled the valley several times while all on board viewed the spectacle of the tremendous waterfall.

When all had arrived at Great Whale, the group was given a full briefing on the current status of the project and the future prospects as we saw them. The briefing was principally my responsibility, but I was ably assisted by Air Force and Bell people involved in the project.

Then on to the social highlight of the visit, cocktails in the lounge, and a full course dinner in the dining hall. For the occasion the tables had been arranged in a "U," with the senior guests seated at the head of the "U" and others distributed on either side. In view of the rather august gathering a certain amount of protocol seemed to be called for. Advised by A/V/M Wray, we gave the places of honour to our senior U.S. guests, followed by Mr. Howe, Mr. Campney, Mr. Lesage, and the rest.

The dinner was excellent, starting with shrimp cocktail, followed by steak and fresh vegetables, topped off with, as I recall it, fruit and ice cream. The cook had excelled himself, and certainly must have left with the visitors the thought that, whatever the hardships of the Mid-Canada Line, a poor diet emphatically was not one of them.

The next morning there was more briefing, but principally an inspection of the main site and a helicopter trip for some of the party to a nearby lakehead distribution point and doppler station. At the doppler location a tent had been erected in case of weather problems, and we used it as a gathering point for the group, to outline to them the status of the doppler job in the vicinity and generally across the Line. General Partridge had come out to the doppler site, but I missed him from the tent briefing session. I imagine the General's days included too many briefings; at any rate I found him outside, busy helping our Bell transport foreman to fix a balky portable electric generator. He was that kind of man, and I understand flew every type of aircraft that came under his command to satisfy himself as to their capabilities and suitability for their role.

Judging by the "thank you" notes that I received over the next couple of weeks, the party was duly impressed with our progress. Naturally we had put our best foot forward, but the job was really moving ahead, and the target date of January 1, 1957 still looked like a possibility. Steady progress was being made in the west, where a substantial number of buildings were by this time ready for the installation of electronic equipment. In Knob Lake and Great Whale too, some buildings were close to completion. [At] Great Whale, it was necessary to establish a water and sewer system for the site since there was no existing municipal system. The water had to be pumped from some distance up the river to avoid the salt. Pumped to the station site, it was filtered and purified, then stored in a water tank.

The drive to build the dopplers across Ungava was well under way, and those in the Bay area were starting. There were two added complications in the Bay area: Bear Island and the Tropospheric Scatter system.

Bear Island is almost exactly half way between Cape Jones at the northeastern lip of James Bay, and Lake River on the western shore. About six miles from north to south and perhaps a mile or so wide, in winter it is just part of the frozen bay when seen from the air, and for the brief summer appears as barely more than a shoal or sand bar. Except in August, the real summer month, when temperatures sometimes reach 80 and 90 degrees during the day, dropping sharply at night, and the island becomes a riot of wild flowers.

We had heard wild tales of the island, of the prevalence of polar bears, who might even attack small boats, and similar fantasies. Somewhat disappointingly the tales proved to be pure myth. True there were polar bears on the island from time to time, but never more than two or three, from observation of our people. The intricacies of doppler coverage dictated that we should have two doppler stations on the island, one at each end. There was therefore a rather substantial amount of construction to do, and a fair sized construction camp needed to house the personnel doing the work. Access to the island from the sea was feasible, particularly for small boats, but in the interests of speeding things up, we decided to test the possibility of an air strip.

It was easier than we had anticipated. The island surface consists basically of flat layers of shale, sparsely covered with top soil and moss. A few days with a bulldozer produced a quite adequate 4000 foot strip with a shale surface. Material and personnel came in by both sea and air during the summer, and the towers and buildings for the two sites were started without undue difficulty.

The tropospheric scatter system consisted of five stations, starting with Cape Jones, coincident with the doppler station at that point, then across the bay to Lake River, and in three more hops to Ramore, where with the necessary change of frequency, the circuits were picked up by the Trans Canada Telephone microwave system. In the year since Pole Vault, design of the scatter antenna had changed substantially. Based on designs of the Blaw Knox Co. in the U.S., modified by our consultant, the B.R. Perry Co., the antenna dish, which it will be recalled was a circular aluminum mesh of paraboloid shape for Pole Vault, was now a solid square paraboloid shaped sheet of fitted steel plates, supported by substantial steel struts. The probe, or focal point of the antenna, previously attached to the dish by fibre glass spars, was now mounted on a separate steel clad structure fixed at the proper focal length from the dish. The whole structure was much more rugged, and therefore more suitable for continued use in the tough Arctic climate.

In this particular system the hops between stations were comparatively short (under 150 miles) so the final power amplification stage at each station was one kilowatt compared with 10 kilowatts in the Pole Vault system. The electronics were therefore less expensive, and there was substantially less hazard of radiation from the Klystron power tubes.

One of the scatter sites was in permafrost territory. For the towers, wood piles driven hard intci the permafrost were used as in Winisk. For the buildings, which were comparatively small, a different method was used. The active layer of soil was scraped off and a gravel berm built up six inches to a foot on top of the permafrost. A thick layer (about 6 inches) of styrofoam was laid on the berm to prevent heat conduction; then the floor slab and wall foundation was built up from there. With well drained gravel and a thick insulating layer of styro-foam, this resulted in solid support for the building structure.

The winter had been an active one for all concerned. But the back of the construction job was broken in the west and the east. In the Bay area we had caught up with the material deficiencies caused by the 1955 off-loading situation at Winisk, though construction was lagging at this difficult site. Great Whale was in good shape. The next step in the construction program was the drive to get material into the Bay sites during the 1956 shipping season, to get these sites completed as to construction, and get on with equipment installation right across the line.

For the Special Contract people at headquarters and myself the days were filled to overflowing, including a lot of travelling. During the eighteen months of peak effort on the Mid-Canada project, I travelled approximately 125,000 miles, practically all by air, to various parts of the Line, and since we were still involved in additionsto Pole Vault, to the Labrador coast as well. This was in all kinds of aircraft – from commercial jets to North Stars, DC3's, Cansos, Dakotas, Norsemen and Cessnas – landing on anything from a full airport to a ploughed field. In between times, there were a few short expeditions in swamp buggies, Bombardier tractors and helicopters. Russ Cline, Cliff Frost and other senior Bell people were equally or more active, and the Air Force in particular were assiduous in trips to the Line, concentrating on Winisk.

Chapter 18

Equipment, a Tea House, and Marguerite Bourgeoys' School

In telling the story of major projects like the Mid-Canada Line, one tends to concentrate and enlarge on the visible, active construction in the field. The story is fluid, sometimes spectacular, and the elements of the struggle with Nature in a rugged climate, with the associated problems of people, places and things, present an ever-changing picture to the interested reader. Without discounting the problems, successes and failures of the field activity, it must be remembered that the whole purpose of the exercise, the raison d'etre for all the construction, was to house the detection and communications equipment which together formed this early warning line, and to accommodate the people required to man it.

The spacing of doppler detection stations, the height and rigidity of the towers, the scope of doppler coverage, of communications laterally and rearward, of signal interpretation and screening at Section Control Stations – all [of] these were part of the overall operational and technical requirements of the system, as established by the Systems Engineering Group of the Air Force, and by the transmission and equipment engineering groups of the Management Contractor.

The detailed design of the Line did not spring full grown from the office of the S.E.G. or the Management Contractor. The overall concept was new, [and] the basic operational requirements took a while to establish. The designers were feeling their way as to the capabilities of the doppler equipment, and many details as to transmission and equipment limitations had to be probed, bearing in mind the essential point of using existing designed equipment as much as possible in order to meet a very tight schedule. Despite this last point, it was found necessary to employ some equipment of new design, and to use existing designed equipment in new ways.

The electronics people of S.E.G., D.R.B., and the Management Contractor worked closely to establish the necessary parameters for all the various systems and components. An experimental line from Montreal to Ormstown was used to work out the problems of Mark II versus Mark I doppler; and the four station test line up the valley from Ottawa was utilized to test out both equipment and, to a degree, construction concepts.

With the parameters of the various parts of the system established, the equipment engineers proceeded to write requirements specifications. Some 520 of these very detailed specifications were written through 1955 and early 1956. When each specification was completed, it was sent to the Department of Defence Production for procurement action, with the required delivery date and suggested sources of supply. D.D.P. called for tenders in some cases, [and] in others negotiated a contract (e.g. with R.C.A. for the doppler equipment) and named the M.C. as the follow up agent.

The basic doppler equipment was the Mark I AN/FPS-503 system developed and manufactured by R.C.A. The microwave system was a Marconi product, operating in the 2000 Megahertz range, and coded DQ 38. It was really an adaptation of the Marconi system used for the R.C.A.F. ADCOM network. Beyond these two main equipments, there were scores of other items, from surveillance radar systems to consoles and display screens for S.C.S. operations rooms, to telegraph systems, HF, VHF, and UHF radio equipment, navigation beacons, test boards, etc. All told 15 major and about 70 smaller firms supplied equipment for the Line. Engineering of the total system so that all of the component parts from so many suppliers would work together was the task of the transmission and equipment engineers. That the system did get put together and work smoothly is a tribute to the skill of the people involved.

Specifying and ordering equipment was concentrated in 1955, as early in the year as possible to alow time for manufacture, packing, and transportation to the Line. Some items lagged and were identified and ordered later. At a meeting of the Mid-Canada Executive Committee on January 12, 1956, it was laid down that specifications and requirements for all remaining major electronic items must be available to D.D.P. for procurement action by the end of February 1956.

The possibility of delay in equipment delivery beyond the point where installation could be completed by the target date was very real. For example, the R.C.A. doppler equipment was of new design and was bound to encounter difficulties in the early stages of manufacture, likewise the other items of new design. Moreover, the schedule we had to meet was a tight one, even for standard equipment of existing design. Consequently continuous close liaison between our equipment engineers, D.D.P., and the manufacturers was absolutely essential.

The follow up and expediting action lasted through to the delivery of all items on site, plus expediting of minor deficiencies during the installation period. Sources of equipment were far flung, from Manchester, England and Germany to California, and all points in between. Equipment had to be shipped to marshalling areas (usually funnelled through Montreal), had to be export packed, and its transport to the Line synchronized with sea and air lift of construction material and other supplies. A complete record of all shipments of the 180,000 different components was kept at headquarters in Montreal, and checked against their arrival on site. There were trouble spots. The blitz put on early to get diesel units airlifted from the United Kingdom has already been described. In another case equipment had been shipped from the British factory but was held up on the London docks because of a dockers' strike. One of our expediters, by what means I never found out, pried the equipment out of the massive congestion on the docks and got it shipped over to us.

The eventual result of these efforts was that on April 3, 1956 the first installation crews in the field at the western end of the Line were pleased to find that all the necessary electronic equipment had arrived and was ready for installation. Six installation contractors had been chosen, and the Line divided between them. Installation work at each doppler site took a team of 12 men between two and three months. Somewhat larger teams were assigned to the S.C.S.'s to cope with the greater quantity and variety of gear at those main points. All told some 40 teams were needed to complete the installation, representing a total of about 500 men plus supervisors.

Two Management Contractor's men were assigned to each doppler site, and several more at each S.C.S., during the installation. These were the toll test board specialists; there to make verification tests on each piece of equipment as it was installed, then acceptance tests of sub-assemblies, sub-systems, and complete systems for the site, the section, and finally the complete Line. Provision and training of these test board men was a major undertaking of the Management Contractor.

Early in our planning the need for a large group of test board men was identified. At the time there were not more than one thousand trained toll test board men in Canada, capable of making the many equipment and systems tests necessary to bring a complicated network like the Mid-Canada Line into operation. The fact that the Mid-Canada project coincided very closely with the Distant Early Warning Line and with extensive commercial installations made careful planning of this phase of the job all the more imperative. As with construction and tower erection, installation of equipment had to go ahead across the Line within a very short period, requiring that people be working at many points at the same time. In the aggregate it was estimated that about 250 to 300 test board personnel would be required for the project. Since the 1000 trained people were fully occupied on existing and planned commercial projects, this meant an increase of 25 to 30 percent in the number of such skilled people, obviously necessitating an extensive training program.

In the year 1653 Marguerite Bourgeoys journeyed from her home in France to the new settlement of Montreal to found a girls' school, working alongside Jeanne Mance who had started a hospital. The patients were housed in a two room building, originally a stable, near the fort, and the attic was the school room. To quote Thomas Costain in *The White and the Gold*: "The house had been made of green wood, and cracks in the walls had opened through which the winter winds whistled and the snow drifted…. The pupils sat in huddled misery at the raised planks which served as desks, their hinds numb, their noses blue. They were not acquiring education easily, these unhappy children."[1]

Much more comfortable conditions prevailed at the Mid-Canada school which opened on the same spot three centuries later, in July 1955. The Salada Tea building had occupied the site for many years. Once the pride and joy of P.C. Larkin, President of the Salada company, with tea served to all visitors in the tenth-floor lounge from where a good view of the harbour was to be had, the building was now rented out to tenants, Salada having moved uptown. So through the door beside the statue and plaque commemorating Marguerite Bourgeoys, the new group of grown up pupils went in to a world of modern electronics.

Bill Bell directed the whole operation, ably assisted by Doug Pepper and Don McDonald as to course content, and by Andy Neilson in securing and screening candidates – screening both as to technical background and security, for this was a classified project. The call for candidates had gone out to all parts of the Bell company and all of its partners in the Trans Canada Telephone System. Young physically fit men were needed, with high school education, and in general started on a career in the Plant Department of the Telephone companies. Candidates were screened with tests in basic mathematics, electricity and magnetism, before acceptance for the school. After acceptance each student was given an electronic quiz as a basis for starting him in a class with men of the same general knowledge and experience. As the course proceeded a series of weekly and bi-weekly tests were given to ensure that students were really advancing, and thus to screen out those who obviously were not going to make it.

This was intensive training, and no place for those who could not measure up. The course was in two semesters, each of three months' duration. Instructors for the basic course were experienced Plant men from Bell, with a mixture of engineers and Plant people for the advanced course in the second semester. Instruction was a combination of theory and practice, with heavy emphasis on hands on training. Instructional tools such as modular electronic circuit boards which can be put together like building blocks were used, and working samples of every type of equipment or circuit, measuring instrument, diesel, alternator, radio transceiver, etc. to be used on the Line were there, were taken apart, put together, and worked on until students were seeing them in their sleep.

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[1] *Editors' note:* Thomas B. Costain, *The White and the Gold: The French Regime in Canada* (New York: Doubleday, 1954).

Sister Marguerite Bourgeoys teaching Indian [First Nations] girls the French language [that] the white people had brought with them across "the shining sea water" could scarcely have sounded stranger to the [Indigenous students] than did the language of the 1956 instructors to the uninitiated. "What determines the frequency of a multi-vibrator? Draw a circuit of a half-wave diode detector showing input and output connections. Explain what is meant by the term 'heterodyning' and illustrate using figures."

By this time it was clear that maintenance of the Line, at least initially, was going to be the responsibility of a civilian contractor, quite possibly Trans Canada Telephone. This made it all the more important that we have thoroughly trained people, not only to do line up and tests to make sure the whole system worked initially, but also capable of doing ongoing maintenance. Not all the candidates were successful, but the failure rate was low, considering the crash nature of the course, and the high degree of concentration in time and effort required to master the various subjects. Those who fell by the wayside returned to their normal jobs in the Telephone Company with at least some added knowledge to help in their careers.

The first course started in July 1955, and over the next year some 300 men graduated from the school, having taken both the basic and advanced courses. Twenty percent of the graduates came from companies of the Trans Canada System other than Bell, and eighty percent from the five Areas of the Bell Company. It was essential that a cadre of Air Force personnel receive the same instruction. Trades training in telecommunications was normally given to R.C.A.F. personnel at Clinton [Ontario]. To cope with the Mid-Canada requirement, R.C.A.F. instructors took the advanced course at Montreal, thus equipping themselves to give a similar course at Clinton.

And so it was that when the installation contractors arrived in the field in the spring of 1956, graduates of Marguerite Bourgeoys' modern school were there with them. Working in parallel with the contractors they made sure installation plans and specifications were followed, [and] tested components, sub-assemblies and systems, preparatory to section by section line-up and test as the whole network approached completion. I think Sister Marguerite would have approved.

CHAPTER 19

THE SUMMER OF 1956

This was the watershed, the moment of truth. We had to complete field construction, or at least be far enough advanced to permit equipment installation, if an operational date anywhere close to January 1, 1957 was to be realized. We were sure we would meet the schedule, perhaps beat it, in the west; and we were fairly confident as to the eastern end of the Line. The Bay area was the key to overall completion, particularly Winisk and the other western shore sites.

The winter of 1955-56 had come in slowly, witness the late start of the Moosonee tractor train operation, and the slow build-up of ice landing strips on the lakes. Then in the spring, Old Man Winter refused to loosen his grip. The ice break-up on the lakes was later than usual, delaying efforts to get float planes into operation. In fact it was early July before some of the lakes were clear of ice. Hudson Bay wasn't completely ice free until August 15th.

We had hoped to beat the gun through the Straits to get ahead with the all important sea lift into the Bay, so we sent three 500-ton sealers up to the straits three weeks ahead of the normal July 25th opening. With their round, reinforced hull, these little ships were rugged enough to combat occasional ice floes. But no deal. The three ships were stuck in ice in the straits for exactly three weeks before getting through to the Bay.

The efforts of the Department of Transport had produced a formidable flotilla of landing craft of various types and sizes. As mentioned earlier, two 600-ton L.C.T. 8's (Landing Craft Tank) had been acquired in the United Kingdom and towed across the Atlantic. The original idea proposed by one of my Air Force friends was that they could be loaded from ships standing out 8 to 10 miles to sea, as was necessary for any but very shallow draft vessels, then be driven on to the Winisk river beach at high tide, left there while the tide receded, then unloaded directly to trucks through the opened bow doors, using the L.C.T. derrick. However, a further look led to the conclusion that the L.C.T.'s could not be beached with a full load and left stranded during low tide without serious hull damage, which might well have rendered them completely unserviceable. The bow doors were therefore welded shut at a St. Lawrence River shipyard before the vessels went into the Bay, so they were used, and useful, in the sea lift operation as small, shallow draft ships, capable of getting closer in to shore in the shallow waters of the Bay.

Part of the lightering gear was already in the Bay, or came to hand before the Straits opened. The 14 L.C.M.'s had been brought up from Newport News, and the self-propelled and "dumb" barges which had been used during the 1955 season were available. Some large barges, up to 500 tons capacity, were towed into the Bay by the ice-breakers *N.B. McLean*, *d'Iberville*, and *Sorel* early in the shipping season. The *N.B. McLean*, which every year patrolled the Strait and Hudson Bay during the navigation season, left Quebec for the north on June 26th and did not return to her home port until five months later, on November 26th. To maximize sea lift capability for both the Mid-Canada and the D.E.W. Lines, navigation in the Bay was extended nearly six weeks beyond the normal closing date of October 15th, when insurance coverage ceased on the commercial route to Churchill. With the *N.B. McLean* to meet ice obstructions, all of the ships chartered for the Mid-Canada project cleared the Straits except two, the *Steve Aherne* and the *Eskimo*, which for different reasons stayed in the Bay during the winter of 1956-57.

During the shipping season, some 49 commercial freighters and tankers operated in and out of the Hudson Bay area, serving the Mid-Canada and D.E.W. line activities. Grain shipments out of Churchill reached a record of 48 ships that year; so a total of close to 150 ships and smaller craft operated in these waters at the peak of the season.

The following record of ship movements for Mid-Canada purposes during the first three weeks of September is interesting:-

Ship		
Irvingwood	Off loaded at Great Whale Sept.1-8.	Returned to Montreal.
Eastide	Off loaded at various Bay sites Sept.1-11.	Returned to Montreal.
Woodcock	Off loaded at Winisk Sept.1-8.	Returned to Montreal.
Wellandoc	Off loaded at various Bay sites Sept. 2-11.	
Signous	Off loaded at Great Whale Sept. 4-11.	
Soyalovia	Loaded at Halifax Sept. 8-9.	Sailed for Bay sites.
Firth Fisher	Loaded at Montreal Sept. 5-7.	
	Off loaded at Winisk Sept. 17-20.	Returned to Montreal.
Teal	Loaded at Montreal Sept. 5-8.	
	Off loaded at Great Whale Sept.16-20.	Returned to Montreal.

Sheldrake	Loaded at Montreal Sept. 8-14.	Sailed for Winisk.
Sandland	Loaded at Montreal Sept. 9-15.	Sailed for Great Whale.
Wacondah	Loaded at Montreal Sept.17-21.	Sailed for Great Whale.

It was a steady stream. All of these ships plus others which made the trip earlier than September 1st and on into the fall, were chartered by the Management Contractor, using ships' brokers to secure available and suitable bottoms.

In total 41,000 tons of material and equipment for the Mid-Canada job were shipped into the Bay during the season. It was not done without mishap. Rough weather delayed off loading operations many times, particularly at Winisk, resulting in lost time for the ships (hence higher demurrage charges), for the stevedoring crews, and for the construction forces. Perhaps the worst case as far as the ocean going vessels themselves were concerned was that of the *Steve Aherne*. Blown on the rocks off Belcher Island during a storm, the ship had to jettison much of its cargo, then was towed to Great Whale River. In the towing process a tug pilot was drowned. From Great Whale the ship, supported on barrels, was towed to Churchill. Made more seaworthy at Churchill, she sailed for the Straits, only to meet ice there. She finally got through and back to Montreal. Later in the season the *Steve Aherne* again made it into the Bay and wintered there.

The biggest off loading problem continued to be at Winisk, with its shallow shore waters and sand bars. This season, however, at the suggestion of the Air Force construction engineers, caissons were sunk a mile and a half off shore, and a turning basin formed by dredging the tidal flats at low tide, using the material to fill the caissons and build a protective causeway back to shore. This work was completed in September, and resulted in a far better off loading situation, speeding up the whole process. There was nothing we could do about the ships having to stand off 8 to 10 miles at sea. The water was too shallow for a closer approach by ocean going craft, so that was that. One rather interesting situation to do with the long causeway was the expansion and contraction of the oil pipe line in summer weather. The oil barges unloaded by pumping into the oil pipe line at the sea end of the cause-way, the pipes running from there to the storage tanks about two miles away on shore. At the peak of summer, temperatures could vary from 90°F at noon to 0°F at midnight. This wide swing resulted in a variation of approximately six feet in the length of the pipe.

One important factor in the 1956 sea lift which had not been present in 1955 was the shipment of electronic equipment into Bay sites for installation during the fall. To ensure that this equipment arrived in workable condition, we arranged for export packing by a competent contractor. There was some criticism of this later on from the standpoint of cost, but there is no question but that ship transport through rough northern seas and ice floes, followed by open water lightering ashore would have resulted in complete destruction of equipment which had not been properly packed – i.e. with waterproof covering and rugged protective boxes and framing. It was expensive, but short of shipping all such equipment by air – which would have necessitated at least some protective packing and would have been still more expensive overall – there would have been no Mid-Canada Line in the Hudson Bay region if export packing had not been used to the greatest possible extent. Moreover, once material reached its destination, it frequently had to stand outdoors for some time in northern weather. Without protective packing, it would have been ruined.

As tank farms became available at Great Whale and Winisk, oil supplies were brought in by tanker in place of in barrels. The first 9000-ton tanker came into the Bay late in the summer. Oil was pumped from tanker to oil barges, brought to shore, then pumped into the storage tanks. At the existing price of 14 cents per gallon for fuel oil, we estimated we could bring oil from Venezuela to serve the Line in the Bay area and up to half way west to Dawson Creek before the economics would dictate Alberta oil. In practice, however, the Alberta product was used in the western sections, with the two control sections fronting on the Bay served by tanker, generally from Venezuela. In 1957, additional storage tanks were built at Churchill as back-up for the Mid-Canada requirement.

By the end of the shipping season materials were on hand to complete construction except at Winisk and a few contiguous sites. Late shipments into Winisk and nearby sites were going in through Moosonee. To assist in this, Bell people requested the captain of the *Eskimo* to keep his ship operating in the Bay beyond the time when he would normally have headed for the Straits and the open sea. The Captain was quite happy to oblige, but unfortunately stayed too long and had to winter in the Bay, off the shore of Moosonee. The crew was paid off; only the Captain remained, and he spent a considerable amount of his time ashore. One spring day, the Captain being ashore, the ice started to shift. It breached the hull of the *Eskimo* and she sank to the bottom. There was great consternation, of course, with accusing fingers pointing, and so on. The ship was later raised but there was considerable damage done. Some of the blame for the incident was undoubtedly ours by our asking or encouraging the Captain (I was never sure which) to stay in the Bay beyond what proved to be the point of no return. There was also, however, some negligence on the part of the owner and Captain. At any rate the case was settled out of court, with the Mid-Canada project paying part of the damages.

No very serious construction problems had arisen over the rest of the Line during the summer season. Tower erection was well along in the west. Across the whole Line approximately 140 doppler and microwave towers were involved, plus something over 100 light weight towers and masts for navigation beacons, air-ground-air, and emergency radio communications. The doppler-microwave towers were of open steel construction, four feet in cross section, with interior ladders and platforms for climbing, and from 50 to 350 feet in height depending on the propagation conditions at the particular site. Guyed rather than self-supporting towers had been decided upon for reasons of weight, erection time, and cost. However, guying had to be very precise so as to minimize sway at the top of the tower. This necessitated guys from several points on the tower, particularly the higher ones, also the use of pre-stressed heavy steel guy strand, and extremely solid foundations.

The foundations had been well and truly laid by the construction contractors, following detailed plans of our engineers and consultants. Tower steel fabricated by Central Bridge Co. of Windsor, Ontario was on site, having arrived there by all the different transportation media which have been described. Six contractors experienced in steel erection were selected to erect the towers, and two others to place the doppler and microwave antennae. Each contractor was assigned a section of the Line, and work got under way. Actual erection of the towers using experienced men did not result in any major problems. We did, however, have trouble afterwards in maintaining the guys at the proper tension, due to the effect of variable weather on expansion and contraction of the steel. Through the operational phase this necessitated sending men across the line several times to adjust guy wire tension.

In the western section of the Line construction work was nearly complete by the end of the summer, and installation of equipment was well advanced, having started in April and proceeded from west to east. In the east construction was in full spate at the dopplers and at Knob Lake; behind the west, but coming on fast. Speaking of both western and eastern sections, I was able to say to a group of newsmen at Knob Lake at the end of August: “Generally speaking, construction of these sites has reached a stage where initial operation of the Line could be accommodated. Clean up of additional buildings and services is continuing.”

At Great Whale and Winisk the sea lift of major supplies continued to be supplemented by airlift of emergency items, and of course of personnel. Flight control and delivery service was provided at Great Whale by a small R.C.A.F. detachment; at Winisk, Management Contractor personnel performed this function, certainly a far cry from construction and maintenance of telephone plant.

The Press tour referred to extended from August 27th to September 1st, and was organized by the R.C.A.F. under the direction of Group Captain Poole. The party included 19 reporters, mainly from eastern Canadian papers, but including three men from the United States and two from the United Kingdom. They visited Knob

Lake, Great Whale, Winisk and Cranberry Portage, plus a number of doppler sites near these main stations. At Cranberry Portage reporters from The Pas and Flin Flon joined them for the day. The group was briefed by the four zone engineers as well as Group Captain Poole and myself. Of course, they also talked to many other people on the various sites and along the way.

Everything went smoothly, but we narrowly escaped an accident in the west. Six of us were being flown from Cranberry Portage to one of the dopplers in a Norseman float plane. One of the newsmen had never been in a small aircraft before, so his buddies were pulling his leg about the hazards of bush flying. Suddenly there was a splash of oil across the windshield; the oil line had broken, and a pool of oil slowly spread across the cabin floor. Our inexperienced friend was turning a light shade of green, and the rest of us were anything but comfortable. Fortunately we were over a lake, about a thousand feet up. I've never experienced as rapid a drop in a plane in my life. If we had been over land, the plane and its occupants could have been a write-off; but we reached the lake safely, before the engine seized, thanks to our pilot, one of the Lamb brothers. Transferred to another Norseman, we continued the trip.

The Lamb brothers: there were six of them, five flyers, sons of Tom Lamb, a pioneer bush pilot in Northern Manitoba. The father had had a heart attack, but the sons were operating the business out of The Pas. Tom Lamb started bush flying back in 1925 with an old Vickers Vedette. By 1956 the family owned three big Norsemen aircraft and five Cessna 180's, all on floats. "Five brothers flying," said Gregg, one of the boys. "There's Douglas, Dennie, Donald, Jackie and myself. There's still one more, Connie, but he's going to school out in Tacoma. We had to send him away from here until he gets his Grade 12. If he stayed here the first thing you'd know he'd be flying with the rest of us. Somebody's got to get an education."

Reaction of the reporters to the project was interesting, as expressed in articles written for their papers in the weeks that followed. Transportation problems obviously had impressed them also some of the human factors involved in the operation. Here are a few very brief extracts:

William Casagrande in the *Montreal Star*:

> *Quoting Group Captain Poole:* The Line is steadily dispelling many of the unknown or little known factors which made the sub-arctic forbidding to all but hardy pioneering spirits.
>
> *Speaking of navigation:* The dean of the civilians flying at this base (Knob Lake) Edmund Richards of Winnipeg, said "Lakes and rivers are good enough. Even in winter they're easy to see." A fog can cover a field in 15 minutes in the Quebec-Labrador region. Both

amphibious planes and helicopters have been stranded at remote sites in this un-predictable area.

On the Eskimo: Father Charles de Haugeneuf has started a Roman Catholic community at the base (Great Whale) since it sprang up two years ago.

Father Charlie as he is popularly known is now working on an English-French-Eskimo [Inuktitut] dictionary to promote better understanding. Asked how the white workers feel about the Eskimos [Inuit], he said that "it's pretty hard not to like a guy who smiles at you the way they do, even if you can't speak with them."

Since the early warning line assembly area was built, a common ball field was cleared between the two communities (Schefferville and Knob Lake S.C.S.) and a six team softball league launched. The Bell Telephone employees won the championship this year.

Arch Mackenzie, [Canadian Press] Staff writer:

The impression left by the country from Labrador to northern Manitoba in the vicinity of the 55th parallel is that this sub-arctic region will yield its riches reluctantly. Some of it just doesn't seem worth the effort.

There are Canadians from Newfoundland, Quebec and Alberta (at Great Whale). There are Australians, Britons, Germans, and French. Some fly, some dig, some erect steel towers or assemble delicate electronic panels. Some cook and some are clerks.

Ernett Henderson of Longueuil, Quebec, just outside Montreal, has been atop a small hill on the east coast of Hudson Bay for seven months in charge of a seven man construction crew. The last snow went August 4th. Their food comes in by helicopter. Their snow white tents contrast with the yellow-green muskeg dotting the granite hilltop.

Fishing often lies at the doorstep. Lake trout of eighteen pounds or more can be had by shore casting. A few miles from Knob Lake, two men caught 200 speckled trout in a few hours.

There are caribou, polar bears and black bears depending on the locale. "A black bear won't hurt you, but he may knock you over if you get in his way," says a construction man. "He's frightened too."

Lloyd Lockhart in the *Toronto Star*:

> The average intermediate station (doppler) can hardly be spotted from the air. The plane circles, dipping over a lake surrounded by rock. There it is – one oblong building painted green, with a tower adjacent. To the side is a smaller building – a survival nut in case of fire. There's a fence to ward off thieving bears. Beyond the fence – nothing. "What would happen if the Russians bombed this station?" asked one reporter. "How could they find it?" was the reply.
>
> The climate up here wouldn't charm the average housewife, and the terrain, by and large, is uninspiring. Mining, yes, tourists, no. It will be a long time before Great Whale River has a chamber of commerce.

Kingsley Brown in the *Ottawa Citizen*:

> By night and day, in fog, snow or fine weather, around the clock and around the seasons, these Canadian pilots are working the throttles of their big transports, flying boats and helicopters, droning over the trackless tundra with sometimes only the sun and the stars to guide them, with holds filled with steel girders, eggs, gravel, cabbages arid beef, fresh milk, kegs of nails and sewer pipe, slipping nimbly between the swirling ice-filled fogs and the harsh, unfriendly mountain tops.
>
> Bill Martin of Knob Lake reduced it to stark reality by re-marking: "It isn't the clouds the boys mind, it's the hard centres."

Chapter 20

Planning for Maintenance

In November of 1953 the Defence Committee of the Canadian Cabinet made the decision to undertake the construction and operation of the Mid-Canada Line. In August 1954 tne broad plan of the R.C.A.F. Systems Engineering Group as to design and implementation was submitted to and approved by both the Canadian and United States Governments. The detailed planning and construction phase proceeded from there and, as we have seen, was approaching completion by late 1956. Obviously arrangements for manning the Line, both in terms of military operations and technical maintenance had to be complete by the time the Line was ready for service.

The operational requirements were established by the R.C.A.F. early in 1955, and planning for the operational and maintenance phase continued through 1955 and into 1956. The Air Force decided at an early stage that while they must be in overall control and carry out their operational role, it should be possible to have maintenance and logistic support of the Line provided by a civilian contractor, assuming satisfactory arrangements for such a joint venture could be made. This was considered for a number of reasons, but principally because of the number of people and wide variety of skills required to maintain this very intricate system. Well over a thousand maintenance and logistics personnel would be required initially, tapering to perhaps 800 later when the doppler stations could be left unattended except for routine visits. Technical skills required ranged from highly specialized electronics work to diesel mechanics, high riggers and cooks, and would require extensive training facilities and training staff. Under R.C.A.F. manpower ceilings, and with important Air Force operational commitments elsewhere, civilian maintenance of the Mid-Canada Line was a logical choice. The same approach was taken by the United States Air Force in manning Pole Vault (after full military manning for a short period) and for the Distant Early Warning Line.

In October 1955, the R.C.A.F. asked us to submit for their consideration the broad outline of a plan for civilian maintenance of the Line. Accordingly on November 9th we wrote to S.E.G. covering our thoughts on such a plan. It was our understanding that the Air Force would retain responsibility for operational interpretation of identification data received within the Line, and would cover this by a small group at each Section Control Station. These R.C.A.F. people would carry no responsibility for the technical maintenance or other support features of the Line. The civilian contractor would be expected to be in full charge of maintenance with respect to equipment, buildings, towers, grounds, etc., also for resupply, provision of maintenance materials, transport and logistic support generally, and for the complete administration of the sites including feeding, housekeeping, etc.

We indicated that should the Federal Government so desire, the Bell Telephone Company, in association with the other six companies of the Trans Canada Telephone System, would be willing to undertake the manning (i.e. the civilian work as outlined above) of the Mid-Canada Line as Prime Contractor. Recognizing the problems we were having with an ambivalent control situation in the construction phase of the job, we said: "our desire would be that the contract be arranged in such a way as to clearly indicate the responsibility and authority of the Trans Canada Telephone System for the work, should they be chosen as the Prime Contractor."

An outline was given of our organizational concepts, both as to the basic unit – i.e. staff for a Section Control Station and contiguous dopplers – and the necessary headquarters and rear echelon support structure: "In the initial stages of changeover from the construction to the operational phase, during which this organization would be forming, we would consider it wise to retain the new department within the framework of the Special Contract Department. However with the termination of the construction work we would expect that the new Special Maintenance Department (later known as M.C.L. Plant Department) would probably find its logical place within the Bell Telephone Toll Area."

On November 22nd, in response to a further request of the R.C.A.F., we provided a very approximate view of the annual cost of our suggested plan. The figure given, excluding helicopter operations, was $10,400,000, of which roughly half would be the maintenance contractor's labour, overhead and fee; the remainder to cover travelling, board, lodging, camp management, materials and transport other than helicopters.

Discussion and planning continued chiefly within the Air Force for some months following this preliminary expression of views. It was not until about March 1956 that we started to get into detailed negotiations. In April J.V. (Vern) Leworthy joined Special Contract as Area Plant Manager, to head up the maintenance organization which it was becoming clear we were going to be asked to provide. Shortly thereafter, Vern selected Hugh Dawe to be his Area Plant Supervisor, in charge of all staff work associated with electronic and telecommunications maintenance, and Basil Hutchison to be Area Buildings and Logistics Supervisor, in charge of support services (as the title implies). This trio of thoroughly competent people, highly trained in both technology and administration, were essentially responsible for the outstanding job done in preparation for the maintenance phase, and in providing maintenance and logistic support for six of the seven sections of the Line during the first two years of its operation. The Government people were impressed with the "new team" as they called them.

On May 16th the Deputy Minister of Defence Production advised that "it is our intention to commence negotiations with the Bell Telephone Company just as soon as we have a definite requirement for the maintenance and operation of the Mid-Canada Line from the Department of National Defence." Through May and June the R.C.A.F. and D.D.P. evolved a plan outlining the scope and responsibilities of the various Government agencies and the civilian contractor, the idea being that Bell would be asked to make a proposal based on that plan. On June 20th, at a meeting in Ottawa Bell representatives were handed the R.C.A.F.-D.D.P. suggested outline, and asked to make a proposal based on that general approach.

On July 31st we submitted our proposal on behalf of Bell and as agent for the Trans Canada Telephone System. The proposal was comprehensive, and followed the R.C.A.F.-D.D.P. plan as closely as possible. There were, however, a number of areas in which we proposed a different approach.

Discussions followed through the next month or so, culminating in a full dress review of our proposal on September 5th. Agreement was reached on a number of items, with further negotiations required on others. Our letter of September 14th covered our understanding regarding these. The following quotes from that letter set out our position at that time. The first problem was the old one of responsibility versus authority. The R.C.A.F. approach, while giving responsibility for maintenance to the civilian contractor, was that the officer comanding the S.C.S. would have final authority in any case of dispute or personnel conflict, and that the contractor's representative on site would follow his directive. "The contractor must assume the burden of the fault as a matter of providing service while the merits of the case are being investigated."

This we could not accept, and we said so:

> It is an axiomatic principle of organization that anyone assigned responsibility must be given adequate authority to discharge the responsibilities laid on him. Our approach has been, therefore, to make sure that there be a clear understanding on both sides of the responsibilities involved, and also to ensure that the civilian contractor is given the necessary authority to discharge the responsibilities laid down.
>
> We understand it to be the wish of the Government that the civilian contractor be fully responsible to the A.O.C. Air Defence Command for maintenance and logistic support of the Line to the end that the R.C.A.F. personnel who are responsible for the operation of the Line may be able to discharge their function satisfactorily. If our understanding is correct, then the civilian contractor must be given adequate authority and control of procurement, maintenance procedures, and his personnel to carry out that responsibility.

There were a number of points regarding subcontracts:

> We feel it is essential that those services on the Line which for reasons of special skills and overall efficiency are to be subcontracted, should be handled as our direct subcontracts. Subcontracted work would simply be a substitute for providing our own people to carry out our responsibilities, and we must therefore have direct control.
>
> We feel that in the maintenance phase of the job it would not be too difficult to accommodate ourselves to D.O.T. control of this annual resupply (sea lift) since the degree of urgency to meet specific target dates, which has been present in the construction phase, will not be a factor. We understand that D.O.T. responsibility will also include loading and unloading the ships, i.e. we would present the goods to them at the loading port and would receive the goods from them at dock-side in the Bay.
>
> Our position is that aircraft operation, both helicopter and fixed wing are absolutely vital to the fulfilment of our responsibilities as maintenance contractor. The basic concept of transport to doppler sites is by helicopter, and D.D.S. maintenance is entirely dependent on immediate availability of aircraft to lift personnel and maintenance material from S.C.S. to doppler sites. Direct control of the people operating these aircraft is therefore essential, and we could not accept the maintenance responsibility for the Line without having the authority to directly subcontract for such aircraft operation.

On R.C.A.F.-Contractor relationships:

> The contractor has the responsibility of maintaining the Line as close to 100% efficiency as possible. This means that he will stand ready and willing to provide service to the satisfaction of the R.C.A.F. and will endeavour to meet this maximum efficiency. He would be subject to direction of R.C.A.F. policy questions by the A.O.C. Air Defence Command, who has overall responsibility for the Line, but he must be able to exercise full authority over his own staff in the direction of the job which he contracts to do. Thus any direction to the contractor governing his technical function must come from the A.O.C. or his senior people at Air Defence Command to the Plant Manager, and would flow from him directly to our field forces.
>
> We definitely would not be agreeable to direction on technical matters being given through the military chain of command to the

> Section Commanding Officer and from him to the contractor's on site personnel.
>
> This means that all direction to civilian personnel on site must come from their own supervisors.

We had made our position clear, and this necessitated still further discussion. A meeting between Mr. Golden, Deputy Minister of Defence Production, Mr. Rolph, Executive Vice President of Bell, and myself was followed by correspondence between Messrs. Golden and Eadie. This culminated in agreement as of November 2nd that Bell, acting for Trans Canada, would take on maintenance of six of the seven sections of the Line, with Canadian Marconi Co. maintaining one section – i.e. the eastern section centering on Knob Lake and extending eastward to Hopedale. There was some further dotting of i's and crossing of t's during the ensuing weeks, but the basic arrangements, pretty much as in our proposal with the specific points outlined above, were settled.

The M.C.L. Plant Department had been building up staff to meet their future obligations. The headquarters group had four main tasks to accomplish initially:

(1) Obtain personnel for the different jobs. This involved borrowing telecommunications people from Bell and other members of Trans Canada, also recruiting from various other sources the men needed to man the many other trades required in the operation. Many of the installation technicians had agreed to stay on the Line for a period, but it was essential to establish a steady flow of trained people so that there would be no disruption of service due to a bulk turnover.

(2) To accomplish this flow of personnel, M.C.L. Plant took over the Montreal (Marguerite Bourgeoys) school in September 1956, then shortened and rearranged the training course to one of three months for maintenance personnel.

(3) The contract with the R.C.A.F. specified that complete practices and procedures for all equipments on the Line should be prepared by the civilian contractor. This was a major undertaking, but was tackled with a will, so that by the second year of Bell's contract a full set of practices was available. These were also made available to the Marconi Company.

(4) Development of adequate accounting procedures to provide satisfactory cost control and bases for forecasting. This involved extensive review with D.D.P. and the Cost Inspection and Audit Division in Ottawa.

I am not going to pursue the maintenance story here. It is another interesting story. Adequate staff was recruited, trained as necessary, and made available in the field to take over from our construction and installation forces starting in the fall of

1956 in the west, and extending through the first half of 1957, as the Line gradually came to operational readiness. A considerable amount of clean-up work was left for them to do, and they did it to everyone's satisfaction.

Chapter 21

Costs and Criticism

The Mid-Canada Line was an expensive project. It cost $230 million. In addition to essential, and elaborate, electronic systems, it included:

(a) erection of 264 buildings, from aircraft hangars to radio transmitter units, representing a total of 16 million cubic feet of building space, and spread through 7 major, 5 intermediate size (Scatter) and 90 smaller sites, a total of 102 locations across 2800 miles of Canada's sub-arctic territory.

(b) approximately 250 detection and telecommunication towers, including 16 large tropospheric scatter dishes and about 140 heavy steel towers of 50 to 350 feet in height.

(c) three permanent full size air strips and eight temporary strips.

(d) transportation of over 200,000 tons of material to and along the 55^{th} parallel of latitude by common carrier, sea lift, fixed wing air-craft, helicopter, tractor train, barge, boat, and canoe.

It was a high cost project for two basic reasons:

(1) It was in a remote part of the country, thus requiring heavy expenditure for transportation and accommodation, and to cope with the severe climate.

(2) It was required in a hurry, necessitating parallel action at 102 sites along the 2800 mile system.

The first estimate of total cost, made by the R.C.A.F. Systems Engineering Group, and approved by the Government in August 1954, was $102 million.

This estimate of necessity was based on very limited information. The broad concept of the system had been tentatively established, and an educated guess could be made of equipment costs. However, site, building and tower plans were non-existent, and there was no experience to go on as to transportation costs.

Bell's first estimate of costs was submitted in May 1955 just after being appointed Management Contractor. By that time we had a few more hooks to hang the estimate on. The broad, but by no means complete outline of what would be required at the Section Control and Doppler stations was taking shape, though there were few specific building plans as yet. The type and scope of the doppler detection and microwave systems were pretty well established. Transportation costs, however, were still largely an unknown quantity. Our estimate of total costs submitted May 1955 was $169 million.

Thereafter we issued quarterly reports on the status of the job to the Air Force, D.D.P., and others involved. This included an updating of the cost estimates. Our forecasts as of August and November 1955, as well as February and May 1956, retained the overall total of $169 million. Detailed building and site plans were evolving during this period, and included substantial additions, both as to number of buildings and their elaboration. However, we had found that we had overestimated equipment costs by about $12 million, and I hoped consciously or unconsciously that this would balance increased building and transportation costs. Estimates of the general contractors, particularly in the Hudson Bay area, were of little use, since it was only at the end of this period that they had anything like complete plans for their sites. Furthermore I think it is true to say that we in Bell were so preoccupied with getting on with the job to meet the target date, that estimating of costs was secondary in our thoughts.

For whatever reason, we stayed with the overall figure of $169 million too long. With our status report of August 1956 we increased the forecast to $179 million. All of the increase was in the construction category, but it was not enough. It did, however, alert the Air Force and D.D.P. that there could he a very substantial overrun of costs. The Executive Committee therefore directed that we make a complete review of costs. This was done, and a revised estimate submitted on October 10th of $206 million. A more detailed breakdown was then requested, resulting in a further revision, made partly with the assistance of the R.C.A.F., to a total of $203 million. Again the increase was predominently in construction costs, where it was proving very diffitult to get a firm view from the contractors due to material ordered but not delivered or billed, "stuck in the pipe costs" so to speak. Transportation was also proving to be much higher in cost than previously estimated.

The jump in estimated expenditure from $169 million to $203 million was very disturbing to the Air Force and to D.D.P. They were faced with the necessity of getting increased authorization from Treasury Board, having accepted our lower estimate for over a year. They felt that our close field contact with the general contractors should have enabled us to assess their costs and revise the estimates earlier; and they were consequently uncertain of the adequacy of the higher total new forecast. The increase was also bothersome to the political people. Mr. Howe, on being advised of the higher estimate, wrote to us on January 3rd. "It is a matter of great concern that the project be completed within the final figure of two hundred and three million dollars," he wrote. "I would request, therefore, that the utmost care be exercised in these closing phases in order to keep the expenditures to a minimum." The emphasis had obviously changed from doing everything possible to meet the target date to making sure that costs were kept within limits.

Cost estimates were kept under continuous review from October 1956 through to the end of the project. On February 13th we forwarded to D.D.P. a revised view of buildings and structures cost, estimated jointly by contractors of D.D.P., D.C.L., and Bell. A complete review of all costs ensued, was discussed on March 14th with representatives of D.D.P., D.C.L., and the R.C.A.F., and presented formally to the Air Force with our letter of March 20th, 1957. This was the final estimate, and totaled $230 million. The actual total did not materialize for some time, with late billing, etc., but it proved to be very close to this final estimate.

There was a lot of concern within the Air Force, D.D.P., and Treasury Board about this new, much higher figure. It was emphasized that the new total must not be exceeded. Inevitably we, as the Management Contractor, incurred considerable criticism for the higher costs. While accepting some of this criticism as justified, we tried to make clear the attendant circumstances. In a letter to Mr. Howe Mr. Eadie said:

> I think I should point out the the stress on this project from the first has been one of urgency as to time, and that this unquestionably contributed to higher costs. We were urged, for reasons of operational need, to do everything possible to meet the target date of January 1, 1957, a delay of even a few months being a matter of great concern. It was generally recognized, I think, that this approach would result in heavier costs than would be the case in a more normally spaced program. The expediting of material by air in place of by slower transportation media, together with low labour productivity due to delays in plans and in promised material deliveries, have been important factors. Also to meet this date it has oeen necessary to work through the extremely difficult annual freeze-up and break-up periods, when efficiency of operation drops markedly.
>
> There may well have been some inefficiencies in our own management of the project -a job of this size never gets done with complete efficiency. I can assure you, however, that in the selection of people to do the job, and in close and unstinting attention to all details of its management, we have done our best to bring the Mid-Canada Line into service on a solid base of engineering management, quality of workmanship, and, as far as possible, on time. As mentioned earlier, we are continuing our efforts with respect to cost control and sound management in the final phases of implementation.

To keep the record straight, I think it is important to set down the major differences batween the final cost estimates and the earlier figures, and to explain those differences.

Estimated Costs in Thousands of Dollars

	R.C.A.F. Est. Aug. 1954 (a)	Mgmt. Cont. Est. May 1955 (b)	Mgmt. Cont. Est. March 1957 (c)	Difference (b) to (c) Amt.	Pct.
	$	$	$	$	
Construction	20,233	62,395	108,060	45,665	73
Contingency	25,135				
Transportation	8,473	25,650	42,455	16,805	66
Signal and Wireless Equip.	42,865	47,075	35,302	(11,773)	(25)
Service Equip. and Furniture	---	4,606	2,885	(1,721)	(37)
Management Contractor, Consultants and Misc.	---	16,750	24,028	7,278	43
Total under Mgmt. Cont. Control	96,706	156,476	212,730	56,254	36
Helicopters, Lightering, and other items not under M.C. control	4,904	12,948	17,517	4,569	35
Total cost	101,610	169,424	230,247	60,823	36

Comparison should be with the first Management Contractor estimate of May 1955, and not with the earlier R.C.A.F. view which, as indicated, was based on extremely meagre information. Of the total increase of $61 million between the May 1955 and the March 1957 estimates, $62 million was in construction and transportation. Signals and wireless, i.e. all the electronics, was lower by $12 million, due to overestimating in the first place, and to good prices secured on a competitive basis, chiefly by D.D.P. The decrease of $1.7 million in Service Equipment and Furniture was due to an accounting decision to charge fuel oil and gasoline for the first year's operation of the Line to operations rather than capital.

Management Contractor's direct costs – i.e. salaries, overhead, travelling, and office expenses – represented $14.2 million of the $24 million shown; up $4.7 million, essentially due to increase in the scope of the job to be managed. These direct costs were 6.6% of total costs managed, compared to an original estimate of 6%, and well within commercial experience of engineering supervisory costs. The remaining $9.8 million of the $24 million total consisted of the management fee, unchanged at $1.75 million, miscellaneous items such as the training school and various small subcontracts (up $1 million), and consultants' fees up $1.6 million, again due to the increased size and complication of the whole job, and to the fact that available design data was minimal to start with.

Transportation is obviously a function of the amount of material and personnel transported. Both the May 1955 and March 1957 estimates show transportation at 40 percent of construction costs. Some $6 million of the $17 million increase occurred in the fall and winter of 1956-57. Longer and late fall voyages into Hudson Bay accounted for $1.4 million of this, and a winter air lift into Winisk and Great Whale to speed up construction there represented $2.7 million. Additional oil supplies, stevedoring, trucking, and rail transportation, all due to more material movement over a longer period, accounted for $2 million.

The key to the whole cost overrun was construction. The May 1955 estimate was predicated on a total of 120 buildings on S.C.S. sites, with a single building plus survival hut at each doppler station. The doppler building requirements did not change, but 45 buildings were added to S.C.S. sites, making a total of 165, or an increase of 37 parcent. In terms of total cubic contents of buildings, the final figure of 16 million cubic feet was 28 percent above the May 1955 estimate. In addition, extra air strips, tractor train operation, fire loss at Knob Lake, extra road, harbour, and back fill work, accounted for some $11 million of the increase.

In the period from the fall of 1956 through the spring of 1957, a number of factors combined to lengthen the total construction period, mainly for the Bay sites, thus increasing costs. Some of these factors were:

(1) Major, sub trades, particularly plumbing, heating, and electrical, made slow progress due to inadequate staffing and poor material deliveries.

(2) The winter was unusually severe, even for Hudson Bay, resulting in inability to work outdoors for extended periods, and in inefficient performance in buildings using temporary heating arrangements. We had one bad accident when a worker fell from one of the large Scatter antennae during the numbing cold.

(3) Due to the fall freeze-up and storms in Hudson Bay, two ships did not reach their destination at Great Whale and Winisk, resulting in shortage of material.

The cost of the whole project was high: 36 percent above earlier estimates, basically because 28 percent more building space was provided and there were unforseen or underestimated costs of air strips, harbour at Winisk, roads, tractor trains, sea lift and air lifts. Undoubtedly there was some waste, but much of this was due to the crash nature of the project. I am also convinced that the multi-agency, ambivalent contractual arrangements were responsible for some of the high cost.

Chapter 22

The Final Blitz

> I am pleased to report that the first section of the Mid-Canada Line, running from Dawson Creek, B.C. to Stoney Mountain, Alta., went into operation yesterday, October 8, 1956.

Thus Mr. Eadie to Mr. Howe on October 9th. "Ready for operation" would perhaps be more accurate than "went into operation" since operational manning of the section was not yet a fact. But it was the first sign that completion of the project was in sight. The road to the end took a while and was a bit bumpy, but we were on the way.

A December 4th memorandum of mine set out our expectations for status of the Line as of December 31st (with January 1st being the target date set by the Chiefs of Staff for overall service). As will be seen, we were going to miss the target in the east.

Dawson Creek to Winisk:

> All buildings essential to the operation of the Line will be sufficiently completed to permit installation of equipment and operational use as required. With the exception of one detection station, all towers will be complete. The electronic and power installation will be sufficiently complete to permit limited operation of this entire section of the Line with the exception of the one D.D.S. where steel shortages, plus difficult transportation conditions in the Bird-Winisk muskeg area have delayed erection of the tower.

Winisk to Hopedale:

> Transportation conditions in this section of the Line are particularly difficult, the only access being by sea or air. Equipment is being installed in most of the stations but transportation conditions have caused shortages which have hampered the work. No part of this section of the Line will be operational by December 31st, but there appears to be good reason to believe that a date of March 1st for limited operation can be met.

The most difficult section was from Winisk to Great Whale River.

> Construction has been completed to the point where electronic installation work is under way at all sites except four. Four towers are still to be erected.... A substantial amount of work remains to be

> done on antenna erection and diesel installation. Limited operation of this section by March 1st appears probable if steel shortages and transportation difficulties can be overcome. Installation work is under way at three of the five Scatter sites.... By March 1st it is expected that the Scatter system will be operative without diversity (i.e. on one frequency band only).

From Great Whale to Knob Lake steel shortages and transportation problems were causing delays, but in both the Great Whale-Knob Lake and Knob Lake-Hopedale sections, limited operation by February 15th looked possible.

> It should be appreciated that additional small items of equipment must be installed as received from suppliers up to the late spring of 1957. Clean-up of many small items associated with buildings, fencing, helicopter pads, etc. will be accomplished as conditions warrant over the first half of 1957. Some buildings at Section Control Stations (drill-recreation halls) will not be constructed until the summer of 1957.

In a further memorandum on December 11th:

> I am advised this morning that the radio-relay system is now working from Dawson Creek continuously through to site 521 which is approximately 200 miles east of Bird, Manitoba. In other words the three complete sections from Dawson Creek through to Bird promised for the year end are working in so far as communications are concerned with a further 200 miles on the leg from Bird to Winisk. Our installation people are quite confident that the detection gear required to make these three sections operational by the 1st of January will be in service by the end of the month.

The basic difficulty was transportation into the Bay sites, complicated by steel shortages and late deliveries generally. The jettisoning of cargo from several planes in trouble and from one ship (the *Steve Aherne*) under severe storm conditions was an important contributing factor. Slowness of plumbers and other subcontractors did not help, and there was a considerable amount of confusion and plain loose management on the part of both the general contractors and our own people.

Conditions were particularly difficult at Winisk, and in my view were not helped by continuous probing of the Air Force and injection of their views in detail into the field situation, thus adding to the confusion and frustration of the staff on site. However, the R.C.A.F. saw the possibility of undue delays – which was probably realistic – and proposed a winter air lift of remaining material required, estimated at 5000 tons, into Winisk and Great Whale. This was a sound, though expensive, move and did much to help clean up the construction job earlier than might otherwise have been the case. Further, and probably more importantly, the R.C.A.F. decided to delay the construction of the drill-recreation hall and sewage treatment plant to a later date, thus limiting the amount of work to be finished at Winisk at this time.

I have a copy of our schedule charts issued January 20th, 1957. These charts had been issued quarterly to the Air Force and D.D.P. through-out the project. As of January 20th, then, Dawson Creek to Bird was shown as operational (i.e. ready for operation) at January 1st or earlier; Bird to Winisk at February 1st; and all other sections by April 1st. There were some riders on this:

> Due to late deliveries, some equipment will be installed after the installation periods shown, but it is expected that all essential equipment will be in place by the S.C.S. operational dates.
>
> Major construction work will be complete at Dawson Creek in March 1957, at Cranberry Portage in April, and at Stoney Mountain, Bird, Great Whale River and Knob Lake in May…. The drill-recreation halls (these had been delayed in planning) at Stoney Mountain, Cranberry Portage, Bird, Great Whale River and Knob Lake, as well as the control tower and steam lines at Great Whale will be completed during the summer months.

Incidentally we certainly needed that control tower. In July of 1957 there were 1030 flight arrivals and departures at Great Whale River, including commercial flights and activities associated with mining and exploration as well as Mid-Canada business.

We didn't quite make the April date either. Late in March, I advised Mr. Eadie that the Line would be ready for limited operation by April 1st except for the 120-mile gap across James Bay. Perhaps the best feel of the final stages can be obtained from the minutes of the Mid-Canada Executive Committee meeting on April 26th. This was the 17th, and it turned out to be the last meeting of the Committee.

Air Commodore Whiting reported on his visit of April 23-24th to Winisk and Great Whale River. He considered the rate of progress and site optimism to be much improved.

Results of the air lift to Winisk and Great Whale River were given:

Originally estimated	5000 tons
Contracted for	3100 tons
Finally estimated	2750 tons
Airlifted to date	2100 tons
Still to be lifted	650 tons (approximately)

Construction contractors' completion dates:

Dawson Creek	Work ceased	15th March
Stoney Mountain	Work ceased	31st March
Cranberry Portage	Work to cease	31st May
Bird	Work to cease	30th June
Great Whale River	Work to cease	1st August
Winisk	Work to cease	1st September
Knob Lake	General contractor withdrew 31st March; some subcontracting work continuing.	
Hopedale	General contractor now withdrawing.	

A lag in plumbing and electrical work at dopplers, particularly in the Great Whale area, was reported, but the Committee was assured that two crews were moving from site to site to clean up this work.

Management Contractor construction personnel west of Hudson Bay were down to 15 to 20, most of whom were involved in inventory preparation. The size of the Special Contract Department stood at about 405. Numbers were steadily decreasing and it was hoped to close the departrnent about 1st October.

As regards equipment installation, it was confirmed that voice communication was possible except across James Bay. Otherwise installation of electronic equipment was about 75% complete in the Great Whale area and 90% complete elsewhere.

We were having some problems in the James Bay Scatter crossing in matching the electric load to the diesel engines. However, with some temporary installations and the use of dummy loads, I indicated that the gap across the Bay would be closed shortly. The Scatter system southward was approaching completion.

132 buildings out of 264 had been taken over by the R.C.A.F. and the Maintenance Contractor by 24th April, and electronically the D.D.S.'s were being taken over at the rate of one per day. Air Defence Command indicated their operational plans as being:

<table>
<tr><td>Dawson Creek</td><td>Occupied 15th March</td></tr>
<tr><td>Stoney Mountain</td><td rowspan="2">To be occupied 1st May</td></tr>
<tr><td>Cranberry Portage</td></tr>
<tr><td>Bird</td><td>Occupied 15th April</td></tr>
</table>

<table>
<tr><td>Great Whale River</td><td rowspan="3">Air Defence Command inspection teams starting out 6th May</td></tr>
<tr><td>Knob Lake</td></tr>
<tr><td>Winisk</td></tr>
</table>

The western portion of the Line would be operational – i.e. fully staffed - on 10th May. As to the eastern sections, A.D.C. hoped to give operational dates after their inspection teams returned.

Canadian Marconi Company, which was the Maintenance Contractor for the Knob Lake section, had 84 men at Knob Lake, with more coming in. Bell people were gradually phasing out as Marconi took hold.

There was also a review of housekeeping and clean up problems, such as disposition of U.S. Navy barges and L.C.M.'s, and oil storage at Churchill.

We were approaching the end. The remainder of the Line was in fact taken into operation by Air Defence Command and the Maintenance Contractors by June, with clean-up of sites and some residual tag ends of construction left in the hands of the M.C.L. Plant Department as regards field supervision.

It may be appropriate at this point to indicate what was meant by operational readiness as compared to final completion. To be capable of operations, the doppler and communications systems had to be in working order, capable of detecting and reporting aircraft crossing the Line. Full completion, in addition to this, meant a station, whether S.C.S. or D.D.S., complete as to outside construction of buildings and towers, interior finish, furnishings, washing and cooking equipment and utensils, drapes, dishes, flatware: i.e. completely ready for R.C.A.F. and maintenance people to move in and operate. Bell's interior decorator was called in on decor, drapes (they had to be fire resistant), furniture, etc. As one commentator put it, "they even studied the effect of different colour treatments on personnel." This whole gamut of activity was largely under the direction of Bill Bell. Getting it completed for 102 sites across the Line was understandably a substantial job in itself.

On May 3rd 1957, the Bell Company gave a dinner for the principal people involved in the Mid-Canada project. The R.C.A.F. and other Government agencies, the construction and electrical contractors, along with senior people from Bell were present. Mr. Eadie was chairman;, Air Vice Marshal Hendrick spoke for the Government agencies; Tullis Carter, President of the Canadian Construction Association and of Carter Construction Company, spoke for the construction contractors; and Jack Kingan, Vice President of Canadian Marconi company, for the electrical contractors and suppliers. It was a good evening: the tensions of the day to day struggle we had all been under eased a bit, people relaxed and were friends.

Late in August I received two communications a day apart. The first from Max Hendrick on August 27th concerned dissolution of the Mid-Canada Executive Committee, and I think should be recorded in full:

> The Executive Committee for the Mid-Canada Line was formed in November 1954 to speak for the Deputy Ministers of the Departments of Government directly concerned with the building of the Mid-Canada Early Warning Line. As anticipated, most if not all complex and contentious problems relative to the building of this Line found their [way] to the Committee –the clearing house. The Committee met for 17 regular meetings in Ottawa, and for many special meetings in Ottawa and at Mid-Canada Line sites.
>
> Despite the varied opinions and convictions of individual committee members concerning technical and managerial matters, the tolerant and patient attitude adopted by all committee members made it possible for the business to be conducted effectively and harmoniously. For this my thanks as Chairman, is tendered to all.
>
> Construction and installation forces are being rapidly withdrawn and should be off the Line by the end of the shipping season this year. The task of controlling costs during the phase out of the construction programme is being handled as a special problem by Mr. Huck. Air Defence Command personnel are now in place and the Line is beginning to play a part in the Air Defence of North America. It has been generally agreed by the members of the Committee most concerned that any remaining construction and installation details can be handled by the normal inter--departmental machinery, and that it would be appropriate at this time, therefore, to formally disband the Executive Committee.
>
> I believe that the Historian looking back on this project will label it a truly remarkable achievement, while we who have been so close to it will remember chiefly the difficulties which we had to overcome collectively. It was indeed a remarkable achievement of pioneering and opening up the frontiers of Canada and in extending the state of the electronic art, and it achieved these objectives in spite of an unavoidable but nevertheless unduly complicated administrative control. All members of the Committee may, I believe, take some pride in the fact that they have contributed to a major achievement in building up the defences of the country as well as to a major example of the democratic system of control at work."

The second letter was dated August 28th, from the legal branch of D.D.P.:

> Referring to your letter of June 4th 1957 to Mr. D. A. Golden, Deputy Minister of Defence Production, I am sending herewith one fully executed copy of the Agreement between Her Majesty and The Trans Canada Telephone System, dated November 5, 1954, covering construction of Mid-Canada Early Warning System. This copy is for your records.

The wheel had turned full cycle. We had the job finished or as good as finished, and the formal contract to do it, all at the same time. As mentioned earlier in this narrative, the general terms of the contract were covered in the D.D.P. purchase order of June 1955; however it was not until this date in August 1957 that we had a fully executed contract.

Also in August I ceased to be exclusively concerned with the Special Contract Department, taking on Bell Headquarters engineering activities as my main preoccupation. I kept the title of General Manager of Special Contract for some time, however, to facilitate the clean-up phase, and to cover signing of invoices and Government claims.

The spill over of completing recreation halls, which had been added to the program late in the game, and other minor additions, was handled during the summer and fall of 1957, with Bell M.C.L. Plant Department acting for the Management Contractor in the field to the extent it proved necessary. Special Contract in terms of people was down to perhaps 75 by October, practically all at headquarters clearing up the paper work, and that residue dispersed to their normal occupations in Bell in the ensuing few months.

On February 28, 1958, the R.C.A.F. advised D.D.P. that they had "completed our review of the management contract and have concluded that by 31st March, 1958, we should be in a position to sign the final acceptance certificate insofar as these aspects (deficiencies) are concerned."

And so the construction phase of Mid-Canada passed into history. By this time operation and maintenance were running smoothly throughout the Line. Bob Spencer, of Bell Public Relations, visiting Cranberry in October 1957, wrote:

> Whatever vague notion I had held about stations on the Line being something makeshift was dispelled immediately we rolled through the camp gate. I found a carefully planned layout of well constructed buildings with every modern convenience and comfort possible. Every building is bright, warm and well ventilated; operations, administration-hospital, barracks, fire hall, power, recreation, aircraft hangar, mess and dining hall, supplies and garage.

> There is a baseball diamond, a hockey rink, indoor badminton, basketball and volley ball courts, ping pong table, a library, a pool table, a juke box, curling in the villange, piano in the mess, a well equipped dark room for the camera club, a horseshoe pitch and an archery range."

Of the Doppler stations:

> The well equipped kitchens in these small stations would make the average housewife flip with envy.

Obviously the gentleman was impressed with the creature comforts of the Line. On a visit to Winisk a few months later, he stressed the working part of life on the Line a bit more, [as well as the following]: "This station is remarkable because it's there. Bringing a baby city into being in that northern wilderness will be remembered always as a great pioneering achievement. It is a monument to every man who contributed of his talent to the romantic enterprise."

To quote the Air Force *Roundel*:

> The Line could easily be named the 'New Canadian Line'. At one Control Station some 23 nationalities are represented by new Canadians. The skills these immigrants have brought from their homelands are doing much to produce a smoothly functioning chain. Most are holding jobs far below their capabilities as they adjust to their new lives. At one base, for example, an ex-Lt. Colonel from the Royal Marines is in charge of dispatching supplies to remote sites.
>
> To visit the Line now that the construction debris has been cleared away, is to find surprises on all sides. No seeming bustle and clatter of equipment, only the softly humming electronic machines, with their flashing lights and low keyed bells make one aware of the twenty-four hour vigilance asainst an invasion which could endanger our very existence.

Bell continued on the job for something over two years. Well before that, the Line was running smoothly. Neither Bell nor the other Trans Canada companies had any desire to be permanently in the maintenance contracting business. Furthermore, D.D.P. found there were several other organizations whose main occupation was contracting, and who in their view would be competent to carry on, now that the initial run in period was over, and complete maintenance practices had been written and tested. Accordingly, Bell handed over to Canadian Marconi Co. in the east, and Canadian Aviation Electronics Company in the west. In a letter to all Bell Area Plant Managers and General Plant Managers of other Trans Canada Companies, Mr. Leworthy said:

> On midnight on May 31 (1959) we turned over to Canadian Marconi company the last section of the Mid-Canada Line for which we had been responsible. All other sections were transferred to the new contractors on schedule between March 31 and this date. The transfers were well planned and smoothly effected.

That is the story of the Mid-Canada Line and of Bell's Special Contract Department. Five years of strenuous effort by a group of dedicated people, of triumphs and disappointments, frustration, criticism; – and accomplishment. I wouldn't have missed it for anything, and I think most of my associates in the Department would say likewise.

On a fall day in Winisk, towards the end of the construction project, I wandered down to the breakwater and looked out to sea. The tide was going out, and a great black raven flew in and landed on the beach. He stood there preening himself, then flew off. To me at that moment he epitomized freedom, his freedom to roam the northern wild, our freedom to live our lives in peace in this great northern land of Canada. That's what Special Contract was all about.

Epilogue

"The tumult and the shouting die." Certainly the captains and the kings departed long ago. The Mid-Canada Line became operational in the May-June period of 1957, with maintenance taken care of for the first two years by Bell, acting for the Trans Canada Telephone System in six of the seven sections, and Canadian Marconi in the seventh section. From 1959 on, maintenance was in the hands of Marconi and the Canadian Aviation Electronics Company.

Mid-Canada is a memory now. It was operational from 1957 through 1964 - the seven year deterrent period for which it was originally planned. In 1964 it was decided to abandon the Line. Towers, which could be a hazard to air navigation, were struck, buildings locked and abandoned. Some commercial use is made of Great Whale River and Winisk. R.A.J. Phillips in *Canada's North* notes that "at Great Whale River, the departure of the military establishment in 1965 gave the provincial authorities the opportunity to take over all the municipal functions that the Mid-Canada Line base had formerly provided."[1] For the rest, the doppler and communication sites are returning to bush, with here and there a pile of rusting oil drums labelled "Trans Canada Telephone System" to tell the story.

Pole Vault is still a working system, at least in part. The northern section, which was extended northward and extensively reinforced as to capacity later by the United States Air Force, is used chiefly for military rearward communications from stations in the far north. The southern section was taken over by Bell in Labrador and Canadian National Telegraphs in Newfoundland Island some years ago, and is used for commercial communications in the main.

In the period since the completion of the Mid-Canada Line the Trans Canada: Telephone System, including Bell, has continued to participate in provision of leased facilities to the Armed Forces. Major projects undertaken since that time include the SAGE-BUIC modernization of the early warning network,[2] and the

[1] *Editors' note:* R.A.J. Phillips, *Canada's North* (Toronto: Macmillan, 1967).

[2] *Editors' note:* The Backup Interceptor Control (BUIC) was the semi-automatic backup to the Semi-Automatic Ground Environment (SAGE) air defense system in the United States and Canada, providing command, control, and coordination systems to conduct the air battle if parts of the SAGE system became inoperative. See Federation of American Scientists, "AN/GSA-51 Back Up Interceptor Control System (BUIC)," https://fas.org/nuke/guide/usa/airdef/buic.htm.

installation of electronic switching machines at nine points across Canada to enhance the use and flexibility of the Defence network.

Despite the relaxation of international tension in some quarters, and the possibilities of détente, we continue to live in a troubled world, and we must protect our national interest. So provision of communication facilities for defence purposes, and the cooperation of the Telecommunication companies in their provision, will continue.

Mid-Canada, Pole Vault and to a large extent Pinetree are passé now, as are all defence projects ultimately. But the effort, the drive, and the esprit de corps developed in building these systems is an important part of the history of telecommunications, and indeed of Canada as a whole.

Further Reading and Research

The story of the Mid-Canada Line still awaits its historian. The main source of archival holdings remains the Library and Archives Canada (LAC), including Record Group (RG) 24 (Department of National Defence), RG 25 (External Affairs), RG 11 (Public Works), and Defence Research Telecommunications Establishment (MG31-J43). A considerable portion of the Defence Construction (1951) Ltd. records (RG 83) at LAC cover the construction of the Mid-Canada Line; more, in fact, than is suggested by the various finding aids. At the Department of National Defence Directorate of History (DHH), the logical starting point is the Raymont Fonds (DHH 73/1223), especially the Chiefs of Staff Committee and Cabinet Defence Committee records, but there are also a number of useful RCAF and army files available. Lester's "Taped Recollections" are held as DHH 77/493. DRB scientist A.G. Chapman's extensive papers, also held by DHH, cover much of the early development of the technology for the MCL.

Jeff Noakes, "Under the Radar: Defence Construction (1951) Limited and the Military Infrastructure in Canada, 1950-1965" (unpublished Ph.D. dissertation, Carleton University, 2005) offers the most comprehensive academic analysis of the MCL planning and construction phase. Some histories of the telephone companies in Canada also briefly discuss Bell's role in the MCL. See, for instance, Robert Collins, *A Voice From Afar: The History of Telecommunications in Canada*, (Toronto: McGraw-Hill Ryerson, 1977); and Jean-Guy Rens, *The Invisible Empire: A History of the Telecommunications Industry in Canada, 1846-1956*, trans. Käthe Roth, (Montreal & Kingston: McGill-Queen's University Press, 2001).

On continental air defence, Joseph Jockel's *No Boundaries Upstairs: Canada, the United States, and the Origins of North American Air Defence, 1945-1958* (Vancouver, UBC Press, 1987) remains an essential source on its subject. It has been supplemented by various recent Ph.D. dissertations that add more depth, including Richard Goette, "Canada, the United States and the Command and Control of Air Forces for Continental Air Defence from Ogdensburg to NORAD, 1940-1957" (Ph.D. disseration, Queen's University, 2009) (published by UBC Press in 2018 as *Sovereignty and Command in Canada–US Continental Air Defence, 1940–57*), and Matthew Trudgen, "The Search for Continental Security: The Development of the North American Air Defence System, 1949 to 1956" (unpublished Ph.D. disseration, Queen's University, 2011). Older but still useful is Melvin Conant, *The Long Polar Watch: Canada and the Defence of North America* (New York: Harper, 1962) and, for the triumphalist "high modern" spirit of the times, Richard Morenus, *DEW Line: Distant Early Warning, The Miracle of America's First Line of Defense* (New York, Rand McNally, 1957). The late Kenneth C. Eyre's landmark "Custos Borealis: The Military in the Canadian North" (unpublished Ph.D. thesis, University of London - King's College, 1981) remains helpful to place the MCL in context, as is David J. Bercuson, *True Patriot: The Life of Brooke Claxton, 1898-1960* (Toronto: University of Toronto Press, 1993). On the intersecting history of the DEW Line, see John N. Harris, "National Defence and Northern Development: The Establishment of the DEWLine in the Canadian North" (unpublished M.A. thesis, Simon Fraser University, 1980) and Alexander Herd, "As Practicable: Canada-United States Continental Air Defense Cooperation 1953-1954" (unpublished M.A. thesis, Kansas State University, 2005).

On the broader theme of Northern development during this era, see Morris Zaslow, *The Northward Expansion of Canada, 1914-1967* (Toronto: McCelland and Stewart, 1988); Ken S. Coates and William R. Morrison, *The Forgotten North: A History of Canada's Provincial Norths* (Toronto: James Lorimer, 1992); and Richard Rohmer, *The Green North* (Toronto: Maclean-Hunter, 1970).

About the Editors

JEFF NOAKES, Ph.D., has been the Second World War historian at the Canadian War Museum since mid-2006. He is responsible for historical content in the museum's Second World War gallery, and until 2016 was one of two historians jointly responsible for historical content in the War Museum's LeBreton Gallery, which displays the museum's collection of large military artifacts. He has also been the historian on museum teams responsible for creating or adapting a number of temporary and online exhibitions. He has worked as a researcher on subjects related to Canada's military and diplomatic history during the twentieth century, and is also the author or joint author of books, book chapters, exhibition catalogues, and articles on subjects related to the First World War, the Second World War, the Cold War, and the Arctic, including *Forged in Fire: Canada and the Second World War* (2016), and, with Andrew Burtch, *The LeBreton Gallery: The Military Technology Collection of the Canadian War Museum* (2015). Along with Tim Cook and Nic Clarke, he is co-author of *Canada in the World Wars* (2016), and with Janice Cavell he is co-author of *Acts of Occupation: Canada and Arctic Sovereignty, 1918-25* (2010).

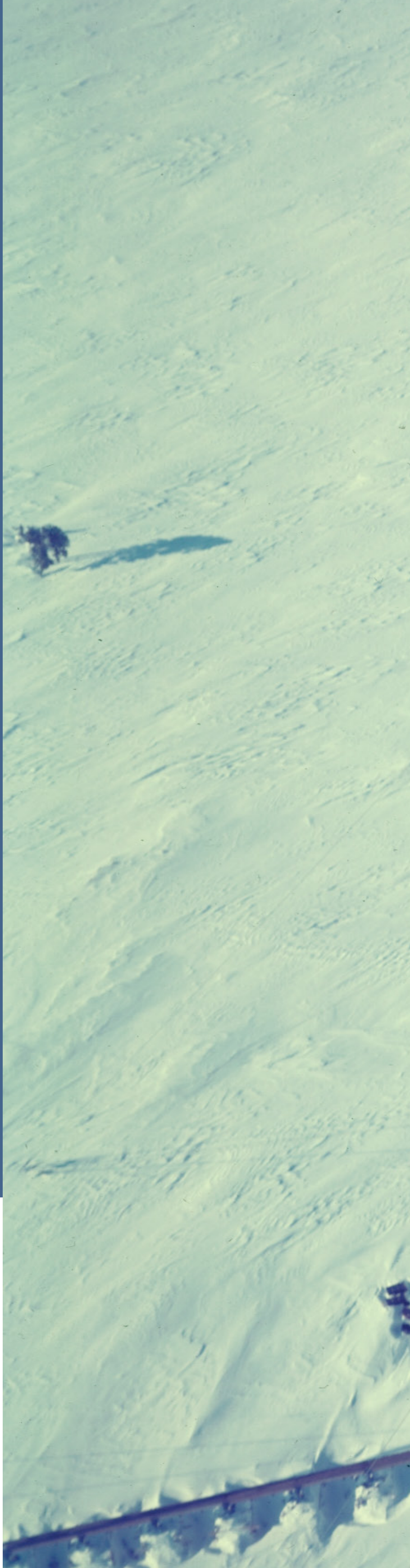
P. WHITNEY LACKENBAUER, Ph.D., is Professor and Canada Research Chair (Tier 1) in the Study of the Canadian North with the School for the Study of Canada at Trent University. He is co-director of the Centre on Foreign Policy and Federalism at St. Jerome's University (University of Waterloo), Waterloo, Ontario; was Distinguished Visiting Professor at the Centre for National Security Studies at Canadian Forces College, Toronto, in winter 2018; and began work on this volume as the Killam Visiting Scholar at the University of Calgary in fall 2017. Whitney is also the Honorary Lieutenant Colonel of 1st Canadian Ranger Patrol Group (1CRPG) based in Yellowknife. His recent books include *China's Arctic Ambitions and What They Mean for Canada* (co-authored 2018); *The Networked North* (co-edited 2017); *Canadian Armed Forces Arctic Operations, 1945-2015: Historical and Contemporary Lessons Learned* (co-edited 2017); *Whole of Government through an Arctic Lens* (co-edited 2017); *(Re)Conceptualizing Arctic Security: Selected Articles from the Journal of Military and Security Studies* (co-edited 2017); *Vigilans: 1st Canadian Ranger Patrol Group* (2015); *Le Canada et l'Arctique* (co-authored 2015); and *The Canadian Rangers: A Living History* (2013).

Arctic Operational Histories, no.6

Special Contract

As part of the Mid-Canada system, 102 sites were established - eight major air stations, 90 doppler and 4 tropo-scatter installations, over a distance of 2,800 miles. Something over 200,000 tons of material were transported to and distributed along the 55th parallel of latitude. This involved transport of every sort: rail, sea, major aircraft, including 12 Cansos of the total of 14 available in Canada; helicopters, the biggest tractor train operation in Canadian history up to that time, truck, barge, canoe and dog team. … This, then, is the story of Special Contract; of its accomplishments and its difficulties. Above all, it is the story of people, of seven people initially, growing to 1,254 at maximum, supervising line contractors employing another 5,500 men, then reducing to zero as the work was completed. Of people, Bell employees and others, who despite very real hardships, long hours and criticism, developed an *esprit de corps* which sustained the whole operation.

-A.G. Lester



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