Defence and Discovery
Canada's Military Space Program, 1945-74

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Contents

Figures

Abbreviations

ACSR	Associate Committee on Space Research
APT	automatic picture transmission
ARPA	Advanced Research Projects Agency
BAL	Bristol Aircraft (Western)
CARDE	Canadian Armament Research and Development Establishment
CAScW	Canadian Association of Scientific Workers
CEPE	Central Experimental and Proving Establishment
CFHQ	Canadian Forces Headquarters
CMSG	Canadian Military Space Group
COSINE	Co-Orbital Satellite Intercept Evaluation
CRPL	Central Radio Propagation Laboratory
CRPP	Canadian Rocket Propulsion Program
CRR	Churchill Research Range
CTS	chief of technical services
DAED	Directorate of Advanced Engineering and Development
DARPG	Development and Associated Research Policy Group
DDP	Department of Defence Production
DDR and E	Directorate of Defence Research and Engineering
DND	Department of National Defence
DOC	Department of Communications
DOD	Department of Defense
DRB	Defence Research Board
DRNL	Defence Research Northern Laboratory
DRTE	Defence Research Telecommunications Establishment
GCCSS	global commercial communications satellite system
ICBM	intercontinental ballistic missile
ICS	Interdepartmental Committee on Space
ICSC	Interim Canadian Space Council

IGY	International Geophysical Year
IPY	International Polar Year
ISIS	international satellites for ionospheric studies
LAC	Library and Archives Canada
MOSST	Ministry of State for Science and Technology
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NORAD	North American Air Defence
NRC	National Research Council
PCO	Privy Council Office
PTV	Propulsion Test Vehicle
RCAF	Royal Canadian Air Force
RCN	Royal Canadian Navy
RPL	Radio Physics Laboratory
SIP	Space Indoctrination Program
SITU	Satellite Identification Tracking Unit
SPADATS	space detection and tracking system
STEM	storable tubular extendable member
TSWG	Topside Sounder Working Group
USAF	United States Air Force
USPACECOM	United States Space Command

Chronology of Canada's Rocketry and Space Program

c. 1916	National Research Council (NRC) created.
1940	National Resources Mobilization Act congregates most scientists in NRC to directly support Canada's war effort.
September 1945	Soviet cipher clerk and spy Igor Gouzenko defects to the Canadian government.
March 1947	Defence Research Board (DRB) created.
1949	NATO created.
February 1951	Defence Research Telecommunications Establishment (DRTE) created.
1956	CARDE reviews its existing propulsion testing and creates the Canadian Rocket Propulsion Program (CRPP).
1956-57	Canadian defence and civilian scientists participate in the International Geophysical Year (IGY)
October 1957	The USSR launches Sputnik, its first satellite.
1958	NORAD created. Albert Fia joins Bristol Aerospace and creates the Special Projects Group.
March 1959	Canada and the US cooperate to create the space detection and tracking system (SPADATS).
April 1959	Associate Committee on Space Research formed.
October 1959	First Propulsion Test Vehicle (PTV)/Black Brant I launched from the Churchill Research Range.
1960-61	RCAF Advanced Technology Evaluation Program created.
1961	Satellite Identification Tracking Unit (SITU) stood up at Cold Lake, Alberta.
1961	RCAF Space Indoctrination Program created.
1961	Canadian defence involvement in SPACETRACK begins.
1961	First launch of Black Brant IIA.
January 1961	Development of Black Brant III begins.
March 1961	Canadian Bristol Aerojet Ltd. formed.

June 1962	First launch of Black Brant III takes place at Wallops Island, Virginia.
September 1962	Canada's first satellite, Alouette I, is launched from Vandenberg AFB, California.
October 1962	Cuban Missile Crisis.
1963	Nuclear Test Ban Treaty signed.
1963	The Co-Orbital Satellite Intercept Evaluation (COSINE) Project begins.
1964	The RCAF Space Defence Program is officially initiated.
1964	Canadian Forces integration initiated.
April 1964	First Black Brant VA launched at the Churchill Research Range.
June 1964	First Black Brant IVA launched at the Churchill Research Range.
c. 1964-66	Science Secretariat created to advise government on space programs.
c. 1964-69	Alouette-ISIS project.
c. 1966	Science Council of Canada created.
1966	Science Secretariat's National Space Study.
April 1967	DRB/Bristol Aerojet Black Brant Development Program ends.
1967	Chapman Report issued.
1968	Department of National Defence unification initiated.
1968	Defence Research Telecommunications Establishment dissolved and re-created as Communications Research Center.
March 1968	*White Paper on a Domestic Satellite Communications System for Canada* published.
April 1968	Department of Communications (DOC) created.
January 1969	ISIS-A launched.
July 1969	Apollo XI moon landing.
January 1970	Interdepartmental Committee on Space first meeting.
April 1971	ISIS-B launched.
October 1971	Ministry of State for Science and Technology created.
November 1972	Anik A1 launched.
April 1973	Anik A2 launched.
1974	Canada ratifies its first national space policy.

Introduction

The dream of reaching outer space has teased the imaginations of humankind since the days of classic civilization, but only during the twentieth century did the knowledge and technologies needed to turn these dreams into fact became available. Yet, like so many great technological innovations of the last century, rocketry was brought to full fruition in total war and space flight during the political and strategic uncertainty that followed it.

Perhaps no other technological competition was a more popular icon of the early Cold War period than the "space race" between the United States and the Union of Soviet Socialist Republics. Fuelled as much by politics, fear, propaganda, and prestige as the need for strategic capability in surveillance, reconnaissance, and if necessary, military strike, the two superpowers engaged in a progressively challenging and expensive contest of innovation above the earth that changed the very nature of the Cold War itself and ultimately defined a new era in human civilization.[1]

Like a handful of other nations, Canada was an active participant in the early Cold War space race. Shortly after the Second World War, for reasons of self-preservation and self-interest, the country took its first steps toward the development of a national rocket and space program that, although not large, had tremendous vision and a high degree of technological success. Born out of scientific curiosity and shaped by technological innovation and the security requirements of the Cold War, the program in later decades fundamentally transformed Canada itself. Most importantly, however, Canada was able to parlay its own national technological competence in this field into political, military, and strategic saliency among its larger and more powerful allies, allowing it to play a considerable part during what was arguably the greatest epoch of discovery since the Renaissance and certainly the most dangerous period of human defence.

This book describes and analyzes Canada's role in the exploration and exploitation of the upper atmosphere and outer space between the end of the Second World War in 1945 and the ratification of the country's first national space policy in 1974. In doing so, it reveals the rich history of scientific and technological innovation in Canada during the early Cold War period and illuminates the central role of military enterprise in shaping dynamic technological change in this field during the post-war economic boom. Supporting other more recent interpretations of Canada's role as an active and astute participant within the Cold War Western alliance, this book assesses what Canada's strategic interests in outer space were within the wider context of the Cold War space race. Its findings demonstrate Canada's attempt at military self-reliance in the 1950s and its desire to remain a salient technical partner within its strategic alliances throughout the 1960s and early 1970s.

With the existence of an intimate relationship between its scientific, technological, defence, and government communities similar to those witnessed in the United States and Britain during this period, Canada attempted with some success to create a national rocketry and space program that would keep it relatively close to the leading edge of technological change as well as technologically relevant within the eyes of its primary strategic allies. Though technological achievement in the upper atmosphere and space was never the largest priority of the government during the early Cold War, Canada nevertheless took pride in it and applied its benefits wherever possible.

Until very recently, the portrayal of Canadian innovation in the post–Second World War period has made no substantial acknowledgment of the country's scientific and technological achievements. Until the late 1960s, Canadian political and economic historians generally characterized the country's evolution through a series of natural resource exploitations designed for global export that would later provide the basis for the creation of a mature manufacturing-based economy. The 1970s, however, saw a considerable shift in the interpretation of Canada's development. During that time, numerous government studies warned of a national failure to exploit industrialization, manufacturing, and trade, and a new generation of historians argued that Canada had failed to break away from its traditional dependence on raw material export after the Second World War. In fact, the country remained largely a semi-industrialized nation stuck in a pattern of arrested technological and economic development.

The catalyst of this new school of thought appeared in 1967 when historian J.J. Brown published *Ideas in Exile: A History of Canadian Invention,* an unflattering and at times damning history of Canadian innovative creation and technology. Though he commended Canadians individually for their inventiveness, he condemned the country as a whole for failing to capitalize on those inventions. Brown concluded that the lack of national innovation was a "psychological rather than financial problem" and described it as a fear of modernization and change. Finally, he castigated the government for neglecting to remedy the situation by encouraging and supporting innovation, as well as sustaining it through some form of succession planning.[2]

Why Brown suggested that Canadians failed to innovate after the Second World War is understandable from a certain perspective. Undoubtedly, the period during which he produced his work influenced him to some degree. In 1967 Canada was already embroiled in what would soon become a bitter debate over the future of its national science and space policies, and the post-war economic and technological expansion that had achieved much was beginning to plateau. At the same time, innovation was being subjected to cautious optimism, as both public and private organizations and investors awaited the outcome of federal policy decisions on the future of various national research and development objectives.

Yet, in the absence of widely published contrary views or arguments, Brown's thesis influenced both public opinion and the academic interpretation of the history of Canadian innovation for nearly fifteen years afterward. In 1982, however, economist Christian DeBresson successfully challenged the Brown thesis by re-examining Brown's data and revealing that a number of his conclusions were erroneous.[3] In particular, the existing evidence did not support Brown's claim that Canada had failed to innovate during the early Cold War period, leading DeBresson to suggest that a revision of the standard historical interpretation was desperately needed. Still, substantial case studies of post-war technological change in Canada remained sparse during the 1980s, and DeBresson was unable to develop his work on the subject. It was not perhaps until the mid-1990s, with the declassification of archives, that scholarly research became more feasible.

Scholars have increasingly argued that military establishments in industrialized nations have played an important historical role in shaping innovation as well as technological and economic change by linking national defence with national welfare. American historians Merritt Roe Smith and Alex Roland have both underscored the convergence of military and economic forces in US Cold War innovation, and British historian C.N. Hill has made similar arguments about the United Kingdom's Cold War military enterprise.[4] Others have examined the Soviet Union, Germany, Japan, and Australia, all of which demonstrated similar relationships between military enterprise and technological change during the early years of the Cold War.

Canada's experience during this period was no different from that of its political and military allies. The emphasis on conceptual design and development of weapons and technology, which dated from the Second World War, demonstrated a fundamental shift in the government attitude toward defence science, a field that had been largely ignored before the war. Although the National Research Council (NRC) had undertaken limited activities before 1939, Canada's scientific and technological community was largely dispersed, underfunded, and isolated from the concerns of national defence.[5] The Department of National Defence (DND) had neither the personnel nor the finances to investigate even simple advanced technology or weapon systems, and Canada's defence policy and doctrine of the period created little requirement for large investments into research and development of scientific projects. Suffice it to say that Canada prepared for the Second World War with largely the same naïveté that had characterized its preparation for the First World War.

Still, the totality of the Second World War inexorably and fundamentally revised this attitude. Canada's National Resources Mobilization Act of 1940 had, among other things, called for the country's scientists and engineers to commit their professional services to the state in the struggle against fascism. The NRC was given the task of organizing defence science, and technology experts were recruited across the country to develop the tools of modern warfare. By and large, after struggle and evolution, the NRC succeeded in gaining an international reputation in the fields of radar, explosives, war medicine, rocketry, ballistics, and chemical and biological warfare.[6]

The war also permanently transformed the relationship between Canadian government, science and technology, and defence. The total mobilization of science and engineering between 1939 and 1945 resulted in the elevation of several technocrats into influential decision-making positions and established a precedent for collaboration and direction that lasted well beyond the end of hostilities. The Cold War and the threat of a third hot war merely expanded the range of national security concerns and the need for science to confront them. The claim that military preparedness for a nuclear Armageddon depended on massive resources and increased federal support for defence science proved far more convincing than ever before. Canadian scientists, once ostracized from defence budgeting and decision making, suddenly found themselves at its very centre. It was from this vantage point that a Canadian rocket and space program was born.

Though Canadian interest in researching the upper atmosphere dated from the nineteenth century, a government-driven rocket and space program began only after the Second World War. Dozens of university space research ventures were initiated in the late 1940s, and the newly created Defence Research Board (DRB) sponsored the design and construction of the first long-range missiles and, later, sophisticated upper atmospheric launch vehicles for both military and civilian applications. In 1955, in cooperation with the US Department of Defense (DOD), the Canadian Army established a permanent launch facility at Fort Churchill, Manitoba, near the southwest coast of Hudson Bay, where the Black Brant rocket as well as several American-built rockets and missiles were tested and employed. At the same time, the DRB initiated discussions with the DOD for Canadian participation in US ballistic missile defence research and development. By October 1957, when the Soviet Union shocked the world with the launch of Sputnik, the first man-made object in space, Canada's plans for its own first satellite project were already well advanced.

Canada's space program reached a zenith during the 1960s. In late 1962, albeit with US aid, Canada launched its own satellite, named Alouette, into orbit.[7] It had also developed critical components for several American space assets and was a key contributor to US manned spaceflight systems. Canada's vital partnership with the United States in North American Air Defence (NORAD) was testimony to its ability in contributing to the deterrence of a Soviet attack. Furthermore, the deployment of Canadian surveillance of space technology provided some of the earliest assessments of Soviet intercontinental ballistic missiles (ICBM) and space-based systems. In addition, DND was engaged in a number of ballistic missile defence projects and counter-space-operations studies, and had solidified working relationships with a number of defence space and intelligence agencies in the United States. This was topped with a super gun launcher program at McGill University, a second Alouette satellite launch in 1965, and the completion of Canada's first rocket development program in 1967. When Canada's space effort finally paused near the end of the decade, a legacy of achievement during the golden age of space exploration, largely based on security and defence, was clearly identifiable.

Yet, as with much of the history of Canadian science and technology, the details of the origin of the Canadian rocketry and space program remain elusive. Historian Douglas Owram devoted only a single page to the history of science and technology in his omnibus examination of Canadian historical literature, most of the entries identified being associated with the history of medicine. Likewise, Carl Berger's study of the writing of Canadian history devotes a single page to the same subject, noting that "literature on the history of science in Canada has concentrated on those features of it that were comprehensible to historians who lacked any formal training in the field."[8]

This may seem somewhat surprising given the considerable literature that exists on US-Canada defence cooperation during the Cold War. However, most if not all Canadian studies on this subject portray the relationship as that between only two actors – defence and government. This study argues that a third actor, the scientific and technological community, also figured in the association and more importantly played a critical part in shaping the evolution of both that relationship and Canada's role in strategic defence with other Western allies.

Such an obvious and biased gap in Canada's space history merits further attention, not only to answer questions about Canadian post-war defence science and space technology but also to identify important aspects of the Cold

War Canada-US relationship not addressed in the literature. The formative years of the Canadian space program paralleled, albeit on a much more modest scale, the evolution of the US space program. The bilateral defence relationship between the two countries was strengthened by the need for cooperative defence in the Cold War security environment and led to the creation of such missile- and space-oriented organizations as NORAD.

Similarly, Canada influenced several American space projects, both civilian and military, and a number of Canadian scientists and engineers took leading roles in American agencies such as NASA.[9] Participation in bilateral space activities shaped Canada's post-war national security, science, technology, and industrial policies. Canada also shared similar experiences in its quest to modernize its post-war defence and to then diffuse that technology into its civilian economy, albeit with less success. The outcome was a comparative yet different linking of national defence to national welfare during this period. These issues alone make the study of Canada's rocketry and space program critical to investigating Canada's Cold War interests and its bilateral security relationship with the United States.

Defence and Discovery is organized along both thematic and chronological lines and focuses on the period of Canada's security-driven space science research and technological development between 1945 and 1974. The book situates the reader within the history of the Canadian space program and its various projects, providing a framework of knowledge for further scholarship and debate. It also analyzes the connection between Canadian science and technology, defence, and government, the actions taken, and their impact on the execution of the country's space program during the golden age of exploration and exploitation.

Overall, this book seeks to reveal the nature of the first three decades of Canada's exploitation of space and to place it within the wider context of the political history of Canadian science and technology. Although the United States, Russia, Britain, and other nations are aggressively recording their space exploration legacies, Canada has yet to embrace, officially or otherwise, telling the great tale of defence and discovery that launched it into outer space.[10] This work seeks to end that status quo by demonstrating that Canada was an active and at times critical element of the Cold War space race.

1

Cold War Security and Aerospace Defence Research Prior to Sputnik

In Canada the study of aerospace-related disciplines such as astronomy and physics may be traced as far back as the eighteenth century, but the direct study of the upper atmosphere and outer space began much more recently.[1] In 1882 and 1883, Canadian scientists participated in the first internationally coordinated study of meteorological, magnetic, and aurora phenomena in northern Canada, as part of a program known as the International Polar Year (IPY). A second IPY was held in 1932, and another generation of Canadian scientists and explorers using new radio techniques successfully conducted Canada's first measurement of the ionosphere.[2] These techniques were improved during the Second World War, as military imperatives provided massive funding and resources to previously strapped research and development in ballistics and space sciences. By the end of the war, sustained government support for national-level science programs had paved the way for an ambitious foray into upper atmosphere/space technology research and development under the aegis of defence-related priorities.[3] During the Cold War, US support and the threat posed by an unstable and potentially hostile Soviet adversary assured Canada an early entry into the exploration and exploitation of outer space.

Science, Defence, and Government

As the Cold War descended into its darkest period, Canadian defence scientists and engineers became acutely aware of their increasingly important role in deciding its outcome. Speaking before an audience in early 1955, J.J. Green, a senior analyst with the Defence Research Board (DRB) of Canada, noted that "no one can foresee how history will judge this century but it is not too difficult to put down on paper some of the things for which we shall be remembered. Among the more important of these, the men and women of the future will, I am sure, record that our generation were the first to apply science to warfare on an organized basis."[4] Green was more correct than he could have imagined, but even then, considerable effort had been required to bring Canada's scientific and technological capabilities to bear, first, in the liberation of Europe and after the war in the ongoing defence of North America.

At the end of the First World War, Canada's national science program remained largely undeveloped. The annual expenditure on government laboratory research was approximately $1 million, and of the nearly twenty-four hundred leading Canadian firms, less than forty had laboratories. In industry, less than $150,000 was spent annually on research and development.[5] Though the National Research Council (NRC) was officially created in 1916 to direct national scientific research and development, its early post-war years were plagued with rivalry and competition from Canadian universities for scarce government funding.[6] The situation improved somewhat during the interwar years, with a notable but limited increase in federal funding and of scholarships tendered through Canadian universities by the NRC.[7] Scientific manpower also increased slowly during this period, though a number of Canadian scientists continued to travel to the United States in search of gainful employment. In general, though interested in scientific development, the federal government remained reluctant to devote significant resources to research beyond those already specified in the NRC Act of 1924.

The detached relationship between science and government in Canada changed drastically during the Second World War. The National Resources Mobilization Act of June 1940, designed to concentrate all of Canada's resources on the defeat of the Axis powers, essentially congregated nearly all of Canada's scientists within the NRC and its ancillary departments. There, they were provided with funding and resources unlike any previously received from Ottawa and were able to rapidly expand the country's scientific capabilities and post-war potential for research and development. Between 1938 and 1945, government research and development expenditure increased sevenfold, from $4.9 million to $34.5 million, or roughly 0.3 percent of gross national expenditure.[8] This outlay decreased somewhat at the end of hostilities, yet, thanks to defence, the massive influx of funding and effort into centralized research and development forever altered the traditional relationship between science and government in Canada.[9]

The war also created an environment that allowed prominent Canadian scientists and engineers, such as NRC president C.J. Mackenzie, to join the upper ranks of the decision makers in Ottawa. A close friend of the legendary C.D. Howe, minister of trade and commerce (and later director of Canada's war munitions and supply), Mackenzie exerted an influence over the direction of Canada's national science and technology efforts during and after the war that members of his profession had not previously enjoyed. Other prominent researchers of the period included John Cockcroft, wartime scientific director of the Anglo-Canadian atomic projects at Montreal and Chalk River; E.G.D. Murray, director of Canada's biological warfare program between 1941 and 1945; Colonel Omond Solandt, a leading expert in Second World War operational research and medicine, and later the first director general of Canada's post-war

Defence Research Board; and George Wright, a major influence in Canada's wartime explosives and propellants programs.

Although the connection between Mackenzie and Howe was not equal to the apparently close relationship between Winston Churchill and his wartime science adviser Frederick Lindemann, there is little question that Mackenzie's regular access to Howe and the innermost circles of wartime government allowed him and his fellow scientists and engineers to enjoy an unprecedented position of power and status within Canada's scientific community.[10] One example of this may be found in the NRC annual report for 1944-45. Almost twenty years after its inception, the NRC explicitly noted for the first time that one of its major functions was to act as "advisor to the various departments of government, particularly those of National Defence, Munitions and Supply and Reconstruction."[11] Such was the result of gaining access to the inner circle of government.

Yet, as the tide of the Second World War turned in favour of Canada and its allies, it remained uncertain whether the end of the conflict would return Canadian scientists to isolation or if they would remain heavily involved in post-war nation building. Any longevity for national scientific research depended greatly on the creation of a solid post-war science policy for Canada. Realizing this necessity, the government, the military, scientists, and industrial leaders met even before the end of hostilities to consider the options. In February 1944, C.J. Mackenzie presented a paper at the Engineering Institute of Canada in which he outlined four basic requirements for a successful future national science program.[12]

First, Mackenzie argued that it was essential to retain the best Canadian scientific personnel within the country or at least the Canadian establishment. Second, the government must continue to expand its financial support for national research programs; if career paths were to remain competitive, salaries and wage structures for scientists, engineers, and technicians required increases and reorganization. Industrial research needed to be encouraged as well, potentially through liberal tax policies and reimbursements for technological developments made available to the public. Third, if the above were to succeed, greater coordination was necessary between the various branches and departments focused on Canadian research and development. Lastly, once the war ended, Canadian research would need to be refocused from a purely military application to a balanced peacetime program of both defence and civilian interests. If all this could be accomplished, Mackenzie stated, Canada might become a world leader in post-war science and technology.[13]

In mid-1944 the Department of National Defence (DND) also began meeting internally to consider the issue of post-war defence research in Canada. It was obvious that, at war's end, a large portion of the military scientific corps would request a release from service and seek civilian employment elsewhere. To ensure that some form of defence research program existed in the post-war period, Air Vice-Marshal E.W. Stedman, the director general for air research, recommended that a permanent Cabinet committee on defence research be formed under a chairman nominated by the government. The idea was endorsed by the Cabinet War Committee and later approved by Cabinet on 3 October 1944.[14] The committee, which was to be chaired by C.D. Howe, would include the three armed service chiefs of staff, the president of the NRC, two representatives from industry, and two civilian members. Cabinet again concurred and approved the terms of reference for the committee on 10 August 1945.[15] It was expected that, after an initial period to consider the issue, the committee would meet near the end of the year.

Ten days after the approval of the committee's terms of reference, Lieutenant General Charles Foulkes was appointed the chief of the general staff.[16] A career infantry officer with the Royal Canadian Regiment, Foulkes had joined the army in 1926; he went on to command the Second Canadian Division and, briefly, the Second Canadian Corps in Normandy. He later commanded the First Canadian Corps in Italy through to the end of the war. His appointment was merited but a bit surprising to some at DND who assumed that, after the war, Canada's top military command would go to the more charismatic and operationally successful general Guy Simonds. Foulkes was not a personable character, but he was efficient, an attribute that probably earned him the position.

Foulkes also clearly understood the impact of science and technology on defence. He required no convincing that peacetime defence research and development were crucial to future Canadian defence planning. Just over a week after he assumed office, he directed his staff to prepare an appreciation of the organization required for defence research in the early post-war period. His immediate concern was that, if defence research were left to the three services, duplication of effort, inter-service rivalry, and reduced post-war defence budgets would seriously diminish any capability. Simply, Foulkes felt that Canada's military scientific effort was too vital to be squandered by inter-service competition.[17]

The creation of a military division within the National Research Council, with an NRC vice-president assigned as its director, was one way of removing defence research from the control of the three services. Foulkes discussed this option with C.J. Mackenzie, but he discovered that the NRC president was reluctant to accept responsibility for Canada's post-war defence research. Although the NRC had assumed this duty in wartime, Mackenzie was anxious to return its focus to fundamental research and the civilian sector.[18] He also argued that, though the NRC had substantial resources, the financial and administrative responsibility for military research was large enough that it ultimately required its own dedicated staff.[19] Mackenzie's advice was accepted, and though neither man could have realized it at the time, the decision was a blessing in disguise. By the end of 1944, the NRC had become riddled with a small number of Soviet spies as well as other security leaks, and their unfettered access to other sections of DND might have proved disastrous for defence research and security.[20]

The end result of the Foulkes-Mackenzie meetings was that neither the armed forces nor the NRC seemed the appropriate vehicle for directing post-war defence research. Another solution was needed. Further analysis from within DND produced a number of options, the most provocative of which was a recommendation from Colonel William Wallace Goforth, head of the Directorate of Staff Duties (Weapons) at Army Headquarters, for a new defence research agency led by a representative at the chief of staff level. Goforth's proposal found immediate favour with the chief of the general staff, who passed it on to his three service chiefs. They too agreed to the concept in principle, though the chief of the air staff, Air Marshal Robert Leckie, had reservations concerning the plan. With a general consensus, however, Foulkes prepared a memorandum outlining the proposal for submission to the Cabinet Committee on Research for Defence.[21]

Surprisingly, the committee met only once, on 4 December 1945, in C.D. Howe's Parliament Hill office. Among those present were Minister of National Defence Douglas Charles Abbott, the secretary of the Privy Council Office, Wing Commander A.M. Cameron, C.J. Mackenzie, and Foulkes and a number of his military staff.[22] Foulkes's memorandum was reviewed in detail, with those present agreeing that research for the three services would be coordinated under a single director general for defence research and that this person should be a civilian with scientific training.

Further, since this course of action simply required reorganization within the department, no Cabinet approval was needed to implement it. All that was necessary was the passage of an Order-in-Council authorizing the appointment of the director general for defence research. A note was made to have the order drafted. Then, a subcommittee composed of Mackenzie and the chiefs of staff was formed to generate a list of potential appointees. It was expected that the position of director general would be filled in short order, and with that, the future of defence research in Canada would be all but determined. With nods and smiles all around the room, C.D. Howe adjourned the committee meeting.

But before everyone left his office, in a show of bureaucratic flexibility and brevity that is seldom observed today, someone suggested that a suitable candidate for director general might be Colonel Omond McKillop Solandt, a senior Canadian operational research analyst who had recently been appointed chief scientific adviser to Lord Louis Mountbatten. A graduate of the University of Toronto, Solandt was both a scientist and a qualified medical doctor who had completed his graduate studies at Toronto's Banting and Best Department of Medical Research.

In 1938 Solandt went to Cambridge, where he worked under Sir Joseph Bancroft. When the war began, Solandt held several senior appointments in medical research in England. Later work dealing with physiological problems related to tank personnel brought him to the appointment of deputy director of the British Army's Operational Research Group, which he then commanded beginning in May 1944. In early 1945, Solandt was appointed to Mountbatten's staff but was soon assigned as a member of the Joint Military Mission sent to Japan to evaluate the effects of the atomic bombs used on Hiroshima and Nagasaki. He returned to England later that year after completing his research. Not a career soldier, he was expected to resign from military service at the end of the war and return to civilian employment. However, his education, background, and experience in both administrative duties and wartime operational research made Solandt an excellent candidate for the position of director general.[23]

The armed service chiefs, who were still in Howe's office, concurred with the recommendation, and a conversation between Foulkes and C.H. Best at the University of Toronto later that afternoon confirmed the nomination. Ten days later, on 14 December 1945, the minister of national defence submitted the draft Order-in-Council for the reorganization of research and the appointment of a director general for defence research; the Privy Council officially approved his request on 28 December. Solandt was then informed of his new assignment, and arrangements were made for his immediate repatriation to Canada. The first phase in the creation of the Defence Research Board was complete.

Science and Security

By the end of the Second World War, science and technology had delivered to the Western allies, among others, the "winning weapon," as it were, in the form of the atomic bomb. Yet even before the end of hostilities, the supposed wartime ally, the Soviet Union, had stolen the recipe for this device and many other Western technological secrets. These actions rapidly degraded the US strategic advantage over the military power of its increasingly acrimonious Soviet ally.[24]

More often than not, the Soviet Union targeted scientists and engineers in its efforts to extract technological secrets. Smart, innovative, and conscientious, many of these people working in wartime defence projects feared the potentially destructive power they had developed and worried about its illegitimate use in the future. Made vulnerable by their feelings of guilt, they sometimes acquiesced to Soviet agent encouragement that they "share" their knowledge with the USSR in the false hope that a balance of power would be established in the post-war world. This proved ineffective in creating a cooperative post-1945 scientific environment, and whatever the intention, it was disastrous for Western security, degraded the West's military technological lead over the Soviets, and ultimately placed the entire Western allied scientific community under many years of close surveillance, suspicion, and prosecution by government.[25]

Canada's scientists were not excluded from this situation. The defection of cipher clerk Igor Gouzenko from the Soviet embassy in Ottawa on 5 September 1945 and his subsequent detention and interrogation revealed that a number of Canadian public servants, including some prominent scientists working with the NRC, might have been involved in spying for the USSR. After accepting Gouzenko's account as true, Canadian officials deemed the situation so serious that Norman Robertson, the under-secretary of state for external affairs, immediately reported the defection directly to Prime Minister William Lyon Mackenzie King.[26]

King displayed particular interest in Gouzenko's alleged security leaks that related to breaches in Canada's defence research. As he noted in his diary on 7 September 1945, Robertson had reported "that everything was much worse than we could have believed ... In our Research Laboratories ... where we had been working on the atomic bomb there is a scientist who is a Russian agent. In the Research Laboratories in Montreal ... there is an English scientist who is ... acting as a Russian agent."[27]

C.J. Mackenzie was immediately notified of the spies in the laboratories, and security experts were brought in to investigate suspects now under surveillance.[28] Arrests were made in February 1946, followed by the convening of a Royal Commission on Espionage and a series of treason trials against various individuals whose names, for one reason or another, appeared in the documents that Gouzenko brought with him to the Canadian authorities.[29] Several other scientists who were not named in the Gouzenko papers were put under surveillance as distrust and paranoia suddenly swept through the ranks of the Canadian scientific research community.

In addition, a number of organizations, such as the Canadian Association of Scientific Workers (CAScW), were investigated by Canadian authorities. Defence scientists associated with such groups often had their security clearances "temporarily" revoked or were simply denied any new clearance and access to restricted projects. Membership at the CAScW dropped dramatically as did that in other unions. Scientists and engineers who did not belong to these associations were encouraged not to join if they wished to retain their employment. For organized defence research labour, the Gouzenko affair proved disastrous.

The history of these investigations and their outcomes is already well explored in academic literature, but it is important to note here that the scientist spy scare and the potential theft of restricted defence technology emphasized two critical points for the Canadian government.[30] First, as historian Donald Avery states, "by the summer of 1946 Canadian military planners no longer considered war with Russia a remote possibility"; furthermore, they agreed that such a war would probably be won by whoever had the best long-range bombers, rockets, and atomic bombs.[31] As early as 10 September 1945, even Norman Robertson and Prime Minister King conceded the grave possibility that any future war between the United States and the USSR would probably come through Canada. There could be no sitting idly by if such a conflict arose.

Second, given that defence technologies were the likely keys to victory in a future conflict, Canadian national security must encompass the organization and protection of strategic research and development.[32] The government directed its law enforcement agencies to respond to the demand for better security as threats became increasingly apparent. Meanwhile, bringing the organization of defence research and development under the umbrella of DND soon became a foregone conclusion.

Creating the Defence Research Board

Although it was understood that scientific and technological innovation was crucial to the development of Canada's post-war defence and security, transforming this idea into reality required a serious commitment. Interestingly, this commitment did exist in two men who were critical to the process: Omond Solandt, the man chosen to become director general for defence research, and Brian Brooke Claxton, the incoming minister of national defence.

As Canada's first post-war defence minister, Claxton was under tremendous pressure to effect the demobilization of the country's massive wartime armed forces while at the same time ensuring that future security requirements were addressed. Fortunately, Claxton, a First World War veteran, was no stranger to the environment covered by his portfolio. After he served with the Canadian Field Artillery on the Western Front, his political career took him to oversight of national health and welfare issues. Claxton felt that people mattered the most and that their innovation would transform defence research and development.

Both Claxton and Solandt understood that scientists and engineers would have little influence in Canadian Cold War military modernization unless

DND created internal positions in which they could serve as advocates for new concepts. Further, the effective management of defence science and technology required leadership and authority similar to that found in the admirals and generals who commanded the armed services. Despite orders from the prime minister to get tough with the department and begin the massive post-war reduction of Canada's armed forces, Claxton remained committed to ensuring that defence research received proper support and funding, was provided with appropriate leadership, and was adequately organized and staffed. Senior-level support was critical to getting past the many obstacles placed in the way of creating a DRB.

Canada's assured access to outer space so early in the Cold War would have been impossible without its investment in defence science and technology. The tools needed for space flight and research were essentially converted weapons of war. Missiles carrying warheads became rockets carrying payloads. The defence research community also had the political and financial means to exploit this technology and transform space research from concept to reality. The DRB was therefore the only organization in Canada that could create the conditions for success; it could advance Canada's own goal to explore and defend the upper atmosphere and outer space as well as make a meaningful contribution to Cold War missile, rocketry, and space programs in the United States and elsewhere.

While the NRC struggled to extricate itself from the growing scientist espionage crisis, Omond Solandt began laying the foundation for the organization and activation of the DRB. From modest temporary accommodations on Slater Street in Ottawa, Solandt and his tiny staff of four, including a First World War veteran from the Veterans' Guard of Canada, compiled initial estimates for budget and staffing requirements, as well as a plan for the review of all existing and contemplated research projects from which recommendations would be made concerning the direction of the research effort. In February 1946, Solandt submitted a request to the Treasury Board for an initial budget of $1 million for defence research within the War Appropriations of 1946-47, over and above the request for $14 million already submitted by the research and development programs of the three services. The funds were to be largely invested in creating the initial facilities and staff with which to complete a survey of Canadian defence research during that year.[33]

Like any new organization, the DRB suffered endless growing pains as DND began reallocating ownership of defence research to it. From the outset, the DRB was faced with complications. The plan to spend all of 1946 in completing a survey and assessing the status and future direction of defence research in Canada was abruptly cut short when the Cabinet Committee on Defence made a hurried request to Solandt for a comprehensive policy paper on the subject no later than the end of April. The sudden announcement of an informal conference on Commonwealth defence science in London, England, during June 1946 demanded that Canada be prepared to table some form of policy during this event, but it had not yet even agreed on the basic principles such a policy might contain. Regardless, there was little time to spare; on 17 April 1946, after a concentrated effort, Solandt produced a draft paper for review titled "Policy and Plans for Defence Research in Canada." The document was discussed in detail at a Chiefs of Staff Committee meeting on 30 April.[34]

The first draft met with a generally cool reception from the committee, particularly from the chief of the air staff, Robert Leckie. A First World War veteran, Leckie had served as director of civil flying operations in Canada and as the commander of the Commonwealth Air Training Program during the Second World War. Appointed chief of the air staff in 1944, he was intensely loyal to the Royal Canadian Air Force (RCAF) and protective of its research and development programs.

Leckie and his technical staff were concerned that the proposed DRB organization was too ambitious and that its authority over each service's research and development programs would be too great. Although it was already agreed in principle that the DRB was to become responsible for all defence research and development, the three services attempted to stake new claims over their respective territories. As DRB official historian Captain D.J. Goodspeed later noted, the RCAF had a particular agenda, already planning for the development of jet engines and fighter aircraft designed and built in Canada.[35] A DRB with comprehensive powers and budgetary authority would interfere with this ambitious post-war agenda.[36]

At the conclusion of the meeting, it was agreed that a revised draft acceptable to all parties should be prepared as soon as possible. Solandt returned with a new paper the next week, yet only a portion of it was unanimously approved.[37] The document was amended, and a final version was approved and forwarded to the Cabinet Committee on Defence shortly after 14 May.[38]

Divided into three parts, the DRB Cabinet policy paper emphasized a number of key points that shaped the future of defence research in Canada. First, Solandt was firmly opposed to forming a static organization that would rotate around Ottawa and its bureaucracy. Although he acknowledged that Canadian efforts were not large enough to warrant separate establishments for research, development, and production, he recommended that DRB facilities in which these were combined should be located throughout Canada to best take advantage of its geographical situation. The choice proved both very popular and successful. As Solandt later reported, "When we were planning the DRB establishments after the war we definitely decided we were going to put them right across Canada, and looking back now it was a very wise decision."[39]

The policy document stressed other points as well. The DRB estimated that, because general war with the Soviet Union or its allies was at least a decade away, it could focus on long-term research and development without concerning itself too greatly with immediate requirements. And though the intent was to develop a completely independent defence research capability in Canada, the initial plan was to concentrate, not on everything, but only on those areas in which Canada had important original ideas or special interests, facilities, or resources to devote to a research problem.[40] To retain access to information on research in which the DRB was not engaged, Canadian military and civilian personnel were attached to other defence research facilities in both the United States and the United Kingdom to act as liaison officers and observers. The chief of the general staff – who felt that, were a major war to arise, Canada would fight alongside either its American or British allies – readily accepted this part of the policy.

Though accepted and ratified, a final part of the policy paper encountered strong opposition from the air staff.[41] In it, Solandt recommended that the DRB concentrate primarily on research, limiting its involvement in the engineering, design, and development stages of defence projects. Further, he suggested that the actual design and construction could take place outside of Canada. This point in particular upset the RCAF senior leadership. During the Second World War, Canada retained limited control over its aircraft design and development and had been unable even to secure Canadian-manufactured Hurricane aircraft for its own defence. As a result, having control over its own aircraft research, development, and procurement had become an article of faith for the RCAF.[42] Leckie and his successors, who had every intention of controlling the research and development for their next generation of aircraft, were reluctant to turn it over to a new Canadian defence research organization, let alone a foreign agency. Any thought of foreign control was anathema to their agenda.[43]

This highly contentious issue and its overall implications for the long-term health of the DRB deserve further consideration. The DRB official history and subsequent recorded interviews with Solandt by scholars suggest that his motive for pushing this policy was to prevent defence researchers from becoming immersed in the administration and bureaucracy of seeing a project through to completion. By allowing his scientists to focus on the fundamental aspects of research, choosing a small number of long-term projects that might take years to reach the design stage, he could provide them with an environment in which to conduct pure research rather than application. Although it was certainly favourable to the scientists themselves because it enabled them to pursue their own interests, this decision was an ill-planted seed that, twenty-five years later, would blossom into accusations of "irrelevance" and "goal displacement" from the federal Royal Commission on Government Organization. Ultimately, the DRB's intent to restrict its efforts to the purely conceptual and research stage contributed to its untimely disbandment.

The appendix of the policy paper suggested nineteen specific fields of research, including guided missiles, rockets, and meteorology. The first two of these fell within the domain of the army's armament research and development establishment, and the latter included investigations into the nature and composition of the upper atmosphere such as those projects already in place under Royal Canadian Navy (RCN) oversight at Fort Churchill. Like its allies, Canada sought knowledge on both rocketry and upper atmospheric conditions early in the post-war period, realizing the importance of both in the development of advanced weapons and defence systems. Canada became particularly proficient in the latter, so much so that the United States curbed its own efforts in the field and relied largely on Canada for data and information.[44]

The Commonwealth Conference on Defence Science, held in London, England, in June 1946, marked the first public announcement of Canada's post-war defence research policy. Despite being overtaken by events, Solandt and the Cabinet Committee on Defence had created a sound baseline document in a very short time that was well received by Canada's allies. At home, the new policy laid the groundwork for the creation of a permanent DRB staff and for the transfer of army, navy, and air force research and development establishments to its authority. Near the end of the year, the DRB had established its Personnel Selection Committee under the leadership of Otto Maas, Canada's wartime director of chemical warfare and explosives programs, and had made arrangements to retain the services of other valuable scientists already working at the Department of National Defence. Previously employed by McGill University's Chemistry Department, Otto Maas himself was appointed director of the DRB biological and chemical warfare research division in 1947.

Finally, the chief of the general staff initiated the legislation required to revise the 1927 National Defence Act to include the Defence Research Board. Despite continued resistance from the RCAF, the issue was put before the newly appointed minister of national defence, Brian Brooke Claxton, on 20 January 1947. A final bill designed to amend the 1927 act so as to include the formation of the DRB was introduced into the House of Commons on 7 February. The bill passed through the required three readings without great discussion or debate, and on 28 March 1947 the amendment became law. The Defence Research Board had achieved legal status and authority.[45]

The initial organization of the DRB clearly reflected its mandate and intent to become the centre of gravity for Canadian defence science and technology research. Under the chairmanship of Omond Solandt, the board was initially a loosely organized collection of advisers, laboratories, sections, stations, and research establishments scattered across the country and tied to any one of the three armed services. As an equal to the chiefs of staff and adjunct to the deputy minister of national defence, Solandt was supported by two deputies – a deputy director general and an administrative deputy. His immediate counsel also included a secretary of the board, scientific advisers from each of the three services, a project coordination section, and liaison offices in London and Washington. The DRB chairman also oversaw the Directorate of Research Personnel and the Directorate of General Services, both of which supported the many other groups under his stewardship.

A number of organizations formed the body of Canada's post-war defence research network. Existing facilities included the army's Canadian Armament Research and Development Establishment (CARDE) at Valcartier, Quebec, the Suffield Experimental Station in Alberta, the Defence Research Chemical Laboratories in Ottawa, the Kingston (biological warfare) Laboratory, the Radio Propagation Laboratory in Ottawa, the Defence Research Establishment at Fort Churchill (renamed the Defence Research Northern Laboratory in 1947), and the Naval Research Establishment at Halifax. Other cells included the Weapons Research Section, the Electrical Research Section, the Special Problems Research Section, the Biological Research Section, the Naval Research Section, and the Scientific Intelligence Section. Additionally, the DRB formed or co-chaired a number of advisory defence research and development committees between Canada's own armed services, as well as cooperatively with allies.

When the DRB was formed, its various organizations employed roughly a thousand personnel, including two hundred scientists and between thirty and forty technical officers. In 1947 and 1948, approximately $4 million was expended on research and development, an amount that quadrupled in the years 1948-49, when materials, supplies, equipment, and salaries were added to the budget. Defence research expenditures continued to increase between $7 and $10 million a year through to 1956 and 1957, a definite indication of Canada's strong commitment to defence science during the early part of the Cold War. More importantly perhaps, the creation of the DRB clearly signalled Canada's intent to take defence research seriously and make a solid contribution to its own strategic interests as well as those of its allies.[46]

Cold War and Hot Physics

Canada worked aggressively to safeguard its post-war sovereignty with a robust and self-focused national security policy. Although it certainly supported the ideals of multilateralism and collective security through the newly created

United Nations, it also ensured that its own interests were being met through the establishment of regional or bilateral security arrangements with its allies.[47] Canada joined other Western nations to form the North Atlantic Treaty Organization (NATO) in 1949 and sought to strengthen its bilateral defence and production ties with the United States throughout the early 1950s. Even increasing anti-American political rhetoric did not deter the government from solidifying a NORAD agreement with the United States in 1957 or the ultimate acceptance of American nuclear weapons into the country soon afterward. It is important to note also that the success of many of these and other Cold War security arrangements was dependent on the development and sharing of advanced defence science and technology.

Like their counterparts in countries allied with Canada, Canadian strategic planners considered how science and technology might play a role in security. Early DRB agendas emphasize those areas in which Canada's military research was strong and in which it could achieve and sustain success.[48] Although Cabinet, DND, and the DRB all understood that the implementation of a large-scale military-industrial production complex similar to that taking shape in the United States was plainly out of the question, ways were sought to maximize those capabilities currently within reach. Interestingly, the science and technology expertise included some if not all of the most dangerous elements of future Armageddon – namely, physics, chemistry, electronics, rocketry, missiles, biological agents, chemicals, and even atomic weapons.

Among the many disciplines that led Canadian defence research toward the threshold of outer space, physics played the dominant role. Here, Canada's expertise was considerable, and the country's scientists had made major contributions to allied wartime programs in ballistics, radar, and atomic energy. They were also considered world experts in the study of the effects of the upper atmosphere on radio and communication, a field that Canadian researchers had investigated throughout the twentieth century.

On 12 December 1901, Guglielmo Marconi received a Morse signal in Newfoundland from a transmitter in England, 2,900 kilometres away. At the time, no one could explain how this was possible, as no one understood how radio waves could travel over the horizon. The following year, two scientists, an American named Arthur Kennelly and an Englishman named Oliver Heaviside, suggested that the radio waves travelled great distances because of the existence of a conducting layer somewhere in the upper atmosphere that reflected them. Their ideas prompted a long series of studies and debates over the definition, origin, and nature of what for many years was known as the Kennelly-Heaviside layer and was later named the ionosphere.

The ionosphere is simply the region of the earth's atmosphere where there is a significant concentration of ions. The region has no definite boundaries; rather, it is a dynamic area anywhere from sixty kilometres to approximately ten earth radii out into space where neutral particles are ionized and subsequently combine into neutral particles again. The degree of ionization depends on a number of factors, such as solar radiation, atmospheric composition, pressure, and temperature. The ion concentration maximum, also known as the electron number density maximum, is typically located at approximately three hundred kilometres from the surface of the earth.[49]

At first, very little detailed study of the ionosphere was undertaken in Canada, but after the introduction of wireless communications, a greater comprehension of its effects became essential to understanding and predicting its impact on radio waves and wireless radio traffic. In the mid-1920s, American scientists G. Breit and M.A. Tuve produced the pulse ionosonde, a tool that revolutionized ionospheric research in the United States and Canada. Essentially a radio transmitter and receiver, it allowed the user to deduce the height of the radio-wave-reflecting level by illuminating the ionosphere with short pulses and noting the time difference between transmission and the return of an echo. Also, the particular frequency was determined by the degree of ionization at the reflecting level, which, when combined with the pulse delay, provided the user with the height level in the ionosphere of that particular electron number density, as well as the frequency required to propagate through it relatively unaffected.[50]

Advanced Canadian research and analysis of the ionosphere began with the influx of federal funding and support during the Second World War. In 1941 the National Research Council constructed an ionosonde at Chelsea, Quebec, operated under the direction of Frank T. Davies, an experienced scientist then employed with the Operational Intelligence Center of the navy. Davies' tasks were to record constant measurements of the ionosphere and predict optimum operating frequencies for military communications. Canadian ships protecting convoys and chasing German submarines in the North Atlantic utterly depended on timely communications, making it essential that the link remain uninterrupted as much as possible. Davies' initial research effort was so successful that further installations were built, including one by the American Carnegie Institution at Clyde River, Baffin Island. In 1943, along with Lieutenant J.H. Meek, who was the superintendent of the NRC Radio Propagation Laboratory, Davies installed another ionospheric station at Cape Merry. By then, Davies and Meek were responsible for overseeing the training and inspection of all stations, including those in Canada staffed by members of the US military. In 1945 seven stations were located across the country.[51]

Figure 1 Frank T. Davies (1904-81) served in naval intelligence during the Second World War, pioneered the Defence Research Board's Radio Physics Laboratory, and was chief superintendent of the Defence Research Telecommunications Establishment from 1951 to 1969. Communications Research Centre, 69-17720.

Ionospheric research in Canada continued after the end of the war. Canada had attained considerable recognition and reputation among its allies as a leader in this field, and both the United States and the United Kingdom took a serious interest in supporting further efforts after the war. In 1946 the Radio Propagation Laboratory assumed the lead in advancing Canada's research activities, and the Department of Transport took over the operations and staffing of the existing ionospheric stations.[52] Meanwhile, three additional stations were built, one each at Baker Lake, Resolute Bay, and Fort Chimo. With the transfer of the

Radio Propagation Laboratory and its cousin organization, the Radio Wave Propagation Committee, to the Defence Research Board in 1947, Solandt recommended that the time had come for a considerable expansion of the facilities and funding then devoted specifically to Canadian ionospheric research. The decision was timely. In late 1947, the US Department of State requested a technical conference with Canada to discuss options for the expansion of ionospheric research, resulting in further recommendations from the DRB to the Cabinet Defence Committee for new and improved research stations all across the Canadian Arctic.[53]

Encouraging such an investment was grounded in very clear reasons, which are critical to understanding the desire for the advancement of upper atmospheric studies in Canada within the larger context of the Cold War. Both the United States and Canada predicted that any Soviet attack on North America would travel via the shortest route, over the North Pole. Early warning against such an attack would thus depend greatly on systems capable of detecting and identifying bombers and intercontinental ballistic missiles (ICBMs) well before they reached Canada's Arctic borders. ICBMs presented a particular detection challenge because the speed and trajectory of their flight sent them into space before they came down onto their target. The design of systems to detect any incoming threat early enough to react to it required a substantial knowledge of the atmospheric conditions that might affect the calibration and operation of the detection system. Essentially, if North America were to be defended against Soviet attack, more knowledge of the physical environment was needed.

Canada had other strategic motives for expanding its expertise in atmospheric research. The physical attributes of the atmosphere in the Canadian North, which were affected by the proximity of the North Pole, the situation of the North Magnetic Pole entirely within northern Canada, and occurrences such as the aurora borealis, presented unique challenges for technologies dependent on radio waves, particularly electronics and communications. The large expanse of Canadian territory and its relatively small population, approximately 17 million in the 1950s, implied that robust long-range communications would become essential to any defence of the country in the case of war and any development of the country during peacetime. Moreover, it was unknown what effects the upper atmosphere might have on advanced aerodynamics, on jet or nuclear propulsion, or on unmanned objects such as guided missiles and rockets. The sound barrier had only just been breached in October 1947, and the effects of supersonic flight on machines, let alone human beings, were still being discovered. Obtaining answers to these and other questions about the Canadian environment ultimately provided considerable value to the development of defence and sovereignty.[54]

Figure 2 The original Defence Research Board Radio Physics Lab in Ottawa, about late 1950s, where many of Canada's military space projects began. It was here that defence scientists and engineers pursued studies of the ionosphere and concepts for Canada's own satellites. Communications Research Centre, 51-RPL-0169.

Upper atmospheric studies in Canada were formalized in February 1951, with the creation of a new suborganization within the DRB known as the Defence Research Telecommunications Establishment (DRTE), which came under the superintendence of Frank T. Davies. Essentially an amalgamation of the Radio Propagation Laboratory and the Defence Research Electronics Laboratory, the DRTE joined the ranks of the ever-expanding DRB as its primary telecommunications research facility.[55] In the DRTE, atmospheric study and analysis was a central focus, as the distribution of its scientific personnel demonstrated.

The DRTE consisted of two primary suborganizations – the Radio Physics Laboratory (RPL) and the Electronics Laboratory. The former, previously the Radio Propagation Laboratory, came under the direction of James C.W. Scott and consisted of six subsections, including theoretical studies, atmospheric physics, radio prediction, and three specialized radio propagation units (high frequency, low frequency, and microwaves). The Electronics Laboratory, under the direction of J.W. Cox, consisted of five sections, including transistor research,

FIGURE 3 Canada's space pioneer. A leading figure in the development of the country's space program, John H. Chapman of the Defence Research Telecommunications Establishment points to a detail on the Alouette I backup satellite. Communications Research Centre, 62-6660.

radio warfare (known today as electronic warfare and countermeasures), components research, navigation research, and radar research.

In 1954 the DRTE underwent a modest reorganization of its radio and electronic research sections to include a third suborganization, the Communications Wing, under the direction of John Herbert Chapman, a recently hired postgraduate.[56] The son of a military officer, Chapman was born in London, Ontario, on 8 August 1921. He became interested in radio and physics at an early age, and during the Second World War, he served as a radar technician with the RCAF in both Africa and Europe. Returning to Canada to complete his studies, Chapman took a master's degree in physics in 1949 and a PhD in 1951, both from the Eaton Electronics Research Laboratory at McGill University. At the DRB, Chapman's new group augmented existing research in radar and applied propagation, as well as focusing on new communications-specific research and development.[57]

The RPL concentrated on a number of projects, giving serious attention to the analysis of auroral disturbances, such as the aurora borealis, that were particular to Canada's northern regions. Under the direction of two scientists, Raymond Montalbetti and W. Petrie, the RPL designed a set of tables to predict the potential impact of ionospheric activity on radio wave propagation for use by the navy. In addition, it tested new communications systems, studied the effects of lightning on radio waves and of birds on radar screens, and directed the research, development, and construction of Canada's first Cold War early warning defence system. Named the McGill Fence early warning line but more often referred to as the Mid-Canada Line, this system employed technology developed at McGill University in Montreal. Its construction began in 1954 and was completed in 1957 at a cost of $250 million. The line consisted of a chain of ninety-eight radar stations, mostly unmanned, along Canada's fifty-fifth parallel. It operated until its closure in 1965, when its function was replaced by newer systems.

With the RPL focused on the ionosphere, the Electronics Laboratory remained largely engaged in standardizing the communications requirements of the three services until 1951, when the initiation of the Velvet Glove air-to-air guided missile program required it to shift most of its support to this new weapons program. Although the lab continued a limited involvement in other missile- and space-related activities, the complexity of the Velvet Glove technologies preoccupied much of its effort until the project concluded in 1954.

The International Geophysical Year

Upper atmospheric research and space science advanced rapidly during the 1950s, eventually leading the Soviet Union and the United States to launch man-made satellites into space in 1957 and 1958. Although the political implications of taking upper atmospheric research to the next level were most germane for the two superpowers, Canada was a key player in the military and scientific aspects of these events. Closely associated with American efforts to gain significant knowledge of the earth's polar regions and to push space science into orbit, Canada's own efforts and cooperation were critical to US security and success at its earliest stages of space flight.

Interestingly enough, the idea of an International Geophysical Year (IGY) was born during a 5 April 1950 dinner party held in Washington, DC, to honour the visit by Sydney Chapman, the renowned British geophysicist.[58] During the evening, Chapman and his colleague Lloyd V. Berkner, a noted American radio scientist and security adviser to the US Department of State, proposed a third International Polar Year.[59] The period chosen for the event was 1957-58, as this followed the previous IPY of 1932 by exactly twenty-five years and was also near a time of maximum solar activity. However, the event was known as the International Geophysical [instead of Polar] Year so as to reflect the advances in the scientific field.

Yet there were other motivations as well. In 1950 the US government was about to release a science and foreign relations report authored by Berkner that strongly emphasized the military and diplomatic importance of the polar regions. The report made the obvious statement that "certain definite benefits which are highly essential to the security and welfare of the United States, both generally and with respect to the progress of science, stem from international cooperation and exchange with respect to scientific matters," and its classified supplement stressed that increased American contact with foreign scientists would be of importance to US intelligence collection.[60]

The primary American agency overseeing the evolution of the IGY agenda was the V-2 Upper Atmosphere Research Panel, a group of military and university interests responsible for the first US sounding rocket program. From 1950 onward, the panel held a number of meetings with American and international scientists to discuss potential IGY activities. Canadians were often invited to these early events, though their participation on committees was formalized only after an agreement was put in place to establish a large research rocket range at Fort Churchill. In 1953 the panel formed a Special Committee for the IGY to work with the American National Research Council to oversee the development of the Fort Churchill site. With assistance from the council's Technical Panel on Rocketry, plans were executed to have the US Army set up an Aerobee rocket tower and a Nike-Cajun launcher at the Defence Research Northern Laboratory (DRNL) station.[61]

In Canada, Donald C. Rose, a scientist with the NRC Physics Division and chairman of the Canadian Organizing Committee, directed IGY activities, with several projects dispersed among many research bodies and universities.[62] Both the DRB and the NRC were engaged in a number of assignments; the DRB was concentrated at Fort Churchill, and the NRC supported various projects across the country. Interesting among the latter was the work of the NRC's Upper Atmosphere Research Section, which was headed by Peter Millman, an accomplished meteor astronomer previously employed with the RCAF. Using visual observation and radar, Millman's research teams collected a range of data on meteors entering the atmosphere at high speeds. Millman discovered not only that meteor trains were persistent visually but also that they maintained "visibility" to radar for some seconds after they entered the atmosphere. He assumed that this was caused by ionization created in the upper atmosphere as the object lost material. Using these techniques in combination with radar observations of the backscatter of echoes, Millman's teams were able to ascertain

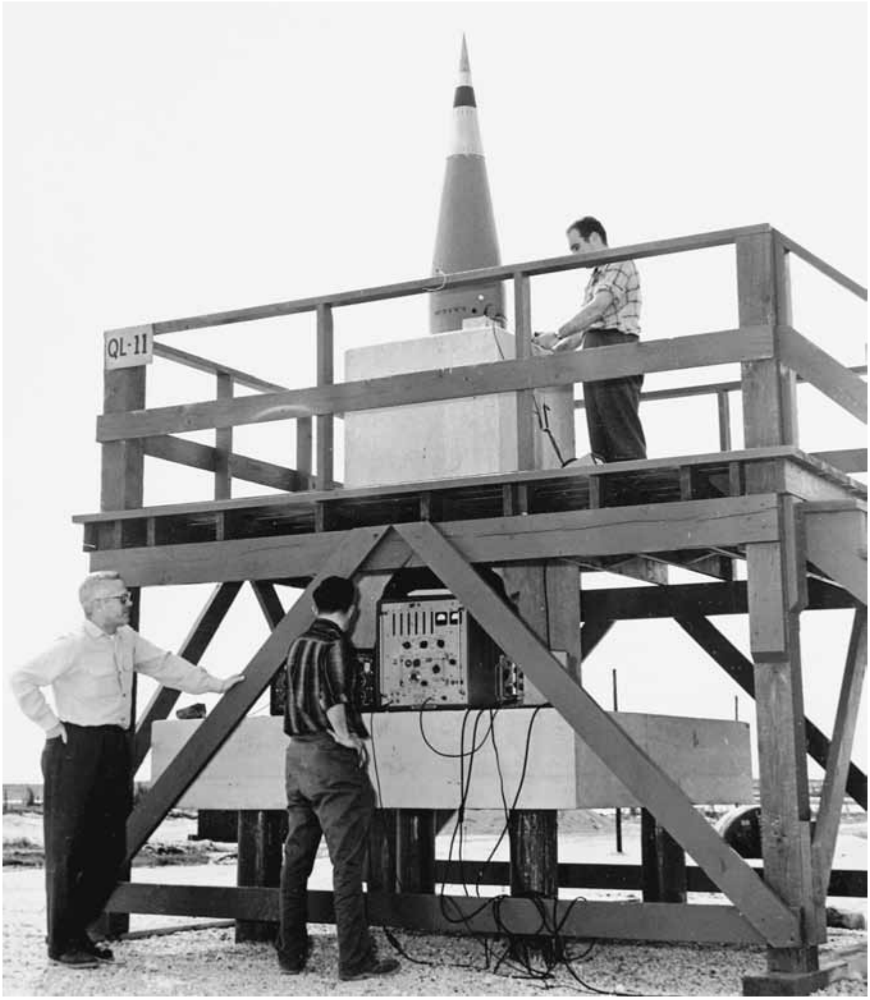

Figure 4 Testing an Aerobee 150 rocket. Communications Research Centre, 72-25814.

the velocities of large numbers of meteorites. Presumably, similar techniques might later have been applicable to the detection of man-made objects re-entering the atmosphere.[63]

The primary DRB objectives for the IGY included the use of a wide variety of rockets to investigate spectroscopic and ionic characteristics of the upper atmosphere.[64] Two of these rockets were instrumented by CARDE personnel to measure infrared background levels of the upper atmosphere at altitudes up to about 250 kilometres. Although these were perhaps a minor accomplishment

Figure 5 Moving an Aerobee 150 to the launch tower. Communications Research Centre, 72-25817.

compared to the American and Soviet satellites then being launched, their deployment marked the first time that Canadian instruments were carried beyond the atmosphere.[65]

The arrival of IGY activities at Fort Churchill completely altered its organization and infrastructure. In early 1956, after many years dedicated to the material testing of equipment and processes for soldiering in extreme environments, the DRNL ended its seven-year partnership with the Operational Research Group and the Biomedical Sciences Group at Fort Churchill to prepare for its new assignment of undertaking geophysical research. As these two former organizations prepared for departure, the DRNL initiated a survey of potential sites for the installation of equipment to take measurements of the ionosphere, which would be employed by Montalbetti's RPL scientists and the University of Saskatchewan. Along with the American rocket launch sites, four other sites were needed for the outlying Canadian ionosphere-measuring stations. Three of these were located south of Fort Churchill, and one was placed to the north. Two

Figure 6 Donald C. Rose served as the first chairman of the Associate Committee on Space Research, Canada's first organized space exploration policy group. National Research Council Archives.

were outfitted with special cameras employing the parallactic photography technique to measure the height of auroral displays, whereas the other two were equipped with an auroral recorder, a magnetometer, and an all-sky camera.[66]

Overall, the IGY was a tremendous success for everyone involved. The range of activities and the data collected contributed enormously to the nascent rocket and space programs then under way and, equally importantly, demonstrated the many possible fruits of labour that awaited innovative countries in the exploration and exploitation of outer space. For Canada, the IGY served as a validation of its emerging scientific and technological capabilities as well as an indicator of what might be achieved if it remained committed to such endeavours. Only time would tell.

The IGY had also demonstrated the high degree of cooperation built up between the United States and Canada in both space science and technology, specifically rocketry. It set the foundation for even greater Canada-US space cooperation in the years to come. Thus, as the IGY wrapped up at the end of 1958, the DRB sought to enter into formal negotiations with NASA regarding an even more ambitious ionospheric research project. The idea? To design and build the next experiments into a Canadian satellite for launch into outer space.

Standing on the Threshold of Space

Because of national security considerations and its commitment to the advancement of defence science and technology, Canada achieved considerable success in developing its upper atmospheric program during the first decade after the Second World War. From a rather conservative beginning, Canada took advantage of its post-war security situation to create the necessary means with which to research and develop space-related technologies, and to employ its limited yet highly professional resources to gravitate toward the centre of rapidly evolving Western space-related activity, usually in the United States. Further, nothing suggests that this trend was accidental: instead, an analysis of events has shown that it was a well-orchestrated manoeuvre on Canada's part, one representative of what would eventually become its modus operandi for gaining access to American rocketry and space ventures.

Canada's significance to the construction of US post-war security provided it with a considerable opportunity to advance its own rocketry and space science agenda. From the beginning of the Cold War, the United States needed access to Canadian territory and Canadian science to develop its technological response to the growing fear of Soviet Armageddon. For its part, Canada was prepared to cooperate to meet its own national security interests, but more importantly, Ottawa's commitment to post-war scientific and technological innovation in defence gave the country the means to take advantage of the evolving strategic situation. Participating in both bilateral defence cooperation and international scientific programs during the 1950s enabled Canada to demonstrate the maturity of its resources and ultimately to leverage those capabilities and its other defence contributions into negotiating its very own satellite project.

At a time when only the two superpowers had the means to break away from Earth's gravity, and only these two nations plus Britain had seriously contemplated launching satellites into space, here was Canada subtly making itself the obvious best option for the continued study of the upper atmosphere – if it had access to certain additional resources. Fortunately, these resources, such as launch facilities, could easily be provided by the US Department of Defense. As a result, Canada became an early party to the exploration and exploitation of space, something that, for most nations, remained the stuff of science fiction.

During this period, other Canadian ventures benefited from the strategy of parlaying limited resources into achieving much larger objectives. What has not been previously identified, however, is that the country employed this tactic to ensure that, at the end of the 1950s, it was well positioned to play a leading third-party role as the world stood on the threshold of space.

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