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# Forging a Space Nation: Policy and Program Development, 1957–1963

Canada entered the space age optimistic yet also uncertain about the role that rocketry and satellites would play in the country's future. National security and the threats of the Cold War dictated the immediate priorities of the space race, and for Canada the situation was at first no different. Projects such as those then under way at the Churchill Research Range, the Black Brant rocket project, the upcoming *Alouette* satellite project, and the Royal Canadian Air Force (RCAF) Space Development Plan were all born out of the Cold War space race between the United States and the Soviet Union. Apart from their obvious connection regarding defence science and technology applications, however, each of these projects evolved in relative isolation of each other, and were not considered equal or mutually inclusive parts of an overall national strategy for Canadian long-term rocketry and space development.

In fact, despite several proposals put forward by the Defence Research Board to organize and coordinate Canada's space activities more carefully, a general lack of knowledge amongst senior political leaders as to the potential long-term impact of space exploration and technology exploitation, and the distraction of more pressing domestic policy and government reorganization issues, resulted in little top-level direction for a formalized national space plan. Further complicated by competing agendas and political conflict between Canada's scientific, defence, and government communities during this period, Canada's rocketry and space program advanced not under a collective umbrella as many of its advocates had hoped, but rather in a piecemeal fashion that at times appeared disjointed, and which had serious ramifications for its future direction in the 1970s and beyond.

## A New Space Agenda?

As Canada neared its own entry into the space age, many of those who guided the country through its first decade of post-war technological modernization retired from their posts. At the highest levels, Lester Pearson's Liberal Party lost the 1957 federal election to the Progressive Conservatives under John George Diefenbaker, and this would have a considerable impact on the formative years of Canadian rocketry and space activities. His party



A.B. Godefroy, *The Canadian Space Program*, Springer Praxis Books,
DOI 10.1007/978-3-319-40105-8_2

came to power just as the space race began in earnest, and much of his country's early space development depended on the health of its relationship with the United States. Diefenbaker, however, came to power on an anti-American platform and seemed little interested in outer space or space cooperation with America unless he could draw good personal publicity from it.[1] Diefenbaker was observed to mishandle Canada's current space activities and future plans in his public speeches on many occasions, and was often accused by the scientific and engineering communities of deviating from facts or announcing new initiatives without substance or understanding of the details in order to simply make a splash with his audience. Further limited in his own knowledge of science, technology, and international relations while other members of his Cabinet had little or no knowledge of rocketry and space developments at all, Diefenbaker nevertheless assumed personal control of the critically important foreign affairs portfolio after coming to power rather than leaving it to the existing civil service deputy ministers, whom he greatly distrusted.

In 1959, Diefenbaker replaced himself in this portfolio with his Minister of Public Works, Howard Green. A veteran politician and confidant of Diefenbaker, but by no means adept at foreign affairs, Green was no better a choice to grapple with the issues of the space

Fig. 2.1 John G. Diefenbaker, seen here with U.S. President Dwight Eisenhower, served as Canada's Prime Minister from 1957 to 1963, critically shaping official space policy and programs during its early years

[1] File 12798-4-40, Vol.1, RG 25, LAC.

race and understood too little, if anything, about outer space beyond it possibly becoming a future battleground between the superpowers. To this end, he encouraged political initiatives that advocated for more international control of outer space without ever really understanding what or how exactly such a situation might influence Canada's own interests going forward.

Disappointments within the Canadian space community soon followed. Notwithstanding the considerable evolution within the scientific and technological communities, the political importance of space and its technological development in Canada remained unappreciated by Diefenbaker's government. For example, the Prime Minister rejected informal proposals from his senior ministers and advisors for the appointment of a science advisor within Cabinet (something similar to James Killian's recent appointment as special assistant for science and technology to the Eisenhower presidency in the United States), and remained opposed to enlarging the office of the Prime Minister with any additional bureaucratic advisors, scientific or otherwise.[2] He also seemed little interested in supporting technological development and engineering, and personally cancelled a number of high-profile national technology efforts early in his tenure, including the infamous Avro Arrow fighter interceptor as well as the national High Energy Project. The general consensus among later historians remains that Diefenbaker made science and technology in Canada a low national priority.[3]

Still, despite political inactivity, overall Canada was investing more in science and technology. By 1961, federal expenditures alone on science and technology development activity exceeded $220 million, almost seven times the amount the country was spending at the end of the Second World War. Nearly 18,000 Canadians worked in professional scientific and technology organizations, which themselves had also greatly multiplied as the country's population and economy grew. This assembly of new scientifically-oriented establishments, however, was represented within Cabinet by only two small committees, the Privy Council Committee on Scientific and Industrial Research and the Advisory Panel for Scientific Policy. Neither was very effective in being taken seriously by the senior political leadership, nor at advocating for space projects beyond those seen as contributing directly to national defence.

Keeping track of space developments within Canada's government at the end of the 1950s ultimately fell to Norman Robertson, a veteran diplomat then recently appointed back to Ottawa as Canada's Under-Secretary of State for External Affairs. Having previously served as Ambassador to the United States, Robertson had some experience in dealing with missile, rocketry, and space issues, but without any ministerial oversight within Cabinet he relied heavily on the chairmen of the NRC and the DRB for advice on this subject. Robertson's attention to every aspect of Canadian statecraft ensured that space activities would not be entirely ignored by the decision makers, but at the same time little more than passing attention could be expected given that it was not perceived to be a high priority with Diefenbaker's government.

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[2] G.B. Doern. *Science and Politics in Canada.* (Montreal and London: McGill-Queen's University Press, 1972), p.144.

[3] Ibid.

Pearson's Liberal party returned to power in 1963, albeit with only a minority government. While certainly better prepared and equipped to handle nearly all aspects of Canada's international affairs – including that related to science, technology, and space programs – neither Pearson nor his Cabinet seemed particularly any more interested than their predecessors in developing a national space agenda or policy.[4] After 1963, the Pearson government turned away from many international issues dealing with science and technology, as internal government reorganization and professionalization of its civil service became a top priority and captured most of the leadership's attention.[5] As Canadian political scientist Bruce Doern later noted, "…Pearson's views of science policy tended to be characterized by a genuine, but superficial, belief that science had to be given greater structural recognition in the inner circles of decision making. Pearson's ultimate agreement to create a Science Secretariat and a Science Council seems to have been the product of internal advice…rather than any indigenous initiative developed by Pearson and the Liberals in their opposition days…". Even under new leadership, Canadian science and technology policy, and thus space policy, was still left to the subordinates of government departments to guide and develop.

The first appointed director of the newly-created Science Secretariat, Dr. Frank A. Forward, rarely met with the Prime Minister and had little influence in shaping the country's national science programs. In fact, from his initial appointment on April 30, 1964 to May 1965, he alone comprised the entire membership of the secretariat. Though he received three deputy directors, an executive secretary, and a small professional staff from June 1965 onwards, all of Forward's efforts during the next year were focused on special studies, legislative studies, and reviews of science policy in other countries rather than advising the Prime Minister on a national scientific strategy for Canada. "The attitude of Pearson, to both the place of science and the need for advisors", observed Bruce Doern, "seems to have been one of general sympathy and benevolent encouragement, without much of a disposition for the machinery itself."[6] Yet another organization, the Science Council of Canada, replaced the existing Science Secretariat on May 12, 1966, and Dr. Forward left his brief post as Canada's top scientific advisor having made very little difference to the country's national rocketry and space agenda.

Pearson remained in power until his own retirement from politics in 1968, but during his tenure Canada's own space policy did not congeal as many had hoped it would. The absence of a clearly-defined mandate or ministerial advocate during both Diefenbaker's and Pearson's terms resulted in a disjointed approach to research and development, as the formation of policy and programs was left up to the discretion and competing

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[4] Despite holding office at a remarkable period in the space race, there is not a single mention of space activities in Pearson's official memoirs. See Rt. Hon. L.B.Pearson, *Mike: The Memoirs of the Rt. Hon. Lester B. Pearson.* 3 vols. Toronto: University of Toronto Press, 1975.

[5] Canada returned to international space issues when it signed and ratified the 1967 Outer Space Treaty and the 1968 Rescue Agreement.

[6] Doern, G.B. *Science and Politics in Canada*, p.145. Doern's work on science policy and politics was published in 1972, soon after these events took place. He had considerable direct and confidential access to many of those involved in the decision-making process, and his views should be considered authoritative in the absence of other published sources.

agendas of those agencies actively engaged in developing space projects. Yet even within these agencies changes of the guard were taking place amongst those who had chosen the original course, and those who followed brought their own new spin on the direction and priority of Canada's future space efforts.

Both the NRC and the DRB also came under new leadership during this period. Dr. E.W.R. "Ned" Steacie, Director of the Division of Chemistry, succeeded Dr. C.J. Mackenzie who retired from his chairmanship of the NRC in 1952. C.J. Mackenzie was the wartime defence science guru with close friends in Cabinet and considerable influence with the government. Dr. Steacie was a very different character, generally distrustful of any government involvement in scientific affairs, much less diplomatic, and not afraid to accuse the politicians of trying to give directions in a field where Steacie felt they had little understanding or right to meddle. Under Steacie's brief appointment as chairman, the NRC often was at odds with the government on issues dealing with national research and development.

Fig. 2.2 Dr. Edgar William Richard 'Ned' Steacie served as President of the NRC from 1952 to 1962, and was a key figure in early Canadian space science policy development

Similarly, at the DRB, in 1955 Dr. Omond Solandt retired from his post as chairman and was succeeded by Dr. A. Hartley Zimmerman, who was then serving as vice-chairman of the board. Dr. Solandt had founded the DRB and shaped it during its first post-war decade, but Zimmerman was not an original member of the defence research establishment and only joined the DRB in 1951 as the Department of Defence Production representative to the board. Made vice-chairman of the DRB in 1955, he formally took over from Dr. Solandt the following year. Also, whereas Dr. Solandt was a trained scientist, Dr. Zimmerman was an engineer, and his post-war perceptions of science and technology were shaped by his return to civilian business after the war, not by national level programs in research and development. The result was a pragmatic but at times short-sighted chairman whose approach to running the DRB favored immediate and predictable returns from programs such as Alouette satellite program over supporting long-term and perhaps riskier research and development goals such as an indigenous launch capability.

## Reaction to the Sputnik Spaceflight

The Canadian public was no less surprised than the American public when it read on the front pages of newspapers across the nation on the morning of October 5, 1957 that Russia had successfully launched the first manmade object into orbit. For readers of the Toronto daily *Globe and Mail* in particular, the front page was also filled with irony. Just below the news outlining the success of *Sputnik*'s spaceflight was a story and photo detailing the rollout of the first Canadian super jet fighter interceptor, the AVRO CF-105 *Arrow*. Across Canada's breakfast tables, readers read about the advent of one technological wonder as it foreshadowed the demise of another.

The reactions of Canadian and American leaders to the Soviet launching of *Sputnik* seemed incredibly different. Though senior American politicians and advisors were not necessarily surprised that a satellite had gone into orbit (recall that the United States had planned to launch a satellite as part of the IGY), they were considerably impressed by the technological magnitude of *Sputnik*. The United States was concerned that the success of *Sputnik* suggested that the Russians had developed an ominous capability to launch nuclear weapons over great distances, far enough to reach North America, or even put them into orbit. As a result of Moscow's achievement the United States brought a science advisory capability right into the White House itself so that President Eisenhower could have immediate consultation on matters related to science and defence.[7] In contrast, there is little to suggest that Canada's government was equally concerned about Soviet technological achievements. Neither Diefenbaker nor Pearson nor Pearson make mention of the

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[7] Dr. J. Killian. *Sputnik, Scientists, and Eisenhower* (Cambridge: MIT Press, 1977), p.2. Dr. Killian, the first special assistant to the President for Science and Technology, later noted in his memoirs, "That a satellite had gone into orbit really did not surprise me…the real significance of the news for me lay in two words: 'Russian' and '184 pound'." By contrast the first American satellite, *Vanguard*, weighed in at roughly just over three and a half pounds.

event or its potential implications for Canada in their memoirs.[8] As well, Cabinet records reveal no significant decisions or statements regarding the Russian launch, and there is no serious mention of outer space in the House of Commons debates until the following year.[9] Diefenbaker did not appoint any additional specialized scientific counsel, although arguably he already had the Privy Council Committee on Scientific and Industrial Research and the Advisory Panel for Scientific Policy, as well as the senior leadership of both the NRC and DRB at his disposal. Similarly, the government did not indicate at first any plans for an organized response to the Russian event. The aloofness of Canada's government to such a monumental historical event is curious and lacks simple explanation.

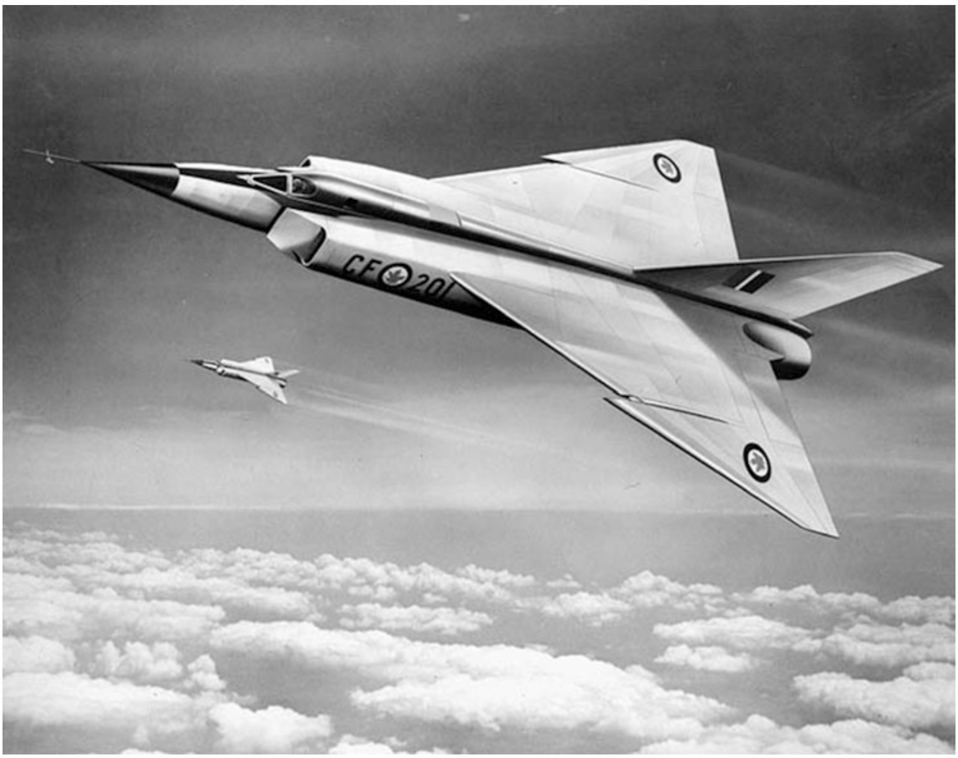


Fig. 2.3 Designer's concept illustration of the AVRO Arrow CF-105 fighter

[8] For Pearson's account of the period, see Rt. Hon. Lester B. Pearson, *Mike: The Memoirs of the Rt. Hon. Lester B. Pearson, Vol.2 1948–1957*. (Toronto: University of Toronto Press, 1975); see also Rt. Hon. John G. Diefenbaker, *One Canada: Memoirs of the Right Honourable John G. Diefenbaker,* 3 vols. (Toronto: Macmillan of Canada, 1976).

[9] Canada. House of Commons Debates Index 1957–1958.

Still, not all parties within government showed complete disinterest. Within Canada's defence research community, for example, there was a real concern amongst the senior staff over the implications of recent Soviet missile and space achievements, because the scientists and engineers knew better what the Russians had truly accomplished. "The announcement of the first flight testing of the Russian ICBM on 26 August, followed on 4 October by the launching of the first man-made satellite," noted one DRB scientist in a secret internal report to fellow board members, "has not only pointed up the illusion of believing that the West has a well-established technical superiority, but in fact stresses the urgency of developing a thoroughly realistic approach to all of the complex problems of the next six, eight, or ten year period, in as short a time as possible."[10] The DRB staff was also concerned about keeping pace with Soviet resources, research, and development. "If the USSR maintains her output of scientists and technicians at the present rate, the race will be lost to the West in point of numbers", the same report noted, "Our hope must therefore lie in conservation of effort and concentration on high quality."[11]

Quality came at a price, however, and Canada's Defence Research Board was increasingly struggling to meet the large debts it constantly incurred in the pursuit of research and development of high technology. The government's ongoing cuts to Canada's defence spending heading into the 1960s in the face of increasing salaries, wages, construction, and equipment costs, was hard felt at the Defence Research Board. In the 1956–1957 fiscal year, approved salary increases alone cost the DRB $1.3 million in funds it had originally allocated towards research. The additional costs were not covered by the DND, of course, and instead were covered by deferring all new construction including a much-needed wind tunnel, reducing contracts with industry, and restricting the purchase of essential laboratory equipment required for proposed new programs including many space research projects. Overall, the situation was not overly promising at the time.

Nevertheless, the importance of missile, rocketry, and space research did not entirely escape senior-level planners at the DND. From a purely military perspective, the protection of Strategic Air Command (SAC) bases in North America by means of an integrated Canadian–U.S. air defence plan remained a priority and this would eventually include proposals for an anti-ICBM system. Similarly, strategic surveillance and reconnaissance was essential to early warning, intelligence analysis, and force protection, and this capability was rapidly transitioning towards secret space-based platforms. The DND needed to be able to defend against missile and space-based threats, if for no other reason than the fact that one plausible scenario for a Soviet attack on the United States indicated that it would likely be met somewhere over Canadian airspace. Yet before military planners could proceed with preparations and training, they needed clear policy guidance from Cabinet and the Privy Council on what Canada's missile and space priorities would be. Was Canada's DND expected to prepare for an imminent Soviet attack, or was it reasonable to assume that the United States would provide protection for Canada and Canadian assets and facilities essential to their own survival? Therefore, defining a space strategy was the first challenge to the evolution of Canada's defence and civilian space programs going into the 1960s.

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[10] Memorandum (secret) 'Some Factors Affecting Defence Research Policy – A Report to Board Members, October 1957', dated October 23, 1957. File DRBS 173-1 (CDRB), RG 24, LAC.

[11] Ibid.,p. 4.

Fig. 2.4 A Royal Canadian Air Force CF-100 returns to Ascension Island after completing a mission to collect U.S. ballistic missile re-entry data. Canada was heavily involved in such projects throughout the 1950s and 1960s

## Early National Agendas for Space

From the outset, Canada's own rocketry and space policy options were limited by politics and the size of its economy. Unwilling and unable to keep technological pace with the rapidly-expanding agendas of either Russia or the United States, Canadian political decision makers sought instead to build a modest yet relevant space program through the development of niche capability, leveraging cooperation with the Americans, and increasing Canada's own influence in international space cooperation and control by attempting to impose itself as the champion of all third-party space interests at international organizations such as the United Nations. Some of these efforts brought success while others did not, but all in some way influenced the early development of Canada's national space policy and agenda in its first decade.

Prime Minister Diefenbaker's Cabinet and the Privy Council first considered a national agenda for space in the summer of 1958, and among the leading figures in government examining the issue at the time was a bureaucrat named Douglas V. LePan, one of Norman Robertson's assistant undersecretaries. Realizing that the superpowers were preparing to dominate outer space both militarily and commercially, he was seriously concerned that Canada, lacking similar technological capabilities or resources, might soon find its own space interests and future plans, whatever they may be, restricted or even threatened. Worse, it appeared that those who already had major launch capabilities, and therefore guaranteed space access, would dictate both the law and rules of space exploitation, while those countries that did not would be forced to accept whatever the major space actors decided. Unsure of the current status or future potential capability of Canada's rocketry and space program, LePan sought out expert advice at both the National Research Council and the Defence Research Board whilst developing his own agenda for Canada's input at the UN.

Consulting administrators, scientists, and engineers from May through August 1958, LePan concluded that the best way for Canada to gain space influence was to promote and, if possible, codify an agreement that made space control an international responsibility.[12] This way, third parties such as Canada could secure guaranteed space access from launching nations, and possibly influence how outer space would be used by all nations going forward. The obvious venue at which to suggest such an option was the United Nations (UN), and LePan immediately set out to prepare his argument for review by the Secretary of State for External Affairs and, afterwards, the Prime Minister himself.

At first glance, LePan's plan looked straightforward. Hoping for the creation of a peaceful outer space environment where Canadian national interests were secure and the country could prosper, LePan suggested that, first, the international community declare space a complete sanctuary and, second, that Canada could play a lead role by offering to build an International Space Flight Development Station (ISFDS) where scientists and engineers from all nations could converge and share their research. Further, in his memorandum he suggested to the Canadian Secretary of State for foreign affairs that perhaps the existing Churchill Research Range, then still under combined Canadian–American joint military control, could be transformed into the new ISFDS.

Although it was probably a well-intentioned plan, LePan seemed horribly uninformed about evolving political trends in rocketry and space events when building his proposal. Though there was no data to prove it, he placed a great emphasis on the notion that the lack of Van Allen belt effects on Churchill Research Range due to its northerly location would make it a preferred launch facility for all future space flights. As well, LePan underestimated both the acrimonious attitude of the Soviet Union towards any space cooperation, as well as the amount of influence that Canada could possibly have in trying to force both superpowers – the Soviets and the United States – into relinquishing their obvious advantages in controlling access to space. He does not appear to have fully appreciated the larger political factors surrounding East–West Cold War relations either, preferring instead to trust without question his own sources. Whatever the reasoning, it was poor advice and a poor appreciation of the situation.

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[12] Memorandum for Mr. Holmes from D.V. LePan, International Control of Outer Space, dated August 20, 1958. File 12798-4-40, Vol.1, RG 25, LAC.

LePan admitted in private correspondence to the Canadian Secretary of State for External Affairs at the time that he based a large part of his proposal upon informal conversations with Dr. John E. Keyston, Deputy Director of the Defence Research Board, and an anonymous paper prepared by concerned scientists from the DRB who worried about the potential weaponization of outer space.[13] Formal consultation was only planned for later once the Prime Minister approved the plan. Although he acknowledged that there could be some difficulties in convincing the government to transfer the Churchill Research Range away from American and Canadian military control, he felt that it should and could be done. What is odd is that this suggestion came almost at the same time as the Cabinet approved the renewal and expansion of the Canadian–American joint test facilities at Churchill out to 1962. As well, the DND and the RCAF were in the process of formalizing a military space agenda, largely at the approval of the Minister of National Defence through the Prime Minister. The obvious dichotomy between strategies under consideration in the Department of External Affairs and what the Cabinet was actually endorsing at the time is both interesting and demonstrative of the disjointed nature of Diefenbaker's government policy during a period of increasing East–West tensions.

At home, however, the issue remained on LePan's agenda. Cabinet requested that detailed studies on Canada's current and proposed future space program be completed, and Dr. Zimmerman submitted two papers outlining Canadian present and future activities in space to the Secretary of the Committee of the Privy Council on Scientific and Industrial Research in December 1958.[14] Both titled "Space Science and Space Technology – A Summary of Points Affecting Canada's Future Position", the first was an executive summary of all Canadian activities to date, while the second provided a more detailed yet still nontechnical analysis of potential space options for Canada going forward. Both papers recounted the natural advantage of Canada's geography in contributing towards the evolution of space science, and highlighted the obvious advantages that space assets could also provide to Canadian defence. To this effect the report advocated the development and promulgation of a national space policy, followed immediately by the creation of an official organization or agency to administer and control Canada's growing rocketry and space activities. Though the focus of the report was, interestingly, directed at expanding the military space capability of Canada, the paper marked the first request to the government to formulate an official space policy for the country. At the time, however, Cabinet was still evaluating all its options and subsequently opted to retain the DRB as the national level space advocate until at least the outcome of LePan's proposal on international space control then tabled at the United Nations.

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[13] Ibid, p.1.

[14] Summary and paper "Space Science and Space Technology – A Summary of Points Affecting Canada's Future Position", dated December 17, 1958. DRBS 170-80/A16 (CDRB), File 4145-09-1, Vol.1. Box 112, Department of External Affairs [DEA], RG 25, LAC.

Fig. 2.5 A U.S. Nike-Hercules rocket lifts off from Fort Churchill c.1960 – a site that Canadian diplomats later proposed could be converted into a International Space Flight Development Station

Perhaps a bit overoptimistic about its diplomatic influence at the UN in the wake of its skillful resolution of the Suez Crisis, Canada fell into the bitter quagmire of international space politics in early 1959.[15] At the beginning of the 1960s, outer space still lacked any formal or legal definition and there were few internationally recognized rules that governed how it would be explored and occupied. Both superpowers realized early on the strategic importance of outer space, and neither were inclined to encourage legal boundaries in it, especially if it meant the possible forfeiture of their own unobstructed access to exploit space both militarily and commercially to their own benefit. While both superpowers publicly called for the peaceful use of outer space, neither was truly interested in making it a sanctuary. National security through space was simply too valuable to be left in the hands of the endlessly quibbling United Nations Security Council.

[15] This contest is examined in detail in Ilya V. Gaiduk, *Divided Together: The United States and the Soviet Union in the United Nations, 1945–1965.* (Washington D.C.: Woodrow Wilson Center Press, 2012).

Equally important, the nature of outer space exploration represented serious challenges to the concept of controlling it internationally. For example, space technology had a duality of purpose that made legal definition difficult. The United States *Redstone* and *Atlas* launchers were employed at the time both as ICBMs and as boosters for its manned space flight program. Similarly, the Russian *R-7* rocket also acted as both an ICBM and the launcher that placed Cosmonaut Yuri Gagarin into orbit. Early satellites had similar dual uses. If either nation was to agree to only using space for peaceful purposes, how then could anyone arguably build a launcher with the lift and capability of sending humans to the moon? Could not the same launcher lift a weapon of mass destruction into orbit? Who would adjudicate over a nation's space and technical programs? What international laws could apply? Just as with air law, the duality of the technology could not realistically deny that outer space would at some point be used for defence purposes, making Canada's call for international control of space far more altruistic than realistic.

However popular with Prime Minister Diefenbaker's Cabinet the international control of space might have been, Canada's UN delegation actually argued that LePan's proposal was simply unviable. While Arthur G. Campbell, then serving in Canada's UN Secretariat in New York, reported back to Ottawa that Canada could champion a third-party space fraternity "to give reality to the claim to equal rights in outer space and to gain a position of influence for negotiating international control of space to ensure that it is used for only peaceful and scientific purposes", he conceded that the generally unfavorable atmosphere within the UN on the development of any international cooperation in outer space would likely kill any such initiative quickly.[16] Back at the Department of External Affairs, Norman Robertson confirmed this in another memorandum prepared for the SSEA the same week, in which he detailed in some depth the status of present outer space activities as well as the announced future plans for many countries including that of the United States. There was nothing to suggest that either the United States or the Soviet Union would at that time suddenly reverse course and endorse international space control at the expense of its own national security or prestige.

Other options were therefore needed. In Ottawa, Robertson recommended to Cabinet that instead of pushing for international legislation Canada should first focus on the development of its own national agenda, which could then evolve further through international forums. He offered that the SSEA support an upcoming Defence Research Board proposal for the creation of a national space program in Canada, if for no other reason than to put Canada in a favorable position as junior partner to the United States and gain access to the technological and economic benefits that would surely arise from the anticipated large-scale American program to go to the moon. Regardless of whatever other objectives might be gleaned from the promotion of international space control, at that time the issue of Canadian benefit clearly stood out as the Department of External Affairs' primary aim.

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[16] (Confidential) Draft memorandum to the Prime Minister on Outer Space – A Possible Canadian Initiative, dated March 16, 1959. File 12798-4-40, Vol.1, RG 25, LAC.

Norman Robertson's approach to emerging Canadian space strategy and policy was calculating if not shrewd. Championing international space control was seen as a way to "enhance Canada's prestige and status in the international community", while, "foster[ing] Canadian scientific progress and provide a focus of interest to maintain and attract scientific and technical manpower".[17] Surely there was political interest in the promotion of outer space as a sanctuary, but not if it jeopardized Canada's own agenda or its relationship with the rapidly-expanding United States space program.

The proposed way ahead for Canada's own space program was not to match the United States' missile, rocketry, and space efforts but rather cooperate with American plans writ large and see what could be gained from it. Far from encouraging some form of altruistic multilateralism, the Department of External Affairs instead sought forums where Canada might leverage its own capabilities to obtain an advantage. Robertson noted in a confidential memorandum to Cabinet commenting on proposed American plans for space that:

> "One point which appears to be relevant to the consideration of a Canadian programme [sic] is that, if Canadian industry is to have a reasonable chance at securing a share in the benefits of the expected United States [space] effort, it behooves us to ensure that government agencies are enabled to keep abreast of the course of developments so that Canada may claim status as a junior partner, at least in the area of space science, with an eye to the possibility of reaching ultimately a production-sharing agreement in the space technology area. Another point is that space exploration seems likely to prove one of the most prolific sources of stimuli to new ventures in many scientific disciplines and accordingly a suitable programme [sic] should serve to strengthen science generally in Canada."[18]

Ultimately, Ottawa chose a middle road. The Prime Minister consented to the pursuit of a Canadian initiative for the international control of space so long as Canada could strongly influence the process, and ordered both LePan and Campbell to proceed, albeit carefully.[19] Consequently, over the summer directives were issued to both the DRB and the NRC to initiate studies on the technical feasibility of a Canadian initiative to improve the outlook for international cooperation in space research and peaceful uses.[20] On June 5, the DRB nominated John E. Keyston to act as representative at the working group with Dr. William M. Cameron, the DRB's Director of Plans, as his alternate. A week later the NRC replied with its own nominations to the working group consisting of Dr. Donald C. Rose as well as the noted physicist Dr. John D. Babbitt. All parties were asked to examine the details of LePan's original proposal, improve upon it wherever they could, and return a final feasibility report to Cabinet no later than the end of August for further consideration by the government.

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[17] Ibid., p.3.

[18] Proposal for Possible Canadian Initiative. (Confidential) memorandum for the minister dated March 12, 1959. File 12798-4-40, Vol.1. RG 25, LAC.

[19] (Confidential) Draft memorandum to the Prime Minister on Outer Space – A Possible Canadian Initiative, dated April 15, 1959 with corrections; and (confidential) memorandum from the Office of the Secretary of State for External Affairs signed by H.B. Robinson and dated May 1, 1959. File 12798-4-40, Vol.1, RG 25, LAC.

[20] (Confidential) letter sent to the President of the NRC and the Chairman of the DRB, International Cooperation in the Peaceful Uses of Outer Space, dated June 1, 1959. File. 12798-4-40, Vol.1, RG 24, LAC.

Ultimately the proposal was deemed to be a failure. Most, if not all, of the current or likely space-faring nations at that time had already developed their own indigenous launch facilities and industries, and since many western countries had already been invited to work out bilateral agreements with the United States on the pattern of the DRB-NASA project, it was doubtful how attractive the remotely-located Churchill Research Range would be to countries with a developed scientific and technological capability of their own.[21] Then there were the more pragmatic problems of staffing and financing. Both the DRB and NRC were already fully engaged at the time with a wide variety of projects, and could not realistically draw any support away from them to fuel new ventures without jeopardizing the existing Black Brant, topside sounder (Alouette), and related space science projects.

Additionally, the United States alone had already invested $14 million in the Churchill Research Range, and both American and Canadian military interests wanted to retain the range solely for rocket launchings and strategic defence missile testing. To suddenly open the range to the United Nations would mean either having to duplicate its military test facilities elsewhere or asking the United States to leave. Neither were considered very feasible options for the Canadian government.[22] Both Dr. Zimmerman and Dr. Steacie did agree, however, that the creation of a Canadian operating facility that attracted requests from international partners was still a possibility, but both also agreed that any such venture must remain entirely under Canadian, not United Nations or some other international form, of control.

If the 1960s were not going to result in a multilateral focused space strategy for Canada, then what road would it take? Various political attempts at championing a multilateral internationalist approach to space access and control, albeit selfishly with the intent of placing Canada in a more favorable position vis-á-vis. The American and Soviet domination of space, at the start of the space age had completely failed. That said, where Canada had succeeded was in forging a strong bilateral cooperative relationship with the United States in both rocketry and space flight. Therefore, while Canada tinkered with middle power politics elsewhere globally during the 1960s, in the exploitation of outer space it chose to remain firmly allied to that country from whom Ottawa could benefit the most.

The adoption of a strong, bilaterally focused space strategy in lieu of some manifestation of internationalism made sense. Senior decision makers within the DRB and the NRC did not foresee Canada undertaking significant space exploration programs on its own given the low level of political attention that such activities had generally received within government thus far. Canada would participate in the great exploration of space, surely, but by 1960 it already lacked any resources to make investments in large-scale endeavors similar to those witnessed in the United States or the Soviet Union. Complex space research, orbital research, space stations, and lunar and planetary exploration were all politically perceived at the time as well beyond the scope of Canadian financing or national necessity.[23] Indeed, where Canada did see itself focusing was on very specific projects that delivered clear benefits to the country while at the same time encouraging cooperation with its main ally.

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[21] Ibid., p.3.

[22] Ibid, p.3.

[23] No author. Outer Space – Proposal For Possible Canadian Initiative 1959. File. 12798-4-40, Vol.1, RG 24, LAC.

### The Black Brant and Other Early Rocketry Projects

Prior to the Second World War, Canadian interest in rocketry was largely limited to amateur groups. Notable among these was the Central Technical School rocket club in Toronto, formed in 1936 and led by a talented young German refugee named Kurt Stehling. Only 15 years old at the time, Stehling and about twenty other rocketeers constructed and flew small gunpowder-propelled rockets, assembled cardboard spaceship models, corresponded and shared ideas and concepts with other groups including the British Interplanetary Society and the American Rocket Society. In 1939, Stehling's club caught the attention of a local reporter, and he subsequently gave an interview on the CFRB radio station. The outbreak of the Second World War ended Stehling's rocketry ambitions for the time being, but after the war the industrious young man eventually went on to work alongside Werner von Braun and James Van Allen in the U.S. Space Program.

Despite the enthusiasm of amateur rocketeers like Stehling, the established academic scientific community in Canada, such as it was, were generally skeptical of the many claims made by these enthusiasts, and like most scientists of the day openly challenged the ambitious claims made by rocketry enthusiasts in various public forums. In the April 1932 issue of *Canadian Defence Quarterly*, for example, the noted pioneer Canadian chemical engineer Ernest A. Lesueur wrote, "We have in recent months been treated in the daily papers to thrilling accounts from certain, not precisely shrinking, enthusiasts as to what is to be expected from rockets and 'rocket planes'", but he then cautioned, "…the average man doubtless believes that it is only a question of time before transatlantic hops will be made by rocket. Heretofore, so far as I know, none of these prophecies has been put forward by an accredited engineer."[24] His article continued in painful detail with the many complexities surrounding velocity and gravity, summarizing, rather unclearly, that space flight with a rocket was essentially theoretically impossible.

Further to this, no evidence suggests that rocketry received official research support from the Canadian government prior to the Second World War. While the National Research Council's (NRC) Division of Physics and Engineering pursued experimentation with ballistics, official histories reveal investigations into rocketry or propellants were noticeably absent from its list of study fields during the 1930s.[25] There may have been many reasons for this, not the least of which was the more pressing concern of widespread economic depression. Historical writing on the development of science and technology in Canada during the 1930s similarly makes no mention of any organized research in rocketry, thus it is unlikely that there were any large-scale projects under way at the time.[26]

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[24] Ernest A. LeSueur B.Sc. 'Rocketeers', *Canadian Defence Quarterly,* 9:3 (April 1932), 374. For a brief overview of LeSueur's professional career see Hugh J. Anderson, "Ernest A. LeSueur: Pioneer Canadian Chemical Engineer", *Journal of Chemical Education*, 72: 5 (May 1995), 390–393.

[25] M. Thistle, *The Inner Ring: The Early History of the National Research Council of Canada.* Toronto: University of Toronto Press, 1966, 345–349.

[26] For studies on science in Canada between 1880 and 1945 see Yves Gingras, *Physics and the Rise of Scientific Research in Canada.* Montreal-Kingston: McGill-Queen's University Press, 1991; Richard A. Jarrell and Yves Gingras (Eds), *Building Canadian Science: The Role of the National Research Council*. Toronto: Canadian Science and Technology Historical Association; and M. Thistle. *The Inner Ring.*

In contrast, government-sponsored guided missile and rocketry technology research and development sharply increased in Canada after the Second World War. Strategically situated between the two emerging postwar superpowers, the United States of America (USA) and the Union of Soviet Socialist Republics (USSR), Canada sought security through its support for science and technology including the employment of guided missile systems for strategic defence. In 1947, for example, the DND formed the Guided Missile Advisory Committee (GMAC), which undertook detailed studies of missile systems that might be employed from static defensive positions or as weapons for other military platforms. Around the same time, ballistics, rocketry, and propulsion technology research and development was initiated at the Canadian Armament Research and Development Establishment (CARDE) at Valcartier, Quebec. This important work later formed the basis of the new Canadian Rocket Propulsion Program (CRPP).[27]

The aim of the CRPP was to contribute to the existing Canadian program of applied defence research, as well as produce a group of indigenous experts in the field who could assist in guided weapons system studies with the armed services.[28] While the CRPP was perhaps the first focused effort to consolidate applied research, it was not the first official Canadian foray into rocket-assisted ballistics. During the Second World War, some graduate science students at Canadian universities were mentored in rocket propellant-related research, and the Canadian Army fielded a limited number of rocket assisted artillery systems towards the end of the war

In addition, the CRPP intended to provide a limited production facility for rocket propellants in Canada, so that early small-scale requirement for Canadian-produced short-range missiles could be economically met.[29] Once the infrastructure had been built and was functioning, the DRB could then potentially contribute to larger-scale projects, including the possible establishment of an indigenous rocket capability within Canadian industry.[30]

The CARDE rocketry and propulsion projects in the early 1950s focused on the development of solid rocket fuels for Canadian-designed short-range weapon systems. Specifically, defence scientists and engineers first concentrated their efforts on the design of a new semi-active radar homing air-to-air missile named Velvet Glove, which was being designed for use with the Canadian-designed CF-100 fighter interceptor. At roughly ten feet long and just under twelve inches in diameter, it was an ungainly product of the pre-miniaturization age and ultimately depended on a microwave radar proximity fuse to detonate its sixty-pound warhead. After considerable testing, full-scale production of the Velvet Glove began in 1953, and approximately 130 missiles were built before the termination of the project three years later. Originally designed to shoot down Soviet bombers

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[27] This program was also referred to as the Canadian Rocket Development Program (CRDP) in some Canadian government reports. See John H. Chapman et al., *Upper Atmosphere and Space Programs in Canada.* (Ottawa: Science Secretariat Privy Council Office, February 1967), hereafter referred to simply as the Chapman Report.

[28] For discussion on wartime research see R.C. Fetherstonhaugh, *McGill University at War, 1914–1918 and 1939–1945.* Montreal, McGill University Press, 1947, pp.321, 336–337. Early post war missile studies are briefly covered in D.J. Goodspeed. *The Defence Research Board,* 127-133.

[29] R.F. Wilkinson, “Rocket Research in Canada”, *Canadian Aeronautical Journal,* April 1959, 138.

[30] Confidential Résumé of Major DRB Activities up to 1962, Scientific Program Rocket Propellant Research and Development, 3. DRBS 173-2 pt.1. vol.7407 RG 24, Accession 1983-84/167, LAC.

at subsonic speeds out to 4500 meters, the missile became rapidly obsolete as newer plane designs transcended the sound barrier and were able to fire their ordnance from much greater distances than the Velvet Glove could reach. Still, defence projects such as Velvet Glove and others resulted in the creation of a solid core of knowledge and experience within CARDE that allowed the organization to pursue larger and more complex propulsion and ballistics projects in later years.[31]

In 1956, Dr. Adam Hartley Zimmerman was appointed as the new chairman of the Defence Research Board, succeeding Omond Solandt who had held the post since the end of the Second World War. Zimmerman initiated a revision of the existing CRPP to focus on more robust solid-state propellants that could be employed in larger rockets and guided missiles similar to those then in use by the United States.[32] The Canadian military was already engaged in joint arctic weather testing of various American-designed surface-to-air missile systems at Fort Churchill, and there was then the strong possibility that similar systems would be built in Canada for strategic defence. Dr. Zimmerman tasked the Aerophysics Wing and the Explosives Wing (later renamed the Propulsion Wing) at CARDE to initiate a revised program to improve the physical characteristics and performance of Canadian solid fuel rocket propellants then in use.[33] The research establishment was the logical choice to pioneer such work, as it had in particular the experience, facilities, personnel, and sustained government funding to undertake just such a program.[34]

Still, CARDE had its work cut out for itself. Although the establishment had developed and tested a number of short-range guided weapon systems after the war, the organization had yet to design solid propellants for use in anything larger than the Velvet Glove missile. Since the aim of the revised CRPP was to design propellants for large-scale vehicles which could launch heavier payloads to high altitude, scientists at CARDE chose to build a new 7.4-meter long Propulsion Test Vehicle (PTV) that was later named Black Brant.[35] It would become the first of a new generation of small payload launch vehicles and marked the official beginning of rocketry production in Canada.

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[31] D.J. Goodspeed, *A History of the Defence Research Board of Canada*. Queen's Printer, Ottawa, 1958, pp.127–133.

[32] DRB List of Technical Fields, July 1959. Zimmerman replaced Dr. Omand Solandt, the DRB's first Director General who served from 1947 to 1955. File 73/778 Vol. 3, Appendix A, Acc. 1983-84/167, RG 24, LAC.

[33] Proceedings of the Second Meeting of the Associate Committee on Space Research, Ottawa, April 8, 1960. Annex C – Description of Black Brant I and II by R.P. Blake. File 12798-2-40 pt. 1, Vol.7841, RG 25, LAC.

[34] Secret memo to Chief (Sciences) from G.D. Watson reviewing progress of Defence Research Board activities dated June 24, 1958. DRBS 173-1, vol.7407, Acc. 1983-84/167, RG 24, LAC.

[35] I.R. Cameron, "Manufacture and Testing of Black Brant Engines", *Canadian Aeronautical Journal*, February 1961, 61. Dr. Cameron was then serving as superintendent of the Propulsion Wing at the CARDE.

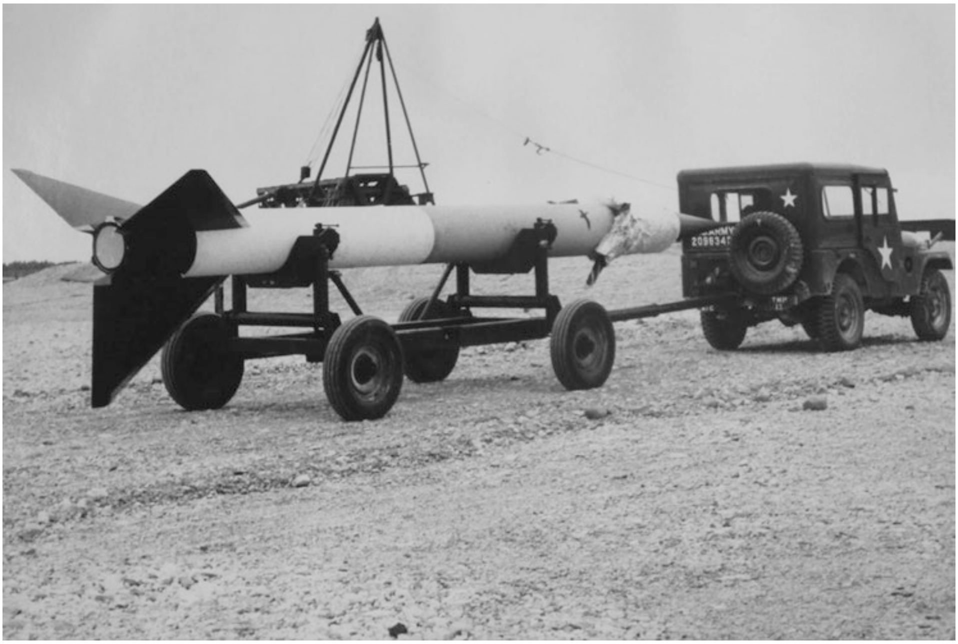

Fig. 2.6 The first PTV/Black Brant I was transported to Sounding Rocket Complex #1 using vehicles left behind at Churchill Research Range by the U.S. Army Engineer's Arctic Test Detachment. Note the small Black Brant painted on the upper stage just below the nose cone

The conceptual design phase of the PTV was shaped by a number of factors. Ongoing advances in Soviet ballistic missiles, rockets, and high-speed aircraft during the 1950s heavily influenced the Canadian decision to pursue a solid- rather than liquid-based rocket propellant program. This was because the DRB was interested at first in developing a propulsion system which could be employed mainly in air defence weapons, and despite the weight constraints imposed by solid propellants, the incredibly short early warning of an impending enemy bomber or missile attack made an instant state of readiness essential. As well, the logistical difficulties and time constraints associated with fueling and emptying liquid fuel rockets at the time simply made them unsuitable as a quick reaction defence weapon.

Another important factor for the Canadian rocket design was stability. Because of its northerly location, high-performance composite rockets had to be serviceable under extreme weather conditions such as those encountered around Fort Churchill. Solid propellants were less volatile than liquid fuels, making them much more suitable for use in extreme temperatures. In addition, given that Canada's main bases were often situated in remote areas and difficult to access or supply easily or regularly, solid fuels were also considered easier to logistically maintain locally for longer periods of time. All of these factors came to shape the decision to pursue a solid booster, despite the limitations that it also imposed on the size and scope of the rocket design project.

The first thing the CARDE engineers needed to do was to begin testing all of the solid rocket fuel variants then in use by similar launchers. The team acquired the details of the British 0.44-meter diameter Skylark from Bristol Aerojet Company of England, which served as the basis for the Canadian PTV design.[36] As with the Skylark, the Canadian PTV model was kept relatively simple in order to facilitate the manufacture and reliability of more advanced models as the CARDE teams gained experience in rocketry development. Consisting of three basic elements, the first PTV personified simplicity with only a motor, the propellant, and the casing. Bristol Aircraft (Western) Ltd., situated in Winnipeg, supplied the rocket casings while Canadair Ltd., of Montreal, supplied the nose cone and the tail fin stabilizers. The parts were shipped to Fort Churchill, where they were assembled locally at the CARDE facilities under the direction of Dr. Ian R. Cameron, who then served as Superintendent of the Propulsion Wing.

Although all of the sounding rockets in the Black Brant series were designed to be capable of carrying a payload, the purpose of the first two launchers built in the series, PTV/Black Brant I and Black Brant IIA, was simply to prove the design. Both rockets employed a highly reliable Canadian-designed motor within a solid composite propellant casing. Known as the 15KS25000 motor, the machine generated 15 s of 25,000 pounds thrust, making it capable of boosting up to 108 kg of payload to an altitude of approximately 97 km. Although the original design relied on thick layers of polyurethane-mica to contain the hot propellant gases, later versions of the rocket incorporated in-situ molded asbestos-phenolic mats instead.[37] Overall, the rocket design proved very reliable in testing, malfunctioning only once during its first twenty-two static firings.[38]

Equally successful was the research team's solid fuel design. The CARDE appropriately named their creation CARDEPLEX, and this solid propellant was used in all subsequent Black Brant designs throughout the project. Based on a solid crystalline oxidizer and an organic polymerizable binder rather than the usual nitrocellulose and nitroglycerine components used in other solid rockets at the time, CARDEPLEX was specifically designed to meet casing requirements that standard nitro-based propellants in use at the time simply could not achieve. The manufacture of CARDEPLEX solid fuel was a two-step process. First, ammonium perchlorate oxidizer was ground, sifted, and then mixed with a smaller amount of another fuel based on carbon, hydrogen, oxygen, and nitrogen, to create the crystalline oxidizer. Then, after blending and curing, the oxidizer was again blended with a polyurethane binder before being poured into the PTV engine casing. The casing itself was internally coated with a heat barrier restrictor and mica filled polyurethane bonding agent that applied easily to both the steel wall and to the propellant.

The CARDEPLEX propellant formulation was finalized in October 1958, and by December Dr. Cameron's teams had completed construction of the first PTVs. Testing of the new vehicle began soon after, with the first static firing of the PTV taking place at the CARDE facility in February 1959.[39] The results of the test, while not perfect, were very

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[36] CARDE. Technical Note [TN] 1421/61 *General Information.* (Unclassified) dated September 1961.

[37] CARDE. TN 1525/63, *Summary of Performance of the 15KS25000 Rocket Engine Used in the First Sixteen Black Brant Vehicles*; and TN 1528/63, *The 15KS25000 Black Brant Engine Ground Operations and Handling Instructions,* dated 1963.

[38] Ibid. CARDE. TN 1525/63.

[39] CARDE. Technical Manual [TM] 343/60. *CARDE Black Brant I Vehicle Trials.* (Valcartier: CARDE, 1960).

promising and gave the team confidence that it had made good design decisions. The design team engineers made corrections to the PTV design, and more tests were conducted throughout the spring and summer, including testing at different temperatures and environmental conditions. With a little effort, it was anticipated that a real launch could be attempted at the Churchill Research Range sometime during the autumn of that year.

The Churchill Research Range proved to be an ideal site for launching Black Brant rockets. Based at Fort Churchill, Manitoba, the northern region military base already served as the home of the Defence Research Northern Laboratory (DRNL), a research establishment tasked with testing military capabilities in extreme conditions. The location provided a huge natural safe zone of impact that was necessary for the conduct of the American and Canadian missile tests, and thus was more than suitable for the operation of Black Brant rockets.[40] There was also the great scientific benefit of Churchill lying near the middle of the zone of maximum auroral activity, and this was even further augmented by Churchill's proximity to the north magnetic pole. This gave both the civilian and the defence scientists and engineers an ideal location from which to conduct ionosphere-related studies that were crucial to the development of both rocketry and space flight.

As previously described, Canada and the United States concluded an agreement to build and maintain a research and test facility at the CRR in 1955 to test fire under extreme cold weather conditions the American NIKE AJAX missile system.[41] This test range was subsequently employed during the International Geophysical Year the following year, and remained under American control until the conclusion of related IGY projects in December 1958. During the IGY period itself, the United States bore the entire cost of the installation (USD$7.3 million), and provided all 86 sounding rockets needed for international scientific experiments. Two of these rockets were designated specifically for Canadian use, and were flown in November 1958 mounted with nose cones instrumented by scientists at the CARDE.[42]

In 1959, the range and facilities were scheduled to revert to Canadian ownership less any equipment the United States chose to remove; however, the United States Department of Defence Research and Development Office (DRDO) expressed an interest to the Canadian government in reopening the site for further joint Canada-U.S. missile and rocketry testing. A new agreement was subsequently completed between the two governments, after which the U.S. Army tasked the staff at the White Sands Missile Range to put the northern facility back into operation. The U.S. Army constructed several new buildings and modernized the launch facilities which would later prove more than suitable for all Canadian rocketry needs. Having previously cooperated with the Americans

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[40] Government of Canada. Chapman Report, 22.

[41] LAC. RG 24, Vol.25, File No. 1200 pt.2 VII. Secret Memo HQS 6001-Guided Missiles TD 8160 (CGS), Surface-to-Surface Missiles and Fort Churchill. Drafted by LGen. S.F. Clark, Chief of the General Staff, Ottawa, dated September 29, 1959. See also Pennie, A. M. *Defence Research Board: Defence Research Northern Laboratory, 1947-1965.* (Ottawa: Report No. DR179, DRB April 1966).

[42] ATI LAC. RG25, Vol.1 File No.12798-4-40. Outer Space – Proposal for Possible Canadian Initiative. (Confidential) memorandum 'International Implications of a Canadian Space Research Program', prepared for the Under-Secretary of State for External Affairs, dated August 27, 1959, p.2.

on the use of the CRR, there was little work now required to allow Canada to test and fire its own rockets from the same launch pads then employed by the U.S. Army, and later, the United States Air Force (USAF).[43] The bilateral cooperation that had started between American and Canadian militaries at Churchill before the space age was now set to last several more years.

A new and inexpensive inclined launch rail platform for the Black Brant I was later designed and installed on one of the existing launch pads at the CRR in the latter months of 1957. Though somewhat makeshift and temporary in measure, the launch rail sufficed for early design and test integration of the rocket and launch platform. The concept consisted of a simple elevating boom that, when horizontal, could have a PTV underslung from three guide rails. The boom and PTV were then simply elevated to any desired launch angle between 70° and 82°, and the forward braces were bolted to ground anchors. Once everything was stabilized and secured the PTV would then be ready for launch.[44]

The first permanent inclined launch rail platform was installed at the CRR in the fall of 1958, approximately 150 m south of the American NIKE-CAJUN assembly building that had been previously built there during the IGY. This new platform provided an almost due east trajectory for Black Brant rocket firings, taking them out over Hudson Bay, which was necessary since there was always a requirement for maximum safety during launches. The PTV was a non-recoverable launcher; therefore, should any problems occur during a firing it was far less likely for falling debris to cause any serious material damage or civilian casualties.

The first group of four PTV/Black Brant I rockets was scheduled for launch from the Churchill Research Range in September–October 1959. Since the rockets were not designed to carry actual payloads but simply test the quality and characteristics of the CARDEPLEX propellant, the first two vehicles were ballasted heavily to ensure that a large stability margin was maintained at Mach 6, while the second pair of rockets was lightly ballasted to what was considered the minimum telemetry weight.[45] Telemetry was measured using a standard 30 by 30 PDM-FM (pulse duration modulated – frequency modulated carrier) radio system with 28 active channels. Accelerometers and skin thermistors were added to supply additional data on the vehicle performance and on the effects of flying at high Mach speeds through the lower atmosphere. Finally, a radar beacon was installed in the nose cone of the PTV to aid tracking of the vehicle throughout its trajectory, to evaluate drag, and to verify its high altitude performance.[46]

The first two flights of the Black Brant I (vehicle No. CC601 and CC602) in 1959 provided the CARDE engineers with the benchmark from which to proceed with the rest of the program. While it was noted that the telemetry from rocket CC601 was not considered of value due to the high roll rate of the vehicle during its flight, rocket CC602 provided much valuable data to crews back on the ground. The two experiments flown aboard CC602, a sodium photometer and an infrared photometer, both performed well beyond

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[43] DND. *Operation Probe High, 20 July 1963.* Churchill: Fort Churchill pamphlet, 1963, 16–17.

[44] I.R. Cameron, "Manufacture and Testing of Black Brant Engines", p.66.

[45] Ibid., p.66.

[46] Ibid., p.65.

initial expectations greatly satisfying research crews on the ground.[47] With these flights successfully completed, Canada's rocketeers moved onto the next task.

The next rocket design was essentially a mature version of the Black Brant I. Engineers at the CARDE had originally designated this evolved rocket the 'Snow Goose', but the moniker was soon dropped from official references and reports in favor of the simpler name of Black Brant II. The new rocket was based on the main requirement to attain from a near vertical launch a minimum altitude of 228,600 m with a max payload of 68 kg. The design philosophy behind the new rocket essentially was that the structural weight was to be a minimum consistent with high efficiency structural design. As a result, the Black Brant II was also slightly longer than its predecessor at approximately 8.43 m from tail to top, and the length of the nose cone was also extended out to 2.18 m. While the Black Brant IIA model continued to employ the 15KS25000 motor originally designed for the Propulsion Test Vehicle, the Black Brant IIB variant was designed to use a newly-designed longer burning 23KS20000 propulsion unit.

As rocket designs evolved and testing proved successful, more sustained operations and support for Canadian rocket launches were also beginning to take shape. With the entry of the Black Brant II into regular service, the DRB, the CARDE, and the various other agencies sponsoring each flight collaborated on the development of formal procedures for the check-out, ground handling, and launching of each rocket in an effort to ensure satisfactory firings from the pad every time. The CARDE engineers and the Canadian military organized dedicated casings and transport vehicles for rocket parts, and put requests into Army Headquarters for specifically-designed vehicles required to support any expansion of the existing program. Finally, launch platforms designed for use with the PTV/Black Brant I were modified to increase the maximum launch angle form 70° to 85°, while another Aerobee rocket launcher was also modified to support Black Brant II series rockets. Though none of the launchers had yet been augmented to support year-round firings, these small increases greatly expanded the potential range of operations for Canada's new "rocketeers".

After the completion of ground, engine, and instrumentation testing in early 1961, Black Brant IIA test flights began and, overall, generally proved successful. The rocket design continued to perform consistently well in flight, and was subsequently utilized in no less than fifty-five experimental launches between 1961 and 1966. The main employer of the Black Brant IIA rocket was the Canadian university researcher community, usually sponsored by the NRC, though a small number were also put to use by the United States Air Force Cambridge Research Laboratory. The Black Brant IIA rocket was the first workhorse of the Black Brant fleet and only finally retired from service in the mid-1970s, though its motor was still used later in both Black Brant IV and VA rocket configurations.[48]

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[47] NRC-DRB Permanent Joint Committee on Space Research – Proceedings of the First Meeting of the Associate Committee on Space Research [ACSR], Ottawa, 2 October 1959, p.2. File. 12798: 2-40 pt.1 DEA, Vol.7841, RG 25, LAC.

[48] A.W. Fia, "Canadian Sounding Rockets: Their History and Future Prospects", *Canadian Aeronautics and Space Institute Journal*, 20:8, October, 1974.


Fig. 2.7 DRB engineers and technicians preparing a Black Brant II for launch at Fort Churchill Research Range, c.1960

As the Black Brant IIB rocket was designed to meet a specific technical requirement to achieve higher altitudes using the new 23KS20000 motor, its production was terminated after only four tests flights in 1963. Once the engineer's objective had been achieved, instead of continuing production of the IIB model, the lessons learned from this interim launcher were incorporated into an improved IIA model as well as the forthcoming Black Brant III rocket.[49]

With the Black Brant IIA and IIB projects well under way, the Defence Research Board next turned its attention to planning the next generation of sounding rockets. The initial success of the first two rockets in the series had demonstrated that Canada clearly had the potential for building a more sophisticated family of sounding rocket for both civilian and defence scientific research. The United States Department of Defense and NASA had also expressed an early interest in Canada's Black Brant program. While the CARDE had taken the lead in the initial project, it simply did not have the resources or authority to undertake a large-scale

[49] Ibid. See also F. Jackson, "Development of the 23KS20000 Motor for the Black Brant IIB Vehicle", *Canadian Aeronautics and Space Journal*, Vol.11:12, December 1965, 377–383.

production of Black Brant launchers. Dr. Cameron therefore made a recommendation to the DRB that perhaps one of the Canadian civilian companies involved in the project could be made the prime contractor for manufacturing additional rockets.

The Department of Defence Production agreed with this recommendation and subsequently conducted extensive market surveys in 1957 and 1958 to establish which companies would be best suited to take over the main portion of Black Brant rocket production. A major concern amongst decision makers remained – would Canadian industry be able to provide adequate technical support for an all-Canadian launch program? It was soon determined that Bristol Aircraft (Western) Ltd. (BAL), one of the CARDE's original rocket suppliers, was capable of meeting the basic requirements of the Black Brant program. Further extensive market surveys conducted by both Bristol and the government in 1959 ultimately led to a solid proposal for a Canadian rocket industry start-up in November. A year later, the government formally awarded a contract to Bristol for three new versions of the Black Brant, to be developed as a joint DRB-BAL project over the next few years. A few signatures later, Canada's rocket industry was officially born.

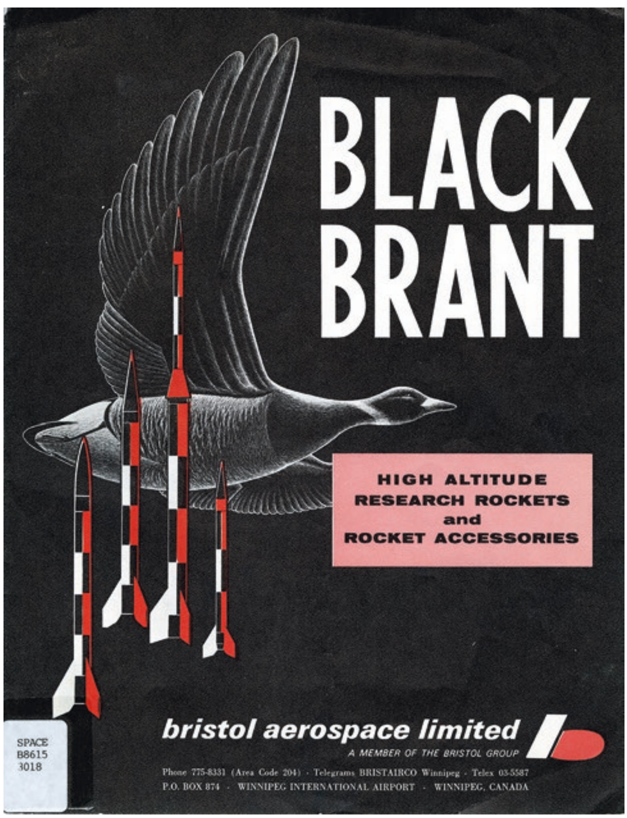


Fig. 2.8 A Bristol Aerospace Limited Information Manual for the advanced generation of Black Brant rockets

Like the CARDE, due to its technical expertise Bristol Aircraft was an obvious choice to undertake a pioneering role in Canada's emerging rocket program. The company, headed at the time by Stanley Haggett, possessed both the technological base and the manufacturing capability to produce the rockets. The company's engineers and scientists, then under the management of Murray Auld, possessed all the specialist techniques and skills needed in working with high tensile and heat and corrosion resistant metals like those employed in launcher systems.[50] Finally, Bristol's manufacturing plant was also located reasonably close to the Churchill Research Range where most Black Brant rockets would be launched.

A young talented engineer named Albert Fia was chosen to head the Black Brant rocket technical team at Bristol. Mr. Fia held a degree in Electronic and Electrical Engineering, and had extensive experience in the development of missile systems for the Canadian Army. He was also a member of both the Manitoba and Ontario Associations of Professional Engineers, and was considered by his peers at Bristol to be an excellent team leader who could successfully direct the complex challenge that now lay before BAL. Interestingly, Albert Fia joined Bristol in 1958 just as the launcher contracts were tendered to industry, and he soon found himself assigned to head the newly-created Special Projects Group that would design and built the next generation of Black Brant rockets.[51]

The three new versions of the Black Brant to be designed by Albert Fia's Special Projects Group covered a range of altitudes and payload weights based on the requirements of potential clients as well as the environment to which the research instruments would be subjected. Both the DDP's and Bristol's own market surveys had identified that research scientists and engineers desired a minimum-cost, highly reliable rocket able to carry payloads of 5kg to 135kg to heights of eighty through to a thousand nautical miles with little dispersion in technical performance.[52] Equally important, designers had to keep in mind that the environmental conditions of northern Canada limited the acceleration loads on the instruments carried in rockets to forty Gs, and the temperature to no higher than 125°F. Such demands were optimistic, and from the very beginning compromises were necessary in order to achieve any success within these design limitations.

The first alteration to the existing design specifications was a reduction of the maximum desired altitude from one thousand nautical miles to just six hundred nautical miles. Next, Fia's design team simplified the development process and the time needed to complete a new plan by incorporating a number of existing CARDE components into the three new designs. It was decided that, for the time being, Bristol could and would continue to employ the Black Brant I's 15KS25000 motor and the DRB's CARDEPLEX propellant rather than attempt to create entirely new components and fuels. Finally, Bristol overcame the remaining design limitations by developing and manufacturing new steels with increased tensile strengths and improved ablative coatings that provided rigidity-to-weight

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50 Anon, "Black Brant: Canadian Bristol Aerojet's Family of Sounding Rockets", *FLIGHT International*, 7 January 1965, 14.

51 Anon, *Bristol Aerospace Limited: 50 Years of Technology, 1930–1980, Volume Two – The Second Quarter Century.* Winnipeg: Bristol Aerospace, 1985, p.66.

52 Ibid., p.15.

ratios very close to the desired rocket specifications. All in all, the Special Projects Group achieved remarkable engineering design success given the difficulties in meeting the original parameters set out by the clients.[53]

The first new rocket in the series, the Black Brant III, was designed to be a scaled-down version of the Black Brant II rocket using a 25cm diameter vehicle in place of its predecessor's 43cm casing and the CARDE's newly-designed 9KS11000 rocket motor. Approximately 5.8m long, the Black Brant III was capable of carrying a 18kg payload to a height of 178km.[54] Testing of the new rocket motor began in late 1961, with fifty-three static firings carried out at the CARDE, followed by another twenty structural and aerodynamic tests at Bristol.[55] By May 1962, everything on the Black Brant III had been tested, re-tested, and tested once more leaving only the final exam for the rocket – proving that it could actually fly.

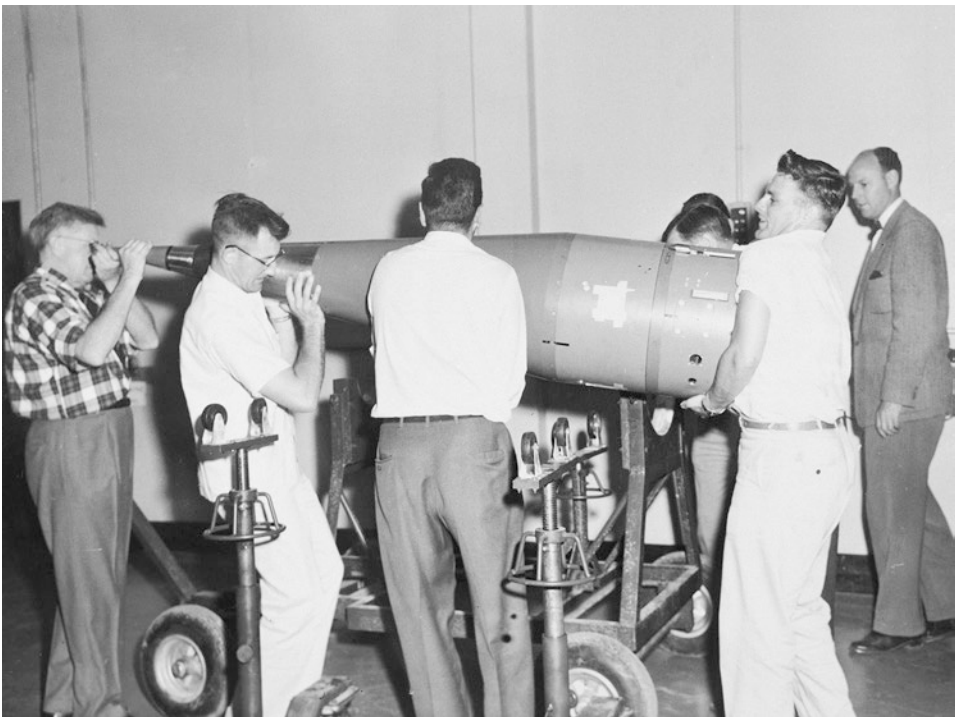

Fig. 2.9 NRC and DRTE scientists, engineers, and technicians prepare to load a scientific instrument nose cone for a Black Brant rocket. From left to right: Dr. D.C. Rose, Bud Budzinski, Dr. Ian McDiarmid, Don Awry, and Dr. Peter Forsyth

[53] Ibid., p.15.

[54] Peter Alway, *Rockets of the World: Third Edition.* Ann Arbor: Saturn Press, 1999, pp.343–346.

[55] A.W. Fia, "Canadian Sounding Rockets: Their History and Future Prospects", *Canadian Aeronautics and Space Institute Journal*, 20: 8, October 1974, 398–399.

The original schedule to launch the first Black Brant III from the Churchill Research Range had to be scrapped after a terrible fire devastated a good portion of the rocket test facility in February 1961. Desperately, the Bristol team sought an alternate launch site to keep the program on track, and fortunately they were able to secure a launch pad at the American Wallops Island rocket range just off the Virginia coast. The entire CARDE/BAL rocket team and four Black Brant III rockets were soon transported down to the American test facility aboard a Royal Canadian Air Force C-130 Hercules transport plane. Ralph Bullock, an electronics engineer serving with Bristol at the time, was on the flight and remembered that on arrival at Virginia the pilot of the C-130 executed a pre-landing show of aerobatics that he considered hardly appropriate for a transport plane let alone its precious cargo. Fortunately, however, all eventually arrived safely on the tarmac and the Bristol team spent the next few weeks conducting the final assembly and checkout of the four Black Brant III rockets.[56]

On June 15, 1962, after nearly four years of designing and testing, the combined CARDE/BAL team launched the first two of the new Black Brant III rockets. Carrying net payloads of 42.1kg and 43.1kg respectively, the rockets performed impressively but less well than the team had estimated. The first vehicle attained a maximum velocity of 1700m/sec, and a range of 98km, while the second rocket traveled faster at 1705m/sec, to a range of 158km.[57] On-board instrumentation on both vehicles recorded a large but short-lived pitching disturbance at six seconds after lift-off that cut nearly twenty percent off both the rocket's peak altitudes. The Canadian rocket team realized that this problem had to be rectified in order to stabilize the rocket and allow it to fly properly.

Despite the rocket team making deliberate adjustments to the remaining rockets, the next two vehicles suffered similar problems during their flights. A third vehicle, launched on June 19, 1962, had been fitted with additional fin cuffs to reinforce the stabilizers, but the rocket's lighter payload was wrenched so severely by a pitching disturbance seven seconds after lift-off that all telemetry with the vehicle was soon lost. Ground tracking films later revealed that the Black Brant rocket had righted itself after the disturbance and continued flying on to an estimated altitude of 144.5km, but the problem of instability remained unsolved.[58]

The launch of the fourth and last Black Brant III rocket brought to Wallops Island took place a week later on June 28, 1962. For this flight, the Canadian launch team attempted to keep the vehicle properly positioned by intentionally spinning the rocket at three revolutions per second whilst it was in flight. It was hoped that this gyroscopic spin would produce sufficient stabilization to keep the last Black Brant III from suffering the same fate of its predecessors. As well, the rocket was fitted with a heavier nozzle in order to give it additional stability. The tail stabilizer fins were canted accordingly and the rocket fired while the Canadians held their breath and their American hosts looked on with some reservation.

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[56] Anon. *Bristol Aerospace Limited: 50 Years of Technology*, p.68.

[57] Anon. "Black Brant: Canadian Bristol Aerojet's Family of Sounding Rockets", p.17.

[58] Peter Alway, *Rockets of the World*, p.343; see also Black Brant III Firings Table in Anon., "Black Brant: Canadian Bristol Aerojet's Family of Sounding Rockets",p. 17.

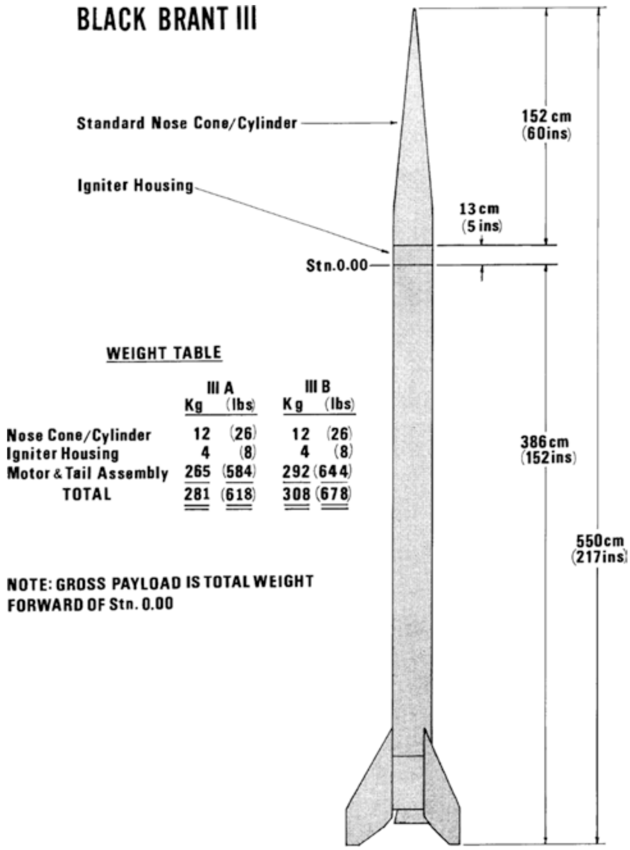


Fig. 2.10 Black Brant III technical diagram

At first the flight went well and things looked promising. The Canadian team let out a sigh of relief as the final Black Brant III passed the point of previous instability without incident and continued to head skyward. As the rocket continued to climb, however, it began a graceful if not desirable helical motion during which, as one observer later described, the rocket used up a great deal of sky before recovering itself and heading off in a completely new direction.[59] The rocket reached a mere 27.6km altitude before plummeting back down to Earth. Downhearted but not defeated, the Canadian team decided to call it a day. The initial tests of Canada's newest rocket design were done.

The CARDE/BAL launch team returned to Canada in July to begin painstakingly to pore over the massive amounts of telemetry and tracking film recorded during the four launch tests. There was much work to be done by the Bristol Special Projects Group. The largest problem – and the one that needed to be dealt with first – was the stabilization

[59] Anon, *Bristol Aerospace Limited: 50 Years of Technology*, 68; and Peter Alway. *Rockets of the World*, p.343.

of the rocket, and until this issue was rectified production of the Black Brant III could not proceed. Among the corrections, the engineers replaced the original fin stabilizer assembly on the rocket with three stronger, lighter, aluminum single wedge fins employing a more pliable plastic insulation known as Avcoat. As well, the fiberglass wrap originally used on the outside of the motor and nose cone to keep it cool during flight was replaced with an internal payload-insulating blanket. Design changes were also made to the motor case liner to give the rocket more thrust and a lighter nozzle. It was hoped that all of these changes would prove successful in improving the rocket's flight.

Two of the newly-redesigned Black Brant III rockets were brought back to Wallops Island, Virginia, where they were successfully launched on December 13, 1962. Both of the Black Brant III rockets achieved near perfect flights and returned full telemetry right until splashdown. The Canadian launch team congratulated one another and returned home, this time much more confident that Black Brant III was now ready to be manufactured for commercial use. Team frustrations returned in July 1963, however, when in preparation for competing for a United States Navy contract a Black Brant III fired from Point Mugu Test Range lost control just shortly after take-off once again due to lateral disturbances. The telemetry and nose assembly was also lost, and although ground-based tracking films showed that the rocket recovered and continued its flight, no other data were returned to the Canadian launch team.

The failed test in July also gave little reassurance to the launch team going into the American sounding rocket competition scheduled for that winter. However, their next launch on November 7, 1963 was a near perfect flight. Sporting a spin-balanced nose assembly the Black Brant III outperformed the team's expectations, but the U.S. Navy was left unconvinced of its long-term reliability and an American order for Canadian sounding rockets never materialized. Demoralized yet not defeated, Albert Fia's Special Projects Group carried on with a final test launch the following spring as the data returned would prove valuable to other work. Fired from a newly-reopened Churchill Research Range, the last of the initial Black Brant III rockets was sent skyward on April 21, 1964. The rocket performed well overall, but still left the Bristol engineers with questions about their design concepts. Answers would have to be sought in the company's next test phase.

Unlike the Black Brant III rocket, the Black Brant IVA was conceived as a two-stage rocket incorporating the Black Brant VA as a first stage and the Black Brant III for its second stage. The new rocket was expected to carry up to 18kg of payload to altitudes of 856km, much higher than the Black Brant III or its successor, the Black Brant V. The Black Brant IV was also the first two-stage launcher design attempt by Albert Fia's Special Projects Group, and he tasked a trusted and experienced colleague, an engineer named Harry Sevier, to lead the effort. Sevier assembled a ten-man team to tackle the Black Brant IV project. Utilizing Black Brant VA and IIIA motors, the goal was to marry up these two stages to produce a light yet robust launch vehicle. While the two separate stages were structurally resilient, however, the staging joint between the two was another matter. The design and redesign of this critical part of the Black Brant IV rocket required several attempts before getting it just right.

The dramatically increased burnout altitude needed of the second stage of the Black Brant IV rocket – approximately 35km – called for a longer and larger diameter exit cone for the nozzle. Also, instead of fins the upper stage now required an odd-looking titanium

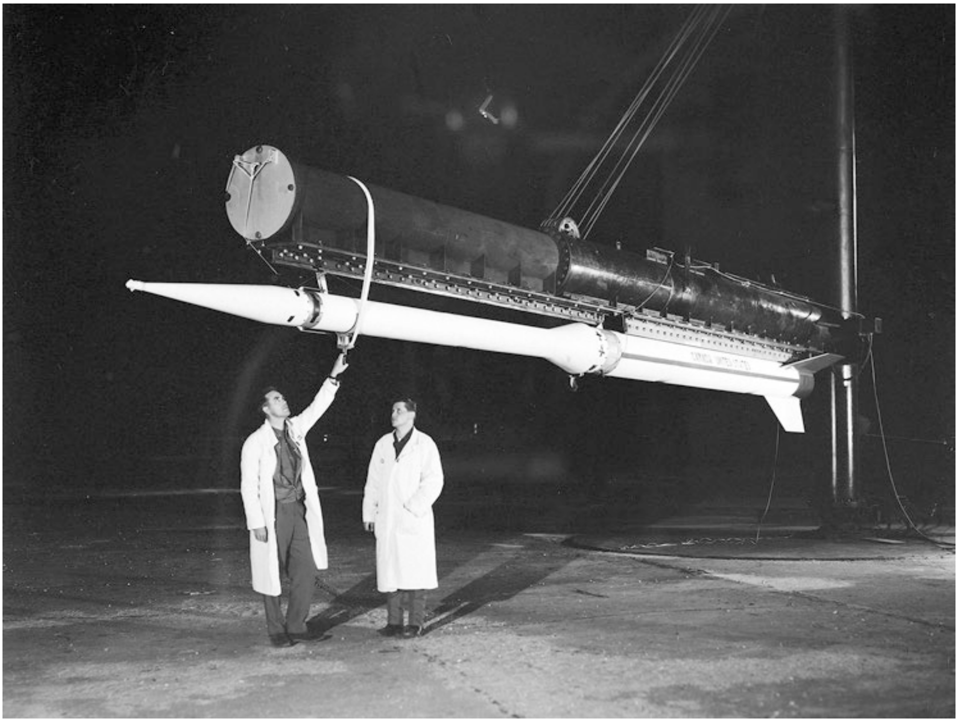

Fig. 2.11 DRB engineers inspect a BBIV on its launch rail c.1963

conical device to keep the second stage rocket directionally stable in its flight.[60] To facilitate separation of the two stages, instead of physically connecting them, the top portion rested on the bottom portion using a sliding fit. The design team then fit a drag ring on the first or 'booster' stage, so that when it stopped firing its higher drag would cause the first stage to decelerate more rapidly than the upper stage and thus simply pull away from the remainder of the rocket. The goal was to achieve a smooth separation in flight and the design appeared valid, at least on design board.

While the first Black Brant IVs were being readied for testing, preparations were also being made to collect as much telemetry from the flights as possible. Though the Churchill Research Range, now fully recovered from the February 1961 fire, was capable of providing all the necessary diagnostics for the upcoming Black Brant IV launches, the high altitudes expected from the rocket merited the use of backup trajectory recorders then located at the tracking facility at Prince Albert, Saskatchewan. Preparations were completed and the rockets were moved to the launchers in May 1964 for their final checkout. Anxious and nervous, the Bristol team held their breath as tests began and the Black Brant IVA rocket vehicle No.01 left the launch pad on June 24, 1964.

[60] *Bristol Aerospace Limited,* p.70.

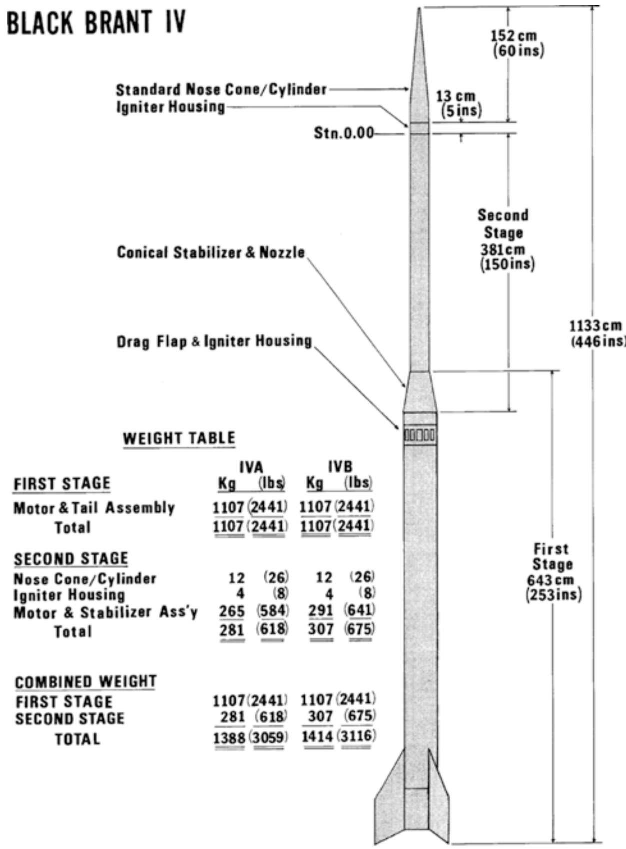


Fig. 2.12 Black Brant IV diagram

Despite their best efforts to prepare for any and all design contingencies, the Bristol team experienced another launch failure. The Black Brant IVA shot into the sky without difficulty and after a short while it was reported that the first stage appeared to be firing as it was designed to. When the time came for the second stage to separate at thirteen seconds into the flight, however, disaster suddenly struck. The ground team saw the exhaust trail wobble and then heard a loud explosion. Flight telemetry was suddenly lost. Still the sustainer engine on the second stage ignited and carried on, but by this point the Black Brant IVA was so far off trajectory that it barely reached an apogee of 470 km versus the anticipated 734km.[61]

61 Ibid., p.70.

The next attempt to successfully launch a Black Brant IV rocket was made on July 2. This rocket suffered a similar fate, but imbedded rocket telemetry later revealed that the rocket had simply staged too early, and that that the internal pressure recorded almost twice the outside ambient pressure immediately prior to separation of the stages.[62] The Bristol Aerospace Limited official history adds further explanation, noting that the initial Black Brant IV flights had failed due to:

> '...inadequate inter-stage pressure venting, which in the absence of any structural joint between the stages, had prematurely pumped the rockets apart. As soon as the separation began, trapped inter-stage air escaped and the thrusting booster immediately drove up into the sustainer nozzle, producing violent oscillations – and collapse of the nose.'[63]

Fig. 2.13 DRB technicians recover the remains of a Black Brant IV rocket somewhere north-east of the Churchill Research Range, July 1964

[62] Ibid., p.70.

[63] Ibid., pp.70–71.

As a result of the initial failures a small number of changes were made to improve the system, namely the installation of a proper inter-stage venting process, a solid explosive bolt to physically connect the two stages, and flush-mounted booster drag flaps that would deploy at the same time the inter-stage bolt was cut. In essence, the redesign of the rocket allowed the Black Brant IVA to separate only when permitted, but to be able to do so very quickly when the command was executed.[64]

The Black Brant IVA design and launch team returned to the Churchill Research Range in January 1965 with two completely revamped rockets and the objective of determining whether or not the design upgrades were sufficient to make the rocket a success. After months of effort Bristol finally reaped the rewards of dedication and hard work. Both the BBIVA rocket vehicles No. 3 and No. 4 flew textbook flights, and two follow-on flights, also faultless, brought an agreeable conclusion to the Black Brant IVA project. An augmented version of the rocket, the Black Brant IVB, later went onto become a very successful commercial sounding rocket used by customers around the world.[65]

With each configuration, the Bristol scientists and engineers altered design parameters and introduced new motors and equipment with every intention of subjecting the rocket to rigorous testing that would push its aerodynamic limits. While success was hoped for with each flight, the engineers accepted it as unlikely. Yet, with each test failure came valuable data and lessons learned that, when applied, ultimately resulted in the overall successful completion of the Black Brant IV program.

The final phase of the DND-sponsored rocket project was the design and flight of the Black Brant V launch vehicle. Both the Black Brant VA and VB model differed little in their external appearance, both at 43 cm in diameter, 7.3 m long, and each tailed with three stabilizing fins. With the intent of lightening the structure to increase the overall range and altitude of the new rocket, the Black Brant VA model was designed utilizing the mechanical interchangeability of the motor cases used for the 15KS25000 and the 26KS20000 engines. This flexibility in the design allowed for a lighter casing using a motor that could deliver almost twice the rocket performance. The former engine was also subsequently employed on the Black Brant VB model.[66]

Still, the new motor design caused some initial problems, with a failure during the first static test revealing inadequacies in the design of the liner, which was required to insulate the highly stressed motor tube from the extreme temperature of the burning propellant. It took several re-designs of the engine and an additional 12 static firings before the DRB and Bristol engineers felt confident that rocket and its follow-on VB model were both ready to fly.[67]

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[64] Ibid., p.71.

[65] Some flights took place from Northwest Territories, Peru, Brazil, Spain, Kauai Hawaii, and Greenland.

[66] Ibid., p.128.

[67] A.W. Fia, “Canadian Sounding Rockets: Their History and Future Prospects”, *Canadian Aeronautics and Space Institute Journal*,.20:8, October 1974, 128; and Anon., *Bristol Aerospace Limited*, p.71.

Other ways to lighten the structure of the rocket were explored. The large and heavy magnesium tail fins normally fitted to Black Brant IIs and IIIs were replaced on the VA model with smaller and lighter units consisting of a thinner aerofoil section that produced much less supersonic drag. The tail fin itself was constructed not out of the usual solid sheet of metal, but instead was made of an aluminum honeycomb composite with bonded aluminum sheet skins. The whole construction was then coated with the plastic insulate Avcoat – a sheet only 60,000's of an inch thick, but capable of reducing 1000 °F external temperature to a surface temperature of only 300 °F. Many of the scientists and engineers were somewhat skeptical of the feasibility of the new design, but from the very outset the new fins worked well and often beyond expectations.[68]

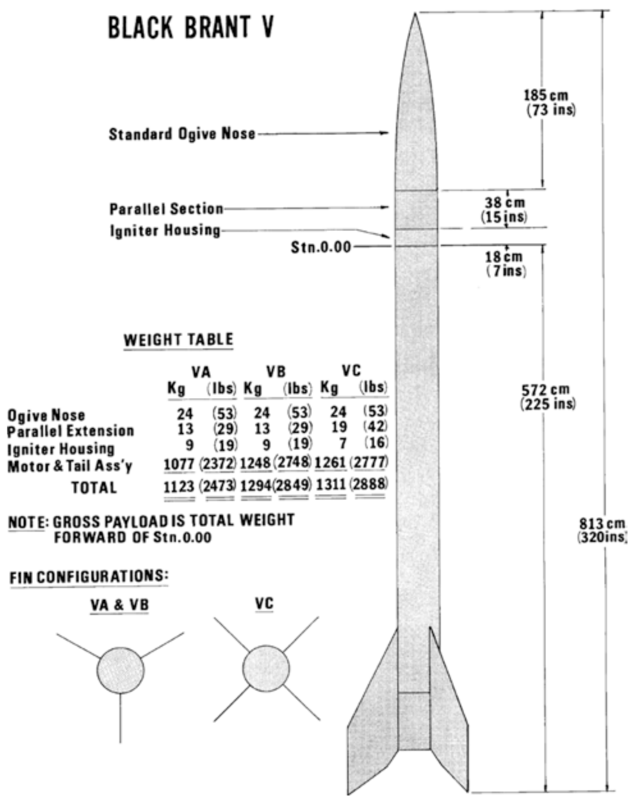


Fig. 2.14 Black Brant V diagram

[68] *Bristol Aerospace Limited*, p.71. See also Chapman Report, pp.61–62.

Built concurrently with the Black Brant IV, the first low-performance Black Brant VA was launched nearly two months before its sibling rocket on April 16, 1964. The rocket performed admirably and paved the way for the first Black Brant VB rocket tests. The first Black Brant VB launched from the Churchill Research Range on June 12, 1965, carrying 140kg of instruments to an altitude of approximately 378km. It was a flawless flight, easily demonstrating that the DRB-Bristol engineering team had honed their skills to the point where few design mistakes, if any, were made. The Black Brant VB rocket continued to perform without error in subsequent testing and was quickly adapted to carry scientific payloads even before the testing was finished. On August 16, 1966, a Black Brant VB rocket laden with a research payload from the Max Planck Institute of West Germany was lofted to 391km above the Earth where it released a cloud of barium. The resulting artificial aurora was visible as far away as Winnipeg, and resulted in a boon of data for the experiment's scientific researchers. The experiment was repeated three days later with another Black Brant VB rocket, which in turn produced another textbook flight and returned much valuable data.[69]

The remaining Black Brant VB rocket test flights were equally successful, bringing a satisfying conclusion to nearly ten years of challenging rocket design and testing. It was a bittersweet end to what many Black Brant engineers called "a labour of love".[70] When the last of the Black Brant V rockets had flown, both the DRB and Bristol could look back with a sense of pride in what was achieved. Essentially, in a little over a decade, scientists, soldiers, and engineers had given their country its very own access to high altitudes and outer space.

## The Associate Committee on Space Research

The initial success of the CRPP, and the subsequent successful flights of the Black Brant I and II series rockets, only whetted the appetites of both the defence and civilian scientific and engineering communities for an expanded Canadian space research program. Yet in the absence of an overarching national-level body to oversee and coordinate all aspects of Canada's space research and development, the agencies that sought to employ Black Brant rockets were, at the most, still only loosely organized to coordinate amongst themselves what was sure to be an expensive and complicated task. Realizing that a more official government-led forum was required for the longer-term planning and execution of Canada's emerging rocket and space program, Dr. Donald C. Rose from the National Research Council called together a group of pioneering space scientists, engineers, and advocates from across Canada to participate in an official space program committee.

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[69] Peter Alway, *Rockets of the World – Third Edition,* Saturn Press 1999, pp.349–350.

[70] Email interview with Dr. Lorne George Mason, Black Brant rocket engineer (1963–1965), December 2000.

Fig. 2.15 Dr. Donald C. Rose, a veteran defence scientist, served as the first chairman of Canada's Associate Committee on Space Research

This newly-formed government advisory body was named the Associate Committee on Space Research (ACSR), and it met officially for the first time in Ottawa on October 2, 1959.[71] Dr. Rose acted as chairman of the twenty-member group, which included senior academics from a dozen universities as well as scientists and engineers from the NRC, the DRB and its subordinate organization, the CARDE, as well as the Department of Transport (Table 2.1). After calling the group to order, Dr. Rose introduced Dr. E.W.R. Steacie, then serving as President of the NRC, who in turn welcomed everyone to the meeting before briefly outlining the proposed objectives of the group assembled before him. Dr. Steacie announced to those assembled, "This committee will provide a mechanism for participation in rocket firings by the universities as well as government departments. It will also serve as the Canadian national committee for the International Council of Scientific Unions (ICSU) Special Committee on Space Research (COSPAR) and will ensure that Canadian representatives at the United Nations are kept informed of the views of Canadian scientists regarding activities in space."[72] While UN-related space activities were deemed important, however, the subsequent record of the early years of the ACSR clearly demonstrates that the issue of rocketry for science and defence was at the center of the group's attention and efforts.

[71] Unofficially, an ad hoc meeting was held at the NRC on April 7, 1959, which resulted in a written proposal for the formation of the ACSR from Dr. Rose to Dr. E.W.C. Steacie on May 13, 1959. See space research folder Vol.7841 File. 12798: 2-40 pt.1 Exhibit "Q", RG 25, LAC.

[72] Ibid., p.2.

Table 2.1 Member of the Associate Committee on Space Research, 1959–1963

**Chairman**
Dr. D.C. Rose, Division of Pure Physics, National Research Council, Ottawa

**Secretary**
Mr. B.D. Leddy, Division of Administration and Awards, National Research Council, Ottawa

**Members**
Dr. J. Auer, Medical Research Council, Ottawa
Dr. J.H. Chapman, Radio Physics Laboratory, Defence Research Board, Ottawa
Dr. R.F. Chinnick, Defence Research Board, PO Box 1427, Quebec
Mr. J.W. Cox, Directorate of Physical Research, Defence Research Board, Ottawa
Dr. P.A. Forsyth, Department of Physics, University of Western Ontario, London
Prof. C. Fremont, Department of Physics, Laval University, Quebec
Dr. G.M. Griffiths, Department of Physics, University of British Columbia, Vancouver
Dr. A. Kavadas, Department of Physics, Dalhousie University, Halifax
Dr. D.P. McIntyre, Air Services, Meteorological Division, Department of Transport, Toronto
Dr. D.W.R. McKinley, Radio and Electrical Engineering Division, National Research Council, Ottawa
Mr. G.S. Murray, United Nations Division, Department of External Affairs, Ottawa
Dr. R.W. Nicholls, Department of Physics, University of Western Ontario, London
Dr. G.N. Patterson, Institute of Aerophysics, University of Toronto, Toronto
Dr. H.I. Schiff, Department of Chemistry, McGill University, Montreal
Mr. M.M. Thomson, Dominion Observatory, Department of Mines and Technical Surveys, Ottawa
Mr. F.R. Thurston, National Aeronautical Establishment, National Research Council, Ottawa
Mr. H.J. Williamson, Telecommunications Branch, Department of Transport, Ottawa
Dr. B.G. Wilson, Department of Physics, University of Alberta, Calgary

Source: Andrew B. Godefroy, *Defence & Discovery: Canada's Military Space Program, 1945–74*

Though such a focus may at first have appeared to be naive, when placed within the context of the period it made perfect sense. In 1959, space exploration was still in its infancy, and even the two main space race adversaries, the U.S. and the USSR, were still mastering the art of making escaping Earth's gravity a routine affair. Without the successful development of rockets, nothing – alive or otherwise – was getting into outer space, into orbit or off on a lunar journey. As well, defence planners and engineers knew that rockets designed to reach the upper atmosphere or farther were simply ballistic missiles without their warheads yet attached. As such, the rocket had huge potential not only as a platform for exploration and science, but also for weapons and defence. Thus, with a continuously acrimonious relationship evolving between the two super powers, the Canadian government saw investment in rocketry development not just being scientifically informed, but militarily prudent as well.

Once an assessment was made of the current status of Canada's rocket-based research program, the ACSR then concentrated on the development of plans to coordinate the nation's future activities. While the National Research Council and the universities were primarily interested in expanding their overall research in space science, Canada's defence sector was keenly interested in upper atmospheric research, atmospheric seeding experiments, atmospheric effect on the re-entry of objects, and larger-scale rocket studies and testing.[73] Together, it was feasible that both sectors could work together cooperatively; it was now just a matter of determining exactly how.

There were also many questions that remained unanswered. It was uncertain whether the NRC or the DRB should become the primary agency responsible for the overall design and construction of rockets and payload experiments, and the details of how nose cones with their delicate cargos would be transported to the remote firing sites in Churchill for checkout and launch had yet to be determined. The DRB and the Department of Defence Production (DDP) had initiated a series of studies on establishing some form of indigenous rocket supplier in Canada, perhaps in cooperation with industry, though it would be a year or more still before any detailed report on the subject would be ready. There were also growing concerns over launch facilities and range control issues, and whether or not there were enough human resources available to successfully engage in sustained Canadian launching activities. All of these concerns were raised during the first meeting of the ACSR, immediately providing the members with a number of issues requiring their best efforts and attention. Lastly, details of the first meeting and the nature of issues discussed by the group were treated as secret, with the Chairman reminding all present that no one should communicate anything to the press or public until it was deemed appropriate to do so.[74] The order, not intended with severity, was rather a subtle reflection of the great sensitivity with which any issues related to rocketry and space exploration were treated during the dawn of the space age. With that final comment from Dr. Rose, the first meeting of the Associate Committee on Space Research was adjourned.

Though the creation of the ACSR certainly focused the wide range of diverse interest in Canada's rocketry program through a single committee and empowered it with some political legitimacy, the executive committee of the ACSR was still faced with the difficult task of validating its plan to expand the current rocket program through government. Since the NRC and the universities had no way of initiating sustainable production, launch, and control facilities on their own, another central agency would have to provide these essential capabilities. The Canadian military already had some of these services in place, but hopes that the defence community alone would drive the expansion in Canadian rocketry development were quickly extinguished. At an executive meeting of the ACSR held on December 10, 1959, Dr. Keyston, then serving as Vice-Chairman of the Defence Research Board, explained why.

There was perhaps some hope that Canada's military would develop strategic missile systems similar to those then being developed in the United States. Canada was in the process of acquiring and equipping the nuclear-capable Honest John Surface-to-Surface Missile for its land forces stationed in Europe; therefore, it might have seemed plausible to the Canadian rocketry community that the RCAF would follow suit with its own launch system. Cabinet previously stressed to DND, however, that the delivery systems currently within the

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[73] Ibid., p.5. Mr. Chinnick also described efforts by the CARDE to design and test a single stage rocket capable of reaching an altitude of 250km with a payload of 68kg, designated the Snow Goose and later, the Black Brant IIA.

[74] Ibid., p.3.

arsenals of Canada's Armed Forces were deemed more than adequate at the time for its limited stock of high-yield nuclear ordnance, and as such the government had no intention of spending large sums to develop larger multistage rockets for military use of any kind.[75]

It was an important if not somewhat confusing government decision. While the government encouraged some development of rocketry and missile systems, at the same time it was setting limits on the level of capability it expected to achieve and sustain. With these restrictions the DRB then had no official mandate to maintain expert knowledge in sophisticated rocketry and launch systems to advise the military staff, but was instead directed to employ the small group of ballistics personnel it was currently employing at the CARDE to act as its rocketry subject matter experts when needed.[76] Those personnel who had worked on the previous Velvet Glove project and were currently engaged with Black Brant program were expected to suffice if another program was started. If further subject matter expertise beyond this was required, the plan was to have the RCAF recall any of its personnel currently on exchange with space and missile systems divisions in the United States.

Nor could mass production of rocketry be justified for defence research alone. Since the CARDE only needed a small number of research rockets every year for its own programmed activities, there was no requirement to build any additional production or control facilities that larger rockets demanded. Neither was Canada yet in the business of conducting multiple satellite launches, the other main impetus for creating a sustainable indigenous launching operation. Unfortunately for the ACSR and other rocket program advocates, any further justification for an expanded rocket program would have to come from Canadian civilian and commercial, not military, needs.[77]

Another suggestion was tabled at the committee meeting. If the ACSR could provide Dr. Keyston with a submission stating the national need for a Canadian rocket, and hence the production and control facilities that go with it, he would be in a better position to have the DRB request that additional funding and resources be made available over and above those already committed to the Churchill Research Range. Further, Keyston was interested in knowing when a two-stage or larger rocket might be necessary for Canada, as this would influence the level of resources required. The issue of opting for the use of American rockets as an alternative was also discussed, but this option immediately raised questions among the group about availability, maintenance, fitting into their handling facilities,

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[75] Proceedings of the First Meeting of the Executive Committee of the Associate Committee on Space Research, December 10, 1959, p.1, file 12798-2-40 pt.1, vol. 7841, RG 25, LAC; Outer Space – Proposal For Possible Canadian Initiative. (Confidential) memorandum 'International Implications of a Canadian Space Research Program', prepared for the Under-Secretary of State for External Affairs, dated August 27, 1959, p.2, File No.12798-4-40, Vol.1, RG 25, LAC. Evidence suggests the decision was taken for economic reasons, not as a result of disarmament ideology.

[76] Throughout this entire period DND maintained a small cadre of military and civilian personnel outside of Canada on official exchange to American missile-related programs and project offices.

[77] Ibid., p.1.

Canadian know-how, and others.[78] In the end, it was decided that the best way to proceed for the present was with a program based on existing Canadian capabilities and resources and then build from there.[79]

Subsequent meetings of the ACSR during the year 1960 produced a tentative budget and agenda for the first series of regular Canadian scientific rocket flights. The number of Black Brant rockets needed for initial university space science experiments was determined as was the substantiation for the development of a number of multistage versions of the rocket for larger scientific payloads. If this activity was sustained or expanded over the next couple of years, it was hoped that larger multistage launchers such as the American Scout rocket might then become a more viable option for Canadian use. The CARDE was again identified as the best government agency to lead Canada's rocketry development; however, it was acknowledged that commercial contractors would very likely also be required to support various production and integration stages of the program.[80] As well, it was determined that arrangements for the transfer of launching facilities at Churchill from the United States back to the Canadian military be initiated as soon as conveniently possible, with an expected handover date arranged for some time in 1962 or 1963.[81]

## First Satellite: The Topside Sounder Project

The idea for Canada's first space satellite evolved within the space science community of the Defence Research Board and select Canadian universities during the early 1950s, but came to fruition after the U.S. National Academy of Sciences made a call for international scientific proposals to be flown on a satellite. Originally tasked by his government to coordinate both internal and international efforts in future ionospheric research, Dr. Lloyd Berkner issued an open invitation in early 1958 on behalf of the NAS to the Western scientific community to submit proposals to them for possible satellite-borne experiments that could explore the characteristics of the 'topside' of the ionosphere. A number of countries returned submissions for topside sounding experiments, including a rather clever offer from the Defence Research Telecommunications Establishment (DRTE) then located in Ottawa.

[78] Ibid., p.2. Interestingly, however, was the fact that the United States owned and operated the Churchill Research Range during the period when the ACSR intended to execute its own rocket research program there. As such Canada was essentially depending on American facilities and assistance already.

[79] It was also agreed that American Nike-Cajun rockets, which were previously employed by Canadian scientists at Churchill, would continue to be used for some future experiments.

[80] Proceedings of the Second Meeting of the Associate Committee on Space Research, April 8, 1960, p.7. File 12798-2-40 pt.1, vol. 7841, RG 25, LAC.

[81] First a fire, then politics, delayed the transition between governments until January1, 1966. The range continued to be funded and operated jointly by the United States and Canada until the late 1960s.

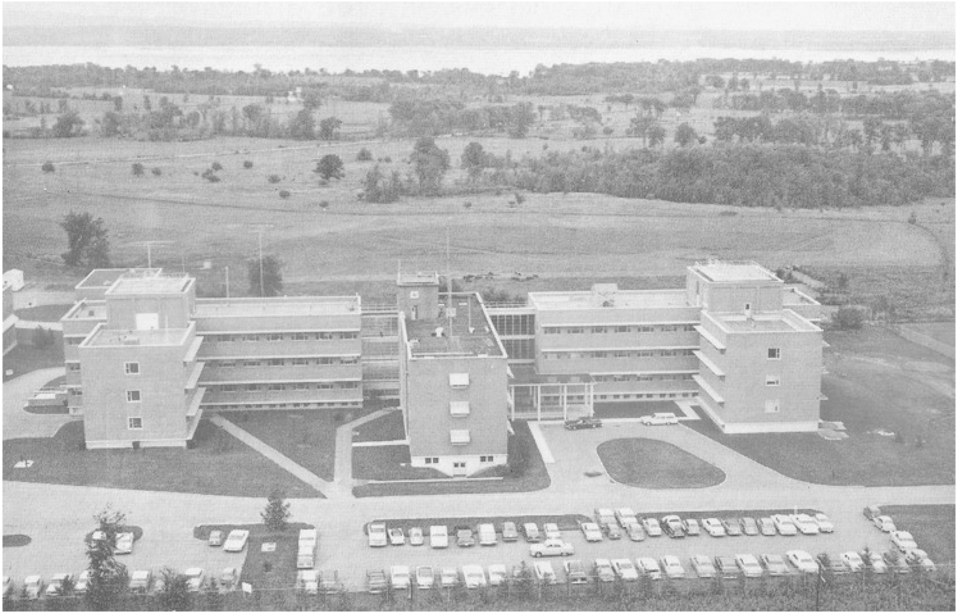

Fig. 2.16 DRTE main buildings at Shirley's Bay west of Ottawa c.1961

Within the DRTE, Dr. Eldon Warren, Dr. Colin Hines, Dr. John H. Chapman, and others had seriously considered the idea of building and launching a Canadian satellite for some time, as had Dr. Peter Forsyth and fellow science colleagues at the University of Saskatchewan. When the DRB began officially canvassing its own research establishments for potential interest, however, at first satellite experiments were not an easy sale to any of its defence scientists. Dr. Hines of DND's Radio Physics Laboratory (RPL) later recalled, "[DRTE Chief Superintendent Dr. James C.W.] Scott called me in and asked if I wanted RPL to do satellite-borne studies. I replied that in due course I did…He told me that there was a proposal for the DRTE to build a baseball sized chunk of equipment for topside sounding to be carried aboard someone else's satellite…I simply replied that perhaps it would be a good thing for us to do in another year or so."[82] Dr. Hines politely spurned the offer in order to properly address other priorities and existing commitments within the RPL, so Dr. Scott instead turned the project over right away to the Electronics Laboratory (EL) for consideration.

Dr. Eldon Warren, however, then currently involved in 'bottom side' sounding of the ionosphere, immediately warmed to the idea. He further developed the concept along with Dr. John Chapman and other talented scientists and engineers in the EL and organized a proposal and briefing for the DRB's senior managers to review. The initial design was

[82] University of Western Ontario Space Workshop. Supplementary Materials: Alouette Satellite, Comments from Colin Hines in adding details to a letter on the origins of the Alouette concept from Dr. P. Forsyth to Dr. J. Scott, September 22, 1981.

considered both original and very technically sound, and subsequently the Electronics Laboratory team got their proposal approved for submission to the NAS.

In their proposal, the engineers at the DRTE reasoned that their submission would meet with greater approval if the satellite demonstrated advanced engineering capabilities. Thus, instead of submitting a single frequency investigation experiment like other international organizations, the Canadians proposed to build a second-generation satellite that could employ a topside sounder capable of sweeping through a wide range of frequencies. When all of the interested agencies met at the American Space Science Board's Working Group on Satellite Ionosphere Measurements in Boulder, Colorado, in September 1958, the DRTE concept indeed demonstrated advanced engineering capabilities that none of the other invited parties had considered in their own designs.[83]

A special independent meeting to specifically consider the topside sounder experiment in detail was called by Dr. Henry G. Booker of Cornell University in October 1958, attracting the attention of at least seven interested groups including the Canadian team from DRTE.[84] Again their proposal met with a favorable response from the committee and the Canadian experiment was eventually selected as the preferred option. Unfortunately, however, just a short time after this happened the NAS cancelled its participation in these experiments and the offer to the DRTE "farm team" was officially rescinded.[85]

Undeterred by this setback, however, the DRTE engineers approached other interested parties in the United States in late 1958, this time their target being the United States Department of Defense. Former DRTE scientist and Communications Research Center historian Mr. LeRoy Helms wrote a popularized account of their visit to the Pentagon in 1958 as follows:

> "It is said that they [Dr. Scott and Dr. Warren] were greeted at DoD by a big Texan USAF Colonel who listened attentively, Cowboy boots on his desk and smoking a large cigar, as these boys from the far north explained their proposal. When they had finished, he put his feet down, snuffed out his cigar and said, "Sure we'll launch for you. But there's a new agency just starting up – called NASA – who are supposed to do international space research projects. Probably won't amount to anything but you'd better go see them first. But if they aren't interested y'all [sic] come right back and we'll look after you."[86]

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[83] Canada Department of Communications, *Alouette 1: Canada's First Venture into Space*. Ottawa: Information Services Booklet, June 1974,p. 6; and J.E.Jackson, R. Knecht, and S. Russell, "First Results in the NASA Topside Sounder Program", in NASA. *Publications of the Goddard Space Flight Center, 1959–1962, Volume II: Space Technology.* Washington: NASA HQ, 1963, p.41.

[84] Evidence infers that the meeting was held at Cornell University at Ithaca, New York, in October 1958. Details available from transcript of presentation made by Colin A. Franklin at the IEEE International Milestone in Engineering Ceremony, Shirley Bay, Ottawa, May 13, 1993.

[85] Transcript of presentation made by Colin A. Franklin at the IEEE International Milestone in Engineering Ceremony, Shirley Bay, Ottawa, May 13, 1993; see also DOC. *Alouette 1: Canada's First Venture into Space*, p.6.

[86] Leroy Nelms, "DRTE and Canada's Leap into Space: The Early Canadian Satellite Program", p.2.

Finally, in early 1959 Dr. Scott and Dr. Warren approached a newly-created United States civilian space authority named the National Aeronautics and Space Administration (NASA). Again the DRTE engineers impressed their potential sponsor – the fact that they already had a carefully planned proposal in hand from their previous attempts certainly helped – but NASA still received the proposal with a degree of skepticism. The American space agency experts were concerned about both the satellite power-supply and antenna design. The Canadian proposal needed to continually generate power throughout its orbit, and called for the deployment of four robust antennas measuring between 23 and 45 m in length yet weighing no more than 4.53kg. The Canadian engineers even later admitted, after the project had succeeded, that they initially estimated that the satellite would operate for no more than a few hours.[87]

Nevertheless, the Canadian scientific proposal was an excellent fit with the emerging mandate of NASA, and after further negotiation the two organizations agreed to cooperate on the launch of the Canadian topside sounder satellite experiment. The two countries made a joint announcement of the arrangement on April 20, 1959, with an official exchange of letters between the DRB and NASA following later in the year on August 25, November 18, and December 6, 1959.[88]

With the advent of orbital capability, Canadian defence scientists once again had the opportunity to expand their investigation of the upper atmosphere. The DND through the DRB in turn supported its ongoing endeavors as the Canadian government saw it as a positive way of acquiring advanced space technology that was then considered critical to future national defence. From the mid-1950s onwards, knowledge of the Earth's ionosphere played an ever-increasing role in the design of modern ballistic missile defence systems, now largely based on wireless communications. As well, the development of advanced weapons systems and defences was increasingly dependent on technologies similar to those developed for space systems including solid-state electronics, miniaturization, and computers. When considering the military value of the data derived from satellites at the time, namely imagery and scientific data, there was little difficulty for the defence science community in convincing their military and political leaders of the need for continued research and financial support.[89]

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[87] J.E. Jackson et al., "First Results in the NASA Topside Sounder Program", in NASA, *Publications of the Goddard Space Flight Center, 1959–1962, Volume II: Space Technology,* pp.41–42. C.A. Franklin and others have suggested that NASA was originally highly skeptical of the DRTE proposal and internally assessed that the satellite would not likely function for more than a few hours. Others have suggested the move was a stalling tactic to ensure that a similar American project, known as S-48, would be launched first. Contemporary American- and Canadian-related archival evidence does not substantiate any of these claims beyond the anecdotal.

[88] Copies of these agreements may be found in J.H. Chapman, P.A. Forsyth, P.A. Lapp, and G.N. Patterson, *Upper Atmosphere and Space Programs in Canada: Special Study No.1*. Ottawa: Science Secretariat, February 1967.

[89] The idea that these innovations might be diffused from the military out into the civilian economy was another factor that drew sustained support. The government saw space technology not just for defence but also as an industrial opportunity. The challenge remained, however, on how best to exploit that opportunity.

## Project S-27: Initial Planning

Concurrently with the making of formal political arrangements with Canada, NASA issued a request to the U.S. Central Radio Propagation Laboratory (CRPL) of the National Bureau of Standards to examine the DRTE (and other) proposals for their scientific merit and engineering feasibility. In considering the Canadian proposal, the CRPL suggested that it might be rather ambitious for a first attempt at examining the ionosphere. Instead, it offered that a fixed-frequency system should be launched as a first-generation experiment, while the DRTE swept-frequency system proposal was developed separately as a second-generation satellite. All parties agreed to this approach and planned for the first Canadian satellite launch sometime in the 1963 timeframe.[90] For the time being, NASA officially designated the Canadian DRTE experiment as Project S-27. Christening the satellite as *Alouette 1* came later.

In January 1960, NASA received another proposal jointly from the CRPL and the Airborne Instruments Laboratory (AIL) for a fixed-frequency experiment. The AIL was to design, construct, and test the satellite payload while the CRPL was to provide scientific supervision and analyze the resulting data. Work began on this experiment, designated S-48, on May 9, 1960. This project would now supposedly precede the DRTE satellite, but being similar in objectives and technique, it was still to complement the Canadian follow-on effort. The main difference between the two satellites was in the instrumentation. The American-designed S-48 experiment emphasized the study of cross-sections through the ionosphere employing both Canadian and American telemetry stations along the 75°W meridian. It also had a low resolution and a fast profile acquisition rate, employing six fixed frequencies providing a downward pulse transmission and echo reception in the 3–9 megacycle (Mc) range. By contrast, the Canadian S-27 experiment emphasized the investigation of polar, arctic, and auroral effects that produced the very complex ionospheric conditions existing over Canada. For this purpose, telemetry stations were established at specific points across the country. As well, instead of employing a low resolution and fast profile acquisition rate, the Canadian satellite intended to work in the exact opposite manner.[91]

The range and scope of the Canadian experiment soon attracted interest from the United Kingdom, which in turn expressed a desire to also participate in the topside sounder program. In return for access to data, the United Kingdom offered the use of three of its own ground telemetry stations – one at the Falkland Islands in the South Atlantic, one at Singapore, and a third station at Winkfield, England, for the collection and distribution of satellite data. Both NASA and the DRB accepted this offer and the United Kingdom officially joined the topside sounder program in 1960. The experiment in turn came under the overall management of the Goddard Space Flight Center, which coordinated the efforts of the various countries and organizations involved.[92]

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[90] J.E. Jackson et al., “First Results in the NASA Topside Sounder Program”, pp.41–42.

[91] Ibid., pp.42–44.

[92] L. Wallace, *Dreams, Hopes, Realities: NASA’s Goddard Space Center, The First Forty Years.* Washington: NASA History Office SP-4312, 1999.

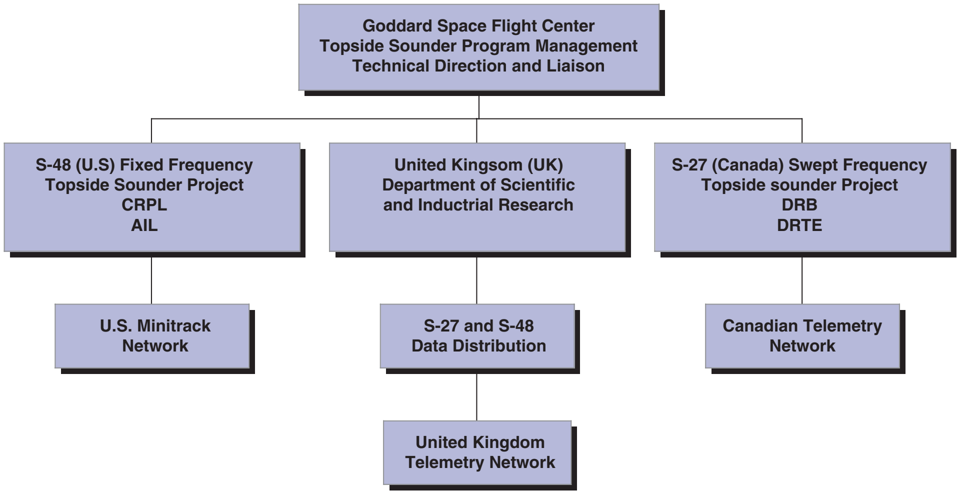


Fig. 2.17 Project management and oversight for the S-27 project, 1960–61

## Design, Construction, and Testing

In the late 1950s, space systems design, construction, and testing remained a largely unproven process, drawing mainly from the existing experience of the aerospace industry. Management and control of technology research and development continued to evolve, and scientists and engineers were figuring out a viable process for coordinating large-scale technology development. At the same time, their leaders were looking for organizations that could innovate, learn, adapt, and sustain adaptation in order to achieve long-term scientific and technological goals.[93] It was within this context that the DRTE was expected to produce Canada's first full-scale satellite.

Understandably, the approach to designing Canada's first experimental satellite was at first conservative. The original concept called for a spacecraft size along the same lines as the first American satellites, roughly no bigger than a grapefruit or basketball. As the S-27 Project evolved, however, the size and complexity of the satellite also grew. The DRTE Electronic Lab satellite team also originally wanted only a single role for the satellite – to measure the state of the ionosphere directly below the satellite as it orbited the Earth. Yet as the project progressed, the designers and engineers added an additional three experiments to the satellite: a sounder receiver to measure cosmic noise, a frequency receiver for "listening" to radio noise in the range of 1–10 kilohertz, and an experiment to measure primary cosmic ray particles such as electrons, protons, and alpha particles, outside of the

[93] S. Johnson, *The Secret of Apollo: Systems Management in American and European Space Programs.* Baltimore: The Johns Hopkins University Press, 2002, pp.2–4.

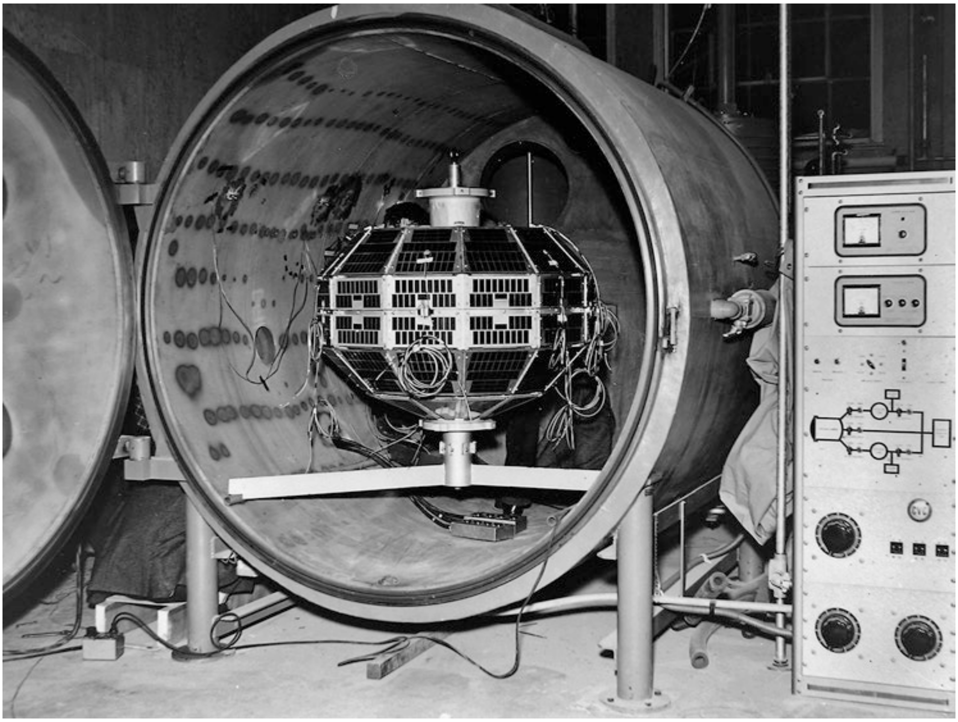

Fig. 2.18 The Alouette 1 satellite undergoing vacuum chamber testing at the DRTE labs, c.1960

denser portions of the Earth's atmosphere.[94] In the end, *Alouette 1* resembled an oblate spheroid measuring approximately 107cm in diameter with a height of approximately 86.5cm. The total weight of the final design was just over 145kg.[95]

As with most satellites designed during this period, the basic shape of *Alouette 1* resembled a clamshell. The satellite design itself consisted of four main components: the structure, the spacecraft electronics, the antenna, and the four experiment payloads. The internal backbone consisted of a pair of thrust tubes, one above and one below, with a pair of circular structure disks between these which served as the mounting areas for the electronic components of the experiments described above. Between the two structure disks was also housed the four erectable antenna units. Surrounding the center of the structure was the solar cell shell that consisted of a pair of spinnings upon which were mounted support channels to carry the flat solar cell panels. Inside the spinnings were diaphragm rings that

[94] Technical specifications for *Alouette* may be found in DRTE Annual Reports 1962 through 1967; see also Department of Communications. *Alouette 1: Canada's First Venture into Space*. Ottawa: Information Services Booklet, June 1974. Numerous technical papers were also published by DRTE staff in various scientific journals, and lists of these are available within the DRTE Annual Reports.

[95] DRTE, *Alouette Satellite 1962 Beta Alpha One.* Shirley Bay: DRB, October 1962.

served the two-fold purpose of stiffening the spinning and providing the attachment between the spinning and the structure disks.[96]

The structure of the satellite, which in turn held all the other components together, posed the largest design challenge. It had to be able to withstand the violent vibrations of launch and the vacuum and radiation of space yet still function to collect and return its data. Several building materials were considered, including sophisticated materials such as micarta, polyurethane epoxy, Teflon, aluminized Mylar, unbonded glass fiber paper, etc., and even some not-so-sophisticated materials such as commercially-available brown wrapping paper. To cope with the vacuum conditions, the DRTE engineers had to avoid materials with high partial pressures that sublimed easily. As a result, aluminum was chosen as the primary material for the body of the satellite, held together with steel and stainless steel fasteners.[97] The structure of the satellite was completed by an cap at either end in order to prevent sunlight from striking through to the interior of the satellite and causing overheating of the electronic components inside.[98]

Temperature, or more importantly the control of temperature, affected every aspect of the design of the spacecraft. Everything from shape, to material used, to launch times, was considered to ensure that the satellite and its precious payload experiments remained within acceptable tolerances during launch and orbit. Up to that time many spacecraft had died quickly in the harsh environment of outer space as one side of the satellite literally cooked while the other half froze to death. The engineers at DRTE were most concerned about their satellite surviving long enough to return useful data to scientists on the ground.[99]

It was estimated that the most critical period for the satellite's life would be during and shortly after launch. Given the size and weight of the satellite as well as the intended orbit, the launch vehicle chosen for *Alouette* was an American two-stage Thor-Agena B booster. Already a workhorse in the American surveillance satellite program by 1960, the upgraded B variant was designed to push larger payloads off the launch pad into orbit and was a preferred choice for the *Alouette 1* experiment. The rocket's first stage – Thor – would propel the Canadian satellite for approximately 165 seconds into the upper atmosphere. Once the Agena B upper stage had successfully separated from the Thor lower stage and resumed its own burn, the Agena would shed its payload shroud leaving *Alouette* firmly attached yet totally exposed to the vacuum of space for two and a half minutes. During this time the satellite would not be spinning, therefore solar heat could not be equalized around the entire shell of the spacecraft. As a result, it was planned to schedule the launch for a time when the satellite would be in the Earth's shadow during its ascent, but even then there remained the problem of aerodynamic heating as *Alouette* reached towards outer space.[100]

As described above, the outer shell of the structure was designed so that the power plant was partly located on the outer surface. Employing 6480 small solar cells arranged in

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[96] J. Mar and H.R. Warren, 'Structural and Thermal Design of the Topside Sounder Satellite', *Canadian Aeronautics and Space Journal*, September 1962, 163.

[97] Department of Communications, *Alouette 1: Canada's First Venture into Space*. Ottawa: Information Services Booklet, June 1974, pp.13–15.

[98] J. Mar and H.R. Warren, 'Structural and Thermal Design of the Topside Sounder Satellite', 163–164.

[99] Ibid., 166–167.

[100] Department of Communications, *Alouette 1: Canada's First Venture into Space*. Ottawa: Information Services Booklet, June 1974, 12–14.

groups of forty-five that almost completely covered the outside of its structure, *Alouette*'s outer skin was designed to charge the batteries located inside the satellite. In order to provide adequate charging currents regardless of the satellite's orientation with respect to the Sun, it had to be able to consistently expose the same number of solar cells at all times.

Fig. 2.19 Dr. John H. Chapman poses with the Alouette satellite at DRTE labs c.1961. A brilliant scientist and satellite pioneer, he would lead Canada's space program development until his early death in 1979

The solar cells were then further covered with paper-thin chips of glass using a special non-reflective and spectrally selective coating that passed ultra-violet light but not infrared light which could cause heating of the spacecraft. In a sense, the solar cells and coating acted as thermal insulators but still let the much-needed light through,[101] and also protected the solar cells from potential micrometeorites and harmful radiation.[102] This constraint influenced the overall semi-spherical design of the satellite, and the power

[101] The glass covers, attached to the solar cells with an epoxy-based adhesive, together with the satellite's spin were designed to keep the cells within a temperature range of –20 degrees Celsius to +50 degrees Celsius. In operation, the spacecraft temperature at times rose as high as +75 degrees Celsius. See also DOC, *Alouette 1: Canada's First Venture into Space*, p.12.

[102] J. Mar, 'Meteoroid Impact on the Topside Sounder Satellite', *Canadian Aeronautics and Space Journal*, November, 1962, 237–240.

requirements of the payload in turn dictated the overall surface area size of the spacecraft. Lastly, the semi-spherical shape also contributed to the temperature control of the spacecraft. The intention for *Alouette 1* to have a slight spin in orbit, roughly two revolutions per minute, not only reduced spacecraft oscillation but also helped avoid the danger of the satellite getting "hot spots" from overexposure to direct daylight.[103]

The design of the interior electronic components highlighted some of the technological challenges still faced in the early 1960s when dealing with advanced systems. Although extensive miniaturization of the electronic content was not considered absolutely necessary for *Alouette 1* it was desirable as much as possible, if for no other reason to lessen the weight of the craft and/or potentially make more room for the onboard experiments. To consider the employment of vacuum tube technology meant possibly providing more power but doing so at the expense of reliability, higher power consumption, greater weight, and ultimately the need for more space in an already small satellite. Instead, the *Alouette 1* team sought out the most modern electronics available to them at the time, building the spacecraft using then ultra-modern solid state transistors which provided less power but were more reliable and provided greater semi-conducting efficiency.

The antennae posed a particular challenge for the engineers at first but in the end resulted in a novel and uniquely Canadian solution. The *Alouette 1* design called for four erectable sounding antennae; two crossed dipoles a hundred and fifty feet from tip to tip, and two crossed dipoles measuring seventy-five feet from end to end. All four antennae were designed to extend in a traverse plane at the center of the satellite exactly 90° to one another, and had to be housed within the satellite in such a manner that the entire payload would fit into its confined payload bus fairing atop the rocket. At first inspection, there was no way the antennae would fit inside the satellite, and they were too fragile to fold and pack alongside the main structure. Further, a multijointed object meant that any one of these could fail, resulting in a partial deployment of the antenna or even no deployment at all. All antennae had to deploy perfectly for the satellite to complete its assigned task.

The solution to the problem was derived from a tool first conceived and developed by Mr. George J. Klein, an engineer with the National Research Council since the Second World War. A taped length of spring steel, previously heat treated and opened flat, was wound on a drum and placed within an antenna assembly with a guide sleeve and an electro-static shield. Altogether, the antenna assembly unit was no more than approximately a foot in length and fit comfortably into the satellite structure housing. Once in orbit, the antenna deployed by pulling the spring steel of its storage drum by means of a simple drive belt, and once guided through the antenna sleeve the metal tape sprang back into its natural tubular shape with about 180° of overlap. Even at a hundred and fifty feet, the antenna proved extremely robust with considerable bending strength.[104] In fact, the concept, later known as the Storable Tubular Extendable Member (STEM) system, worked so well that this method of antenna deployment was employed on nearly all subsequent Canadian and American satellites and spacecraft throughout the next two decades.[105]

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[103] DOC, *Alouette 1: Canada's First Venture into Space*, 14–20.

[104] DRTE, *Annual Report 1962*. See also J. Mar and H.R. Warren, "Structural and Thermal Design of the Topside Sounder Satellite", 164.

[105] Grease and oil were used only in the sealed ball bearings of the antenna extension mechanisms; they had only to operate successfully once to deploy the antennas.

Fig. 2.20 DRTE employee Mrs. V. MacDowell holds a partially deployed STEM antenna unit c.1962

Testing this system on the ground, however, was likewise a difficult proposition. The philosophy employed by NASA at that time was that an identical prototype of the flight version of the unit had to survive a program equaling a hundred and fifty percent of the highest expected design loads. As well, there were several vibration tests that had to be passed where the dynamic balancing of the satellite was proven. Also with *Alouette* and subsequent Canadian-built satellites employing STEM technology, the antennae had to be tested, which in turn proved a real challenge in Earth's gravity. An instrument known as a full extension rig was employed to extend the antennae along a series of hung carriers, while engineers measured rate of extension, drive motor current, and voltage.[106]

So much of the *Alouette* mission depended on the successful deployment and operation of the antenna. To further ensure their success, the design was flight tested in June 1961, when a pair of the STEM were mounted in the nose cone of a U.S.-built Javelin rocket and launched to satellite altitude. Though some improvements were indicated as a result of the test, the experiment was overall very successful and considered proven for a final deployment of the STEM antenna on *Alouette 1* itself.

[106] J. Mar, J. and H.R. Warren, 'Structural and Thermal Design of the Topside Sounder Satellite', 165.

### The Alouette 1 Satellite Launch

Canada's first satellite project remained on schedule and the completed spacecraft was moved to Vandenberg Air Force Base, California, in the late summer of 1962 to undergo final checkout and transfer to the launch pad. *Alouette 1* was ultimately scheduled for a night flight; the planned launch window of 2330hrs to 0130hrs on September 28/29, 1962 was finally chosen, as it allowed for the mission scientists to get as many soundings as possible on the first few orbits after lift-off before *Alouette 1* was fully exposed to the Sun. There was still some concern that the spacecraft might suffer a catastrophic malfunction or failure when it heated up for the first time, so the intent was to ensure that at least some data were returned as soon as possible. This flight plan also allowed mission scientists to ensure that the onboard passive temperature control system was actually working, as it should, by slowly exposing the satellite to progressive amounts of sunlight with each passing orbit.

Fig. 2.21 Dr. John H. Chapman stands before the Thor-Agena B rocket that carried Alouette 1 into orbit, September 1962

After years of planning, design, construction, and testing, *Alouette 1* was launched into outer space from California just before midnight on September 28, 1962. Dr. John Chapman, head of the DRTE *Alouette* team, was there to see her into orbit and later was quoted as saying, "I had my fingers crossed, my legs crossed, and everything else crossed.

At that time, there was still a fifty percent chance of failure in launchings."[107] Dr. Chapman and his team, however, had little to worry about. The launch of the Thor-Agena B took place without difficulty and lit up the evening sky as the American booster lofted its *Alouette* payload into orbit. Accompanying *Alouette 1* into orbit was another smaller payload known as TAVE – the Thor-Agena Vibration Experiment. This small technology satellite returned valuable data that assisted engineers in continuing their improvements to the design of the rocket and develop further versions for other use.

As the rocket rose into the sky all aspects of the flight were closely monitored from the ground. Arrangements were made prior to launch by NASA through the United States Navy to have a tracking ship pre-positioned in the Indian Ocean to monitor *Alouette*'s antenna extension once it reached orbit, but at the critical moment there were equipment and operator troubles aboard the designated ship. As a result, the Canadian launch team were kept in suspense for some time after launch until a later report arrived from a ground tracking station in Johannesburg, South Africa, verifying that the *Alouette 1* antennae had fully extended as the design had intended.

The satellite that some NASA scientists had felt would last but a few hours went on to surpass all expectations. *Alouette 1* enjoyed a near textbook deployment and continued operating well beyond when experts thought it might fail. Within weeks of the launch, scientists on the ground were flooded with detailed data on ionospheric structure collected by *Alouette.* Having "optimistically" planned for a three-month mission (*Alouette* was designed for a nominal lifespan of one year), the scientists collected and processed as much data as possible, but it soon became apparent that the satellite was functioning well and would continue to deliver data for some time. When *Alouette* passed its first birthday in space senior administrators at both NASA and the DRTE were impressed. When the satellite celebrated its fifth anniversary in orbit, both groups were simply amazed. Even then, no one would have presumed that the satellite would continue to function for another five years.[108]

The success of *Alouette* was certainly a great achievement, one that the Canadian defence and scientific community could be very proud of. Compliments came from most international and national scientific organizations, but particularly from the skeptics at NASA and the NAS who earlier had supposedly questioned some aspects of the mission. The admiration for Canada's *Alouette 1* was stated very succinctly in the 1963 publication series from NASA's Goddard Space Flight Center. One author wrote:

> "The success of the NASA program of topside ionosphere studies is evidenced by the considerable amount of knowledge obtained from *Explorer VIII*, *Ariel 1*, and high altitude rocket soundings. Perhaps the most spectacular of these accomplishments to date has been the Canadian swept-frequency topside sounder, *Alouette*,

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[107] T.R. Hartz and I. Paghis, *Spacebound.* Ottawa: Department of Communications – Minister of Supply and Services Canada, 1982, pp.60-61.

[108] Alouette was actually decommissioned after its tenth year in orbit and shut down by ground command. Arguably, the satellite would have otherwise continued to function for possibly many more years even. It was a remarkable technological achievement.

> which will probably yield more data about the upper ionosphere…than all the other programs combined."[109]

The experimental satellite project also demonstrated what Canadian defence scientists could achieve when given a clear mandate and the resources with which to carry out the task. The design and construction of *Alouette*, however, should not be perceived as simplistic or something that was easily repeated. The initial concept in place when Dr. Scott was Chief Superintendent called for the design and construction of a very small payload. But as Dr. Hines noted many years later in an historical interview, as the size of the project grew so did the political and financial headaches:

> "I don't recall when the baseball expanded into a basket ball, as it did in mid preparations, or then to the ultimate size of *Alouette* itself, requiring all the time more and more resources. [Dr.] Frank [T.] Davies replaced [Dr.] Scott as Chief Superintendent, DRTE, part way through, and from time to time bitched about this Albatross Scott had hung around his neck. The program ultimately took over EL [Electronics Lab], all of the finances and manpower that could be pulled together inside DRTE, and ultimately required massive subsidy from the DRB itself."[110]

Undoubtedly, the *Alouette 1* satellite came at a considerable cost – approximately $3 million – and it drained resources, scientists, and engineers from all other projects at the DRTE; those not involved with *Alouette* were understandably somewhat resentful of the impact that the high-profile satellite project had on other quieter, less spectacular, fundamental defence science research activities ongoing at that time. Some even suggested later that the success of the *Alouette* satellite ultimately contributed directly to the demise of the DRTE in the late 1960s when all satellite expertise was transferred out of DND over to the newly-created Department of Communications.[111]

Nevertheless, the data returned from the first *Alouette* satellite about the ionosphere, aside from proving to be extremely valuable to future defence telecommunications research, also revealed that there was much more still to learn about the upper atmosphere than at first realized. In turn, this meant that there was a requirement for additional experiments involving other ionospheric parameters, "which could only be satisfied by subsequent satellites."[112] Canada's scientists and engineers were keen to build and launch those satellites.

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[109] L.J. Blumle et al., "The National Aeronautics and Space Administration Topside Sounder Program". *Publications of the Goddard Space Flight Center, 1963, Vol.II: Space Technology.* Washington: U.S. Government Printing Office, 1963, p.13.

[110] *UWO Space Workshop.* Supplementary Materials: Alouette Satellite, Comments from Colin Hines in adding details to a letter on the origins of the Alouette concept from Dr. P. Forsyth to Dr. J. Scott, dated September 22, 1981. Accessed at http://quark.physics.uwo.ca/~drm/history/space/space_history.html.

[111] Leroy Nelms, "DRTE and Canada's Leap into Space: The Early Canadian Satellite Program", p.23.

[112] T.R. Hartz and I. Paghis, *Spacebound,* p.64.

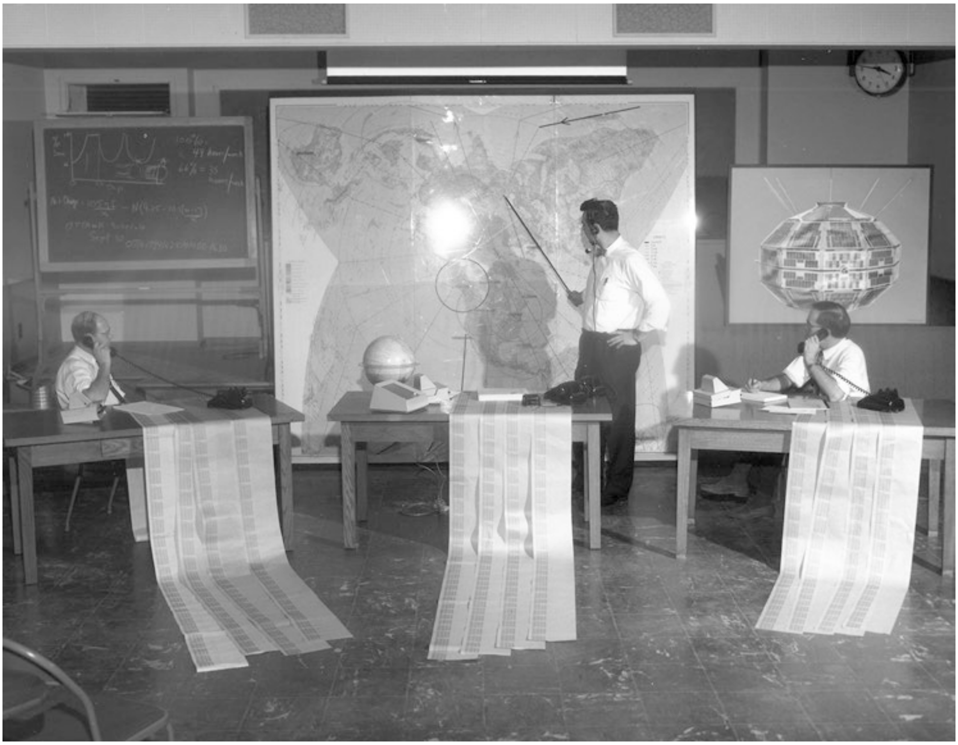

Fig. 2.22 Satellite telemetry receiving station personnel pose for a staged photo as they process data from the Alouette 1 satellite, December 1962

## Conclusion

While no official Canadian space policy was put in place during the early 1960s, neither was any policy that might compromise its existing missile, rocketry, and space cooperation efforts both at home and with its American partners. Instead, the DRB and NRC signed a number of cooperative agreements on space technology development that traded Canadian niche capabilities for more general access to the larger American space program.[113] These agreements were critical as both of Canada's current efforts at that period, the DRB space science program (*Black Brant* and *Alouette*) and the RCAF Space Defence Program, relied heavily on American support for assured access to outer space.

[113] For details of Canada-U.S. space cooperation agreements between 1945 and 1974, see A.B. Godefroy, 'From Alliance to Dependence: Canadian-American Cooperation Through Space, 1945–1999' (Kingston: MA Thesis Royal Military College of Canada, 1999), and by same author, *Allies in Orbit: Canadian-American Defence Cooperation Through Space* (Ottawa: Department of National Defence, Directorate of Space Development, 2000). See also J.H. Chapman et al., *Upper Atmosphere and Space Programs in Canada: Special Study No.1.* Ottawa: Science Secretariat, February 1967.

Apart from those agreements already connected to the Churchill Research Range, several other accords were exchanged between the DRB and NASA concerning the evolving *Alouette-ISIS* program between 1959 and 1964. Three of these were Letters of Agreement (LOA) directed at the *Alouette* program in 1959, formalizing Canada's first official cooperation effort in the launching a satellite and exchanging data obtained from a satellite. A Memorandum of Understanding (MOU) was similarly put in effect in May 1963 between the DRB and NASA concerning the follow on *ISIS* satellite series, a joint program in ionospheric research by means of satellite, which was followed up in May 1964 with a further exchange of notes. The *ISIS* program (detailed below) would continue until 1971.

Canada also signed a number of accords related to satellite tracking. In 1960, an agreement was completed concerning the placement of an American satellite tracking station at St. John's, Newfoundland, with further amendments made to the agreement in 1962 to update the equipment and convert the existing facility into a minitrack station (essentially a modernized version of the original tracking facility). From this agreement Canada gained access to the scientific data obtained from the tracking station and very likely also received certain space intelligence from the American collection point.

General agreements and exchanges of notes with respect to communications satellites were made between the two countries in 1963 and 1964, the latter agreement aiming to secure arrangements for Canada to cooperate in the eventual establishment of a global commercial communications satellite system (GCCSS).[114] At the time, no country in the world had yet established a domestic communications satellite capability, with the United States only having just passed its own Satellite Communications Act in Congress in 1962. Canadian participation in this effort led to its further involvement with the recently-created Communications Satellite Corporation in the United States, and later with the International Telecommunications Union (ITU) and the Interim Communications Satellite Committee. The latter organization was responsible for the establishment of the space segment of the GCCSS generally known as INTELSAT.[115]

Lastly, it is equally important to note the fact that Canada's cooperative space endeavours during this period were very nearly exclusive. With the exception of some aspects of its satellite communications evolution, between 1957 and 1967 Canada did not sign any agreements regarding rocketry or space development with any other country, and had even retreated on more than one occasion from entering into serious negotiations with France and other Western European countries on space cooperation at this time. Though it was interested in the exploration of various cooperative options with Western Europe, Canada simply would not enter into any official agreements that might compromise its already established bilateral arrangements with the United States. A proposal for launcher and satellite cooperation with France and West Germany in 1967, for example, was declined as it appeared to compete for services already provided by the United States. Subsequent proposals from these two countries for agreements were also stalled as Canadian officials

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[114] For technical and legal details of these agreements see Chapman Report, pp.145–200.

[115] Ibid, 2.3 Satellite Communications, pp.14–15.

suggested it would be inappropriate to begin signing space cooperation accords with West Germany when none yet existed for cooperation with closer allies such as Britain.[116] Britain had already received some special consideration in this respect, however, but then cooperation existed only in the exchange or sharing of information and scientific intelligence rather than actual projects or programs, such as had been done previously with the telemetry received from *Alouette*. In the end, Canadian-American space cooperation surpassed all other efforts.[117]

This held true even at the international level. After the failed attempt at instituting international control of space through the UN, Canada maintained only two space-related memberships through this organization. One was with the Committee on Space Research (COSPAR), whose Canadian membership was held by the NRC's Associate Committee on Space Research, and the second was the UN General Assembly's Committee on the Peaceful Uses of Outer Space, whose Canadian membership was organized through the Department of External Affairs.[118] At the time, both committees were more politically esthetic than functionary, as space was still a Cold War battleground and was not yet ready for international laws or control. Essentially impotent, neither committee had any serious influence on the development of Canada's space agenda until the end of the decade.[119]

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[116] Committees and Boards – Canadian Military Space Group pt.1. Proposed Agreement with France Regarding Cooperation in Space Science dated November 30, 1967. Acc 83-84/232 Vol.46 File 1150-110/M16 pt.1, RG24, LAC; and 'Proposed International Space Science Agreement – France,' dated December 5, 1967, Vol.46 File 1150-110/M16 pt.3, RG 24, LAC. Part of the problem was also due to the fact that the DRB, Canada's de facto 'space agency' was itself an arm of the country's Department of National Defence. While this did not present serious problems when dealing with the United States with whom Canada already had a close defence and security relationship, the DRB's involvement in defence matters would very likely send the wrong political signal when dealing with other European nations.

[117] It was suggested that the appearance of Canada's space program depending too heavily on the United States might hinder its ability to form relationships with other European countries, but there is no evidence of action being taken to distance Ottawa from Washington in order to appease European partners or improve options for space cooperation at this time. It simply was not in Canada's national interest to do so.

[118] For a detailed history of COSPAR see Gordon Shepherd and Agnes Kruchio, *Canada's Fifty Years in Space: The COSPAR Anniversary.* Burlington: Apogee Books, 2008.

[119] Canada's signing and ratification of the 1967 Outer Space Treaty is often identified as the origin of Canada's non-weaponization of space philosophy, but the fact that Canada joined such space committees and endorsed various resolutions is often given much more weight than it deserves. Given the nature and scope of the Canadian space program at this time, both the 1967 Outer Space Treaty and the 1968 Rescue Agreement made little difference to Canada's overall agenda, and were treated with no more grandeur of purpose than any other diplomatic activity at that time. For general notes on Canada and space law see A. Beesley et al., "Canada's Contribution to Outer Space Law and Arms Control in Outer Space", *Space Strategy: Three Dimensions.* Toronto: Canadian Institute of Strategic Studies, 1987, pp.94–110.

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