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Chapter 13

Bruce Aikenhead: Canada's Most Versatile Space Pioneer*

Christopher Gainor†

Abstract

Among Canada's early space pioneers, no one can match the career of Bruce Alexander Aikenhead in terms of involvement in the full spectrum of Canada's early space initiatives. Aikenhead helped build Canadian science and communications satellites and the Canadarm for the U.S. Space Shuttle. He helped train the first astronauts for both the United States, and Canada, and even worked on a program aimed at using cannons to launch projectiles to high altitudes. Born in 1923, Aikenhead served in World War II as a radar mechanic with the Royal Canadian Air Force and the Royal Air Force before studies at the University of Western Ontario in physics and mathematics. Aikenhead joined Canadian Aviation Electronics Inc. in Montreal in 1955, where he worked on aircraft simulators, and continued in this field when he joined Avro Canada in 1958. Avro was building the CF-105 Avro Arrow jet interceptor, and after the program was cancelled in 1959, Aikenhead became one of 32 Avro engineers hired by the National Aeronautics and Space Administration (NASA) in the United States to work on its fledgling human space program. At NASA, he helped set up astronaut training in the Mercury program, and then returned to Canada in 1962, re-

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† Sidney, British Columbia, Canada.

joining CAE Industries. He worked for Canadian cannon researcher Gerald Bull on his controversial high altitude cannon program in 1966 and 1967. Aikenhead then joined RCA Canada, where he worked on Canadian satellite programs, starting with the *ISIS 2* upper atmosphere research satellite and then the groundbreaking Communications Technology Satellite, also known as *Hermes*. Once *Hermes* was launched in 1976, Aikenhead went to work as systems engineer for the Space Shuttle Remote Manipulator System, or the Canadarm, which was built by Spar Aerospace in cooperation with the National Research Council (NRC) of Canada. When the Canadarm reached operational status in 1983, just as NASA invited Canada to send astronauts into space, the NRC moved Aikenhead to the Canadian Astronaut Program. When the Canadian Space Agency was set up in 1989, Aikenhead was named Director General of the Canadian Astronaut Program, and served in that role until he retired in March 1993. Today, Canada remains a leader in communications and scientific satellites, and Canadian astronauts and Canadarm2 are integral parts of the International Space Station, all things that were touched by Bruce Aikenhead. His career embodies the international cooperation that lies at the heart of Canada's space program.

I. Introduction

Canada's involvement in space exploration took many forms and had many roots in its early years, prior to the creation of the Canadian Space Agency (CSA) in 1989. The Canadian government facilitated space research starting in 1958, with a scientific satellite program and, a decade later, with concentration on communications satellites. It joined in the United States Space Shuttle program in the 1970s with the Space Shuttle Remote Manipulator System and then the Canadian Astronaut Program. An early and highly unique Canadian space effort was the High Altitude Research Program (HARP) based at McGill University which did research on the use of cannons to launch scientific projectiles to high altitudes. And Canadian engineers who lost their jobs in 1959 when the Canadian government cancelled a high-performance jet interceptor, the CF-105 Avro Arrow, made a big contribution to the development of human spaceflight in the United States when they were hired by the National Aeronautics and Space Administration (NASA). Only one man was part of all these efforts: Bruce Alexander Aikenhead.

II. Early Life

Aikenhead was born in Didsbury, Alberta, on September 22, 1923. His family soon returned to his parents' home province, settling in London, Ontario, where Aikenhead grew up. During World War II, Aikenhead was recruited to service radar equipment in the Royal Canadian Air Force (RCAF), attached to the Royal Air Force in Britain, and later in India. After the war, Aikenhead studied mathematics and physics at the University of Western Ontario, graduated with an honors B.Sc., and then got work in 1950 at Electrohome in Kitchener, where he did design and production engineering for radios and televisions. In 1947, Aikenhead married his wife, Helen, and they had a son, followed by three daughters.[1]

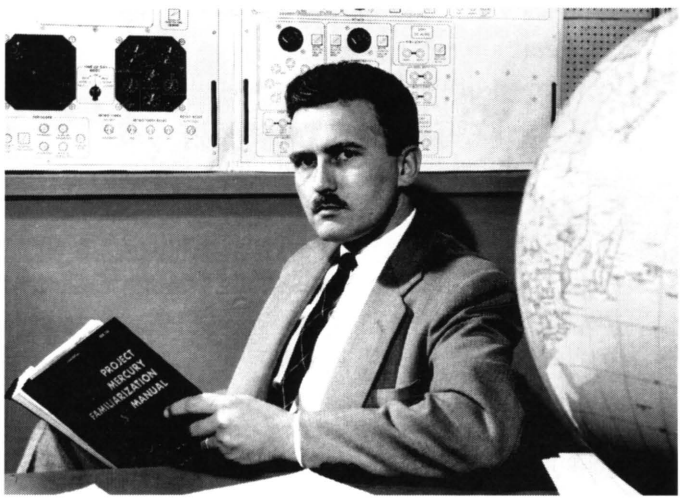

Figure 13–1: Bruce Aikenhead in 1960. Credit: NASA.

After five years at Electrohome, Aikenhead wrote for career advice to a university friend who had helped found a firm in Montreal called Canadian Aviation Electronics (CAE) Inc. CAE had started by making aircraft flight simulators under license, and then was hired by the Canadian government to design and build simulators for the Avro CF-100 jet interceptor aircraft, which was built by Avro Canada in Malton, Ontario, for the RCAF. Aikenhead joined CAE at his friend's urging, but after three years in Montreal, Aikenhead and his wife wanted to move back to Ontario. In August 1958, Aikenhead started work at Avro Canada in Malton and was put to work on a simulator for the Avro Arrow. The simulator used the latest computing technology of the time, and the Arrow, which was capable of flying at twice the speed of sound, had already begun its test flying

program when Aikenhead joined Avro Canada. Aikenhead used flight data from these test flights to ensure that the simulator matched the performance of the aircraft, and also to determine what outputs appeared on the Arrow's control panel under different flight conditions. Six months after Aikenhead started work at Avro, the Canadian government cancelled the Avro program on February 20, 1959, throwing thousands of people out of work and leading to the demise of Avro Canada.[2]

III. Project Mercury

The Arrow's cancellation came just a few months after the creation of NASA and the start of the agency's first human space program, known as Project Mercury. The new agency needed top-flight help, but competition for engineers was stiff because several aircraft and missile programs were gearing up at that time. After being informed of the Arrow's cancellation, NASA officials flew to Malton, today the site of Pearson International Airport, to interview engineers from Avro Canada. They hired twenty-five of them, including Aikenhead.* Many of the engineers were hired for specific skills they had, such as in computing, and others quickly rose to positions of leadership inside NASA's human space program. Most of the first twenty-five Avro engineers reported to work at the NASA Space Task Group, which was responsible for Mercury, in April 1959, at the same time as NASA's first seven astronauts, who were selected to fly the Mercury spacecraft.[3]

Aikenhead started work the same day as the astronauts, went through his new employee orientation to NASA with them, and was assigned to the staff that would train them for their flights. "Our first job in the training aids section was to analyze thoroughly all the pilot's tasks and what sort of training aids would be necessary to develop those skills," Aikenhead recalled.[4] In those early days, the Mercury team was based at NASA's Langley Research Center in Hampton, Virginia. The Mercury astronauts were hired before the Soviet Union recruited its first group of cosmonaut trainees, and thus Aikenhead was one of the very first people charged with the work of preparing humans to fly into space.

He was involved in the development of several different simulators, including the Mercury Procedures Trainer, a device where the fully-suited astronaut sat inside a cockpit that was an exact replica of his capsule to do a run-

* NASA hired another six engineers from Avro in the next few months, and another joined NASA in 1969. Nineteen of the thirty-two Avro engineers hired by NASA were from the United Kingdom, twelve were Canadian, and one was Polish.

through of the entire flight. Aikenhead wrote the specifications for this simulator, and McDonnell Aircraft, which was the prime contractor for the Mercury spacecraft, built one for the NASA center at Langley and another for the launch site at Cape Canaveral. Aikenhead's work on this trainer brought him into discussions with some of the astronauts about instrument and switch layouts on the instrument panel, and the location and type of window for the spacecraft.

After President John F. Kennedy charged NASA in May 1961 with landing astronauts on the Moon in the Apollo program, NASA embarked on a search for a new home for its astronaut program. On September 19, 1961, NASA announced that the Space Task Group would move to a new location near Houston, Texas, and become the Manned Spacecraft Center, the name it would have until 1973 when it became the Lyndon B. Johnson Space Center. The decision to move to Houston "dismayed" Aikenhead, and he and a few others opted to leave NASA and return to Canada rather than move to a location far from home in the deep south of the United States.

Aikenhead had helped prepare Alan B. Shepard and Virgil I. Grissom for their suborbital Mercury flights in 1961, but he and his wife decided to move back to Canada as soon as NASA announced its move to Houston. He contacted his former employer, CAE in Montreal, which offered him a job. Although Aikenhead had also worked hard preparing John H. Glenn for his historic orbital flight aboard *Friendship 7*, repeated delays to the launch meant that Aikenhead was already in his new job in Montreal when Glenn finally flew on February 20, 1962, three years to the day after the Arrow was cancelled. "I stayed home from work and was glued to the radio."

IV. Cannons

One unfortunate aspect of life in Virginia livened up the Aikenhead home after they moved back to Canada in 1962. "Virginia was segregated, so when we returned to Canada we thought there must be something we could do on a one-to-one level to improve human relations," Helen Aikenhead said. So their house in the suburbs of Montreal became a home away from home for international students from McGill University's Macdonald College.[5]

In the early 1960s, the RCAF was flying the CF-104 Starfighter, along with CF-101 Voodoos and CF-100 Canucks, and Aikenhead's first job at CAE was to make sure that the RCAF's Starfighter simulators were up-to-date with changes in the aircraft. Aikenhead recalled that CAE also wanted to use his experience at NASA, and the firm had considered looking at processing imagery beamed back to Earth from space, specifically photos from weather satellites.

> So they sent me down to NASA Headquarters to see about the automatic picture transmission program that was installed on TIROS and Nimbus satellites. This system would transmit a photo to the ground using a facsimile machine technique. In this way, you could get daily weather photos of the area where the receiving station was located. If we could make those receiving stations, we could sell them to the Canadian Department of Transport. In addition, if we could enhance the photos and get it to work, we could sell them to all kinds of people, including NASA.

Aikenhead began by developing the antennas for the system. While Aikenhead was working on this system in 1966, he had a fateful discussion with Eugene L. Duret, another member of the Avro-NASA group who had returned to Canada after the Mercury flights. After deciding that life in Houston didn't agree with him, Duret returned to Montreal, where he got work with one of the most enigmatic, charismatic, and controversial figures in the history of Canadian aerospace, Gerald V. Bull. After getting his Ph.D. at the University of Toronto, Bull went to work at the Canadian Armament and Research Development Establishment (CARDE) in Valcartier, Quebec, where he discovered his love for research into improving cannons. Bull left CARDE in 1961 and went to McGill University where he set up the High Altitude Research Program (HARP) to use cannons to launch projectiles into ever higher trajectories. Starting on property Bull acquired that straddled the border between Quebec and Vermont, HARP won support from the U.S. military and the Canadian government. Soon Bull and his team were launching projectiles from a giant cannon located in Barbados. The research had obvious military implications, but one of its aims was to launch a satellite.

"Gene [Duret] used to visit us quite regularly in Montreal and told us about the projects that Gerry had going," Aikenhead said.

> CAE was a place where the morale pendulum swung back and forth. We had hit a low spot when Gene suggested that I talk to Gerry. Gerry Bull was an absolutely enthusiastic super salesman. I talked to Gerry and he was really enthused about what he could do. He was interested in what I could do and it looked like a whole lot of fun.

In 1966, Aikenhead joined the HARP program as a systems engineer and was put in charge of the payload for the Martlet 4 projectile.

> Most of the work they had done was with the Martlet 2, a projectile that could go to 100 miles [160 km] and expel a payload, usually chemicals that would react with the atomic oxygen in the atmosphere. By photographing the way the trail dispersed from different angles, you could get an idea of the velocity and the direction of the winds at that altitude.

Martlet 3 projectiles were equipped with fins that would extend after launch to generate greater stability, and Bull also had a group developing solid rockets that could survive the high acceleration of launch from cannon, Aikenhead recalled.

> He had another group making a hollow steel projectile which contained another projectile. The projectile was, in effect, the first stage and then the nose would come off and the rocket inside the second stage would ignite. In the nose of the second rocket was the payload. This was the Martlet 4 concept. All our studies showed we could attain orbital velocity. The analysis showed you could put a 20-pound payload in orbit for a fraction of the normal launch cost.

"We took a prototype Martlet 4 to Barbados and it was fitted with a dummy rocket with inert propellant. The thing broke up in the gun," Aikenhead said. While preparations were being made to launch another Martlet 4 in 1967, the program was cancelled after the Canadian government withdrew its support, and the U.S. military, which also supported Bull's work, did not fill the shortfall.

> It looked to be a promising thing, and if it had not been cancelled, I'm sure we would have made orbit. But Gerry had a tendency to jump from one project to another. The upper atmosphere winds [study] project—instead of developing a good bread-and-butter project with it, he kind of got bored with it and left it for other things. He might have set up a division and marketed it. But research and development funds were drying up on both sides of the border, and it was the Avro Arrow all over again.

After Aikenhead left, Bull reconstituted his work on cannons through a private corporation and concentrated on doing research work for various military clients. Bull was jailed in 1980 for breaking the U.S. arms embargo against the apartheid regime in South Africa, and later he began developing cannons for Saddam Hussein's Iraqi dictatorship. He was murdered at his Brussels apartment in March 1990, a few months before the Gulf War. The murder is still unsolved.[6]

V. Satellite Programs

"In 1967 there was a chance of staying with HARP when it was cancelled, but that would involve going to the States, and my son was draft age," Aikenhead said. "Then I heard that RCA [Canada] was looking for people to work on a satellite." The satellite was called *ISIS 2*, and it was to be the fourth Canadian satellite.

ISIS 2 was the last of the ionospheric research satellites that kicked off Canada's space efforts, starting with *Alouette 1* and *2*, launched in 1962 and 1965, and then *ISIS 1*, which was awaiting launch in 1969. The ionosphere is a

layer of electrons in the upper atmosphere that make radio communications, particularly short-wave radio, possible because the signals bounce off it. But changes in Earth's magnetic field caused by changing levels of incoming solar and cosmic radiation can strongly affect the ionosphere, leading to fluctuations and blackouts of radio communications. When satellites began to fly, Canadian scientists started to look at the idea of sounding the ionosphere from above to complement measurements of the bottom of the ionosphere from the ground. The result was Canada's first satellite, *Alouette 1*, and then the International Satellites for Ionospheric Studies (ISIS) program, conducted jointly by the U.S. and Canada. The first satellite in the ISIS program was *Alouette 2*, and it was followed by *ISIS 1*, which was being completed at the RCA Canada plant in Montreal in 1967 when Bruce Aikenhead joined RCA to work as the project engineer for *ISIS 2*.

> This involved working out detailed specifications for the spacecraft itself and for the interfaces with the various experiments, so that everything would work together properly. It was quite an intricate spacecraft. We needed to test all subsystems separately and collectively.

ISIS 2 marked an advance over its predecessors in that it was equipped with two photometers to provide images of auroral activity near the Earth's poles. Aurorae are caused by trapped particles of solar wind passing along the Earth's magnetic field into the Earth's atmosphere near the poles. After *ISIS 2* was launched into a polar orbit from Vandenberg Air Force Base on March 31, 1971, it provided a bounty of scientific data on the ionosphere, and groundbreaking new information on aurorae. The ISIS satellites operated for more than a decade and were given to Japanese scientists after the Canadian research work with them had ended.

Communications satellites had become the Canadian government's top priority in space in the late 1960s, and to support that policy, the government created a crown corporation, Telesat Canada, in 1969. By 1971, Telesat was preparing to launch *Anik A1*, the world's first domestic communications satellite, into geosynchronous orbit the following year. The Canadian government wanted to support Telesat and Canada's space industry by building a satellite that would lead the way in new communications technologies, and it cancelled plans for a third ISIS satellite and shifted funds to the new Communications Technology Satellite (CTS). Most communications satellites in those early years transmitted between large antennas connected to land-based networks. The CTS would experiment with higher frequencies that permitted a much larger bandwidth, and also transmit to small, portable antennas that would open up satellite communications to small communities. "This was to look into the problems you would run into when you have a satellite with direct broadcast capability, with sensitive on-

board receivers and a powerful onboard transmitter, so you could broadcast using very small one-meter antennas," said Aikenhead, whom RCA assigned to work on CTS.

Soon Aikenhead and his family moved to Ottawa, where he was assigned to the Communications Research Centre in the federal government's Department of Communications, which wanted to make use of the expertise of Aikenhead and other former members of the ISIS team. CTS was a cooperative program with NASA and the European Space Agency, and when the satellite was launched from Cape Canaveral aboard a Delta rocket on January 17, 1976, it was renamed *Hermes*. The satellite operated for nearly four years, well beyond its designated two-year operational lifetime. Aikenhead said there was a moment of anxiety shortly after *Hermes* entered orbit, when valves inside the attitude control system were released, and the fuel moving through the plumbing caused an unanticipated "water hammer" effect. But after an initial failure, the system worked properly. *Hermes* conducted a variety of direct communications tests, including direct-to-home broadcasting and telemedicine to remote places in the western hemisphere. Today, direct-to-home broadcasting has become a major industry, and Canadian firms are heavily involved in this field, including manufacturing satellite components and ground stations. Telesat, which is now a private firm, is a major supplier of communications satellite services, including direct-to-home services.[7]

VI. The Canadarm

After *Hermes* was safely launched and established in orbit in 1976, Aikenhead and his family were preparing to move back to Montreal from Ottawa when he got a phone call to see if he was interested in working with the National Research Council of Canada (NRC), which was one of the lead agencies involved in Canada's space program in the days before the CSA was established. "They were setting up a program office to work with NASA on some kind of robotic device to be used on the shuttle," Aikenhead said. The NRC was assigned to supervise work on the Space Shuttle Remote Manipulator System (RMS). It would be built by Spar Aerospace, then Canada's largest space contractor, with assistance from other firms including RCA Canada, which worked on electronic systems in the joints, and CAE, which built the control panel for the robot arm. Aikenhead agreed to join the NRC team, although he officially remained an employee of RCA and later of Spar when it purchased RCA Canada's space operations, working as systems engineer for what eventually became known as the Canadarm.

> NRC was right in the middle of all this, and it was our job to make sure that the people on the Canadian side at Spar did the job to design the hardware to meet the NASA requirements, and at the same time, protect them from growing requirements from NASA for performance or schedule or whatever. We were truly middlemen, and we were sometimes loved by all and sometimes hated by all. But it was great sport. I spent a lot of time traveling back and forth to the Cape [Canaveral] because among the many hats I was wearing was responsibility for the ground checkout equipment. This meant arranging participation by various people at the Cape.

In 1981, Aikenhead formally became an employee of the NRC and Deputy Program Manager of the RMS program.

The arm was 15.2-m long and weighed 360 kg, and although it could not support its own weight on the ground, in space it could move objects with a mass of up to 30 tons. As part of the agreement the Canadian government reached with NASA in 1975, Canada financed the development of the RMS and gave the first Canadarm to NASA, which undertook to buy further arms as they were needed. The arrangement was part of NASA's effort at the start of the Shuttle program to defray development costs and foster international cooperation in space flight, an effort that also led to the European Space Agency agreeing to build the Spacelab research module for the Shuttle.

Aikenhead and the Project Manager, Art Hunter, made a last-minute addition to the fabric sleeve on the first arm just before it was handed over to NASA in February 1981: a patch of beta cloth with the Canada wordmark that incorporates the Canadian flag. Aikenhead said NASA authorized the addition before it was put on the arm, and noted that when the Canadarm was installed in the shuttle payload bay, American flags began to appear on other equipment nearby.

During the years that the Canadarm was being developed, astronauts came to the plant near Toronto where Spar had built a simulator to test the arm's control system and to teach astronauts how to use the RMS. Two astronauts who spent a lot of time in Toronto during this time were Sally Ride and Judith Resnick, who became the first and second American women to fly into space. NRC managers, such as Garry Lindberg, Art Hunter, and Aikenhead, acted as liaisons between NASA and Spar, and Aikenhead remembers taking part in many long teleconferences between NASA centers on Shuttle software issues. "Everyone needed more software, more control capability, and the remote manipulator system was no exception," said Aikenhead.

The arm was due to fly for the first time on the Space Shuttle's second flight, but Aikenhead said the noise and vibrations at the first Shuttle launch were so great they had damaged a wing strut, causing worry about how well the arm would fare at launch. A beefed-up system to dampen sound and vibration was

installed on the launch pad for *Columbia*'s second flight, which began on November 12, 1981. "To everybody's delight, the arm survived launch and the STS-2 mission moved the arm through all the tests we had planned for it," Aikenhead said. He was at Cape Canaveral for the launch, and then he flew to Houston to be present when astronauts Joe Engle and Richard Truly unberthed the arm for the first time.

> My duties also included making sure that the performance was as advertised. So we had to do a lot of analysis of the telemetry data to make sure that the performance in flight was consistent with what had been predicted. We would see if the modeling in the simulator was incorrect or see if the dynamics of the arm in flight were different.

"All in all, the arm led to a substantial amount of business for Canada," Aikenhead said of the arm's successful use for a variety of purposes on the shuttle.

> We had spent about $113 million by 1983, and subsequently NASA has spent far more than that in buying new systems from Spar [which subsequently sold its space business to MacDonald Dettwiler and Associates Ltd]. So it was better than a break-even deal. Canada developed a world reputation for that kind of hardware, and a sophisticated control system that has led to many other products and work by the team. And subsequently we began working on the follow-on system for the space station.

Today Canadarm2 is the central part of the International Space Station's Mobile Servicing System, which was Canada's contribution to the station.[8]

VII. Canadian Astronaut Program

When the RMS was declared operational after passing its first tests in space in 1982, the project office at NRC was wound down. But NRC was getting a new program related to the Shuttle, one for which Aikenhead was uniquely qualified. In June 1983, NASA Administrator James Beggs and Canadian Science Minister Don Johnston announced that Canadians would fly aboard shuttles as part of the newly formed Canadian Astronaut Program. Job advertisements for astronauts appeared in Canadian newspapers the following month, and at NRC, Karl Doetsch and Garry Lindberg, with whom Aikenhead had worked on the Canadarm, headed the effort to select Canadian astronauts for the Shuttle. NASA had also invited the European Space Agency and other users to send researchers into space aboard the Shuttle. "We had done enough homework to know that we needed two types—medical specialists and engineers," Aikenhead remembered. "I was still looking after the [Canadarm] office, while Karl and Gary were run-

ning the recruitment campaign with another branch of NRC. I only got involved at the last to meet the 20 finalists. They had something like 4,900 applicants."

On December 5, 1983, the names of Canada's first six astronaut trainees were announced: Marc Garneau, a naval officer who was an expert in electronic systems and the only French Canadian in the group; physicist Steve MacLean; engineer Bjarni Tryggvason; Ken Money, a physiologist who belonged to a group of Canadian researchers that led the world in research on space sickness; and two physicians, Robert Thirsk and Roberta Bondar, the only woman in the group.

Aikenhead, with his experience at NASA training the Mercury astronauts, was one of two people assigned to train the new recruits at NRC in Ottawa and arrange further training with NASA in Houston. The Canadian astronauts would fly as Payload Specialists, a category of shuttle crew with specific assignments and limited training. The first Canadian astronaut was expected to fly in late 1985, a year-and-a-half away, but in March 1984, NASA called and offered a flight in 1984 for a Canadian astronaut. "We didn't want to send someone along on a joyride. We wanted them to have something useful to do for Canadian scientists, and therefore we needed to organize some experiments in a hurry, and train the person."

The person chosen was Marc Garneau, with Bob Thirsk as his backup. Aikenhead and Doetsch arranged the details of the flight with NASA.

> We were able to get Marc and Bob down to Houston for training, and I had to scramble to organize all the equipment to be stowed on board the locker. We had to get it all flight-qualified and get it ready through the summer and fall.

Equipment for the ten Canadian experiments, known collectively as Canex, had to fit into a locker no bigger than a breadbox and be able to meet NASA's strict materials and safety standards.

Although most of Aikenhead's NASA associates from Project Mercury had left the agency by then, Aikenhead was still well-known in Houston because of his work on the Canadarm, and his presence was a big help for the newly-recruited Canadian astronauts at NASA's Johnson Space Center, Thirsk explained. The preparations for Garneau's flight were "a real rush," but Thirsk said, "Bruce's skills and his completeness helped put the paperwork for our experiments package through, and it opened up doors for us."[9]

Just before dawn on October 5, 1984, *Challenger* lifted off on its sixth flight and the thirteenth mission of the Shuttle program with Marc Garneau and six other astronauts aboard. Aikenhead, by then Program Manager for the Canadian Astronaut Program, spent the flight in a backroom near the Houston mission

control room, ready in case the crew or the flight director had questions or problems. During the flight, Aikenhead noted, Garneau was so silent that "we wondered at one point if he'd really got on board." As a last-minute addition to the crew, Garneau was conscious of the fact that he should do his own work without interfering with other work and be available to help the others when possible. "So Marc tried, as a good navy man, to stay out of the way. We actually had to nudge the system a bit to get a daily voice report from him," Aikenhead said. Garneau's work, and the whole mission, ended successfully after eight days in orbit.

After helping Garneau deal with his postflight tour of Canada, Aikenhead and the others in the astronaut program set to work preparing for further launches. But the astronaut program came to a halt when *Challenger* exploded on its tenth launch in January 1986. "It did mean our astronauts were grounded, and the flights we planned for '86 didn't happen until '91 or '92." For much of that time, the six astronauts left the program to pursue their research while they waited to see what would happen.

But at the same time, Canada had agreed to take part in NASA's new space station program by providing an advanced version of the Canadarm for the station. When Aikenhead's bosses moved on to take over this work, Aikenhead became Manager of the Canadian Astronaut Program. When the Canadian Space Agency was formed in 1989, Aikenhead's title was changed, according to civil service rules, to Director-General of the program. Not long before the new agency was created, Aikenhead reached the age of 65. He was busy preparing for the next two flights of Canadian astronauts, so he decided to stay because "I was up to my ears in things and was having fun." By 1991, Aikenhead was busier than ever as he helped two Canadian astronauts, Roberta Bondar and Steve MacLean, prepare to fly in space.

With Ken Money serving as her backup, Bondar became Canada's second astronaut when *Discovery* lifted off on January 22, 1992, for the first mission of the International Microgravity Laboratory. During her eight days in space, Bondar carried out a set of medical experiments which, among other things, looked into space sickness which strikes about half the astronauts during the first few days of flight. MacLean flew aboard *Columbia* for ten days starting October 22, 1992. Although he had responsibility for a whole set of Canadian-developed experiments, his major task was to test the Space Vision System (SVS), which uses video images of targets placed on objects to tell a computer, and ultimately the operator of the Canadarm, the precise position of the payload and any changes in that position. The SVS is designed to help arm operators on the Shuttle and space station when they can't see what they are moving, and ultimately it may allow computers to do the work of human operators. During Bondar's flight, Aiken-

head worked in the science control room in Huntsville, Alabama, and during MacLean's flight, Aikenhead worked out of Houston much as he did during Garneau's flight.

Also in 1992, Aikenhead was a member of the selection board choosing new Canadian astronauts in anticipation of the space station, and to replace Bondar and Money, who left the program that year. There were 5,000 applications, and Aikenhead, Garneau, and Thirsk were among the group that interviewed the finalists. In June, the agency announced that test pilot Chris Hadfield, engineer Julie Payette, physician Dafydd (Dave) Williams, and geophysicist Robert Stewart would join the program. But within days, Stewart dropped out when he reconsidered his scientific career, and his replacement, Mike McKay, an engineer in the Canadian Forces, also had to drop out due to vision problems.

The Canadian astronaut group now had seven members. As soon as the new astronauts were selected, Aikenhead had to decide who would get a year's training in Houston that would lead to designation as full-fledged Mission Specialists like most American astronauts. Aikenhead chose Garneau, who was already well respected at NASA from his previous flight, and Hadfield, who was also known by the NASA astronauts because of his work as a test pilot. Aikenhead admitted that his decision to designate Hadfield was not popular with members of the 1983 astronaut intake who were still waiting to fly, but within five years, all seven of Canada's astronauts had received mission specialist training and were living in Houston as full-fledged astronauts. "We all understood that he was fair," Thirsk said. "He would make decisions based on facts. He wouldn't base them on personality."

VIII. Conclusion

After MacLean's flight, Aikenhead began to prepare for retirement. His wife Helen had already set up a home in Salmon Arm, BC, and the Canadian Space Agency was moving from Ottawa to a new headquarters at St. Hubert, Quebec, just south of Montreal. Aikenhead retired on March 12, 1993, and the next day he flew out to his new home in the British Columbia interior. Four years later, Aikenhead was given one of Canada's highest honors when he was named an Officer of the Order of Canada. In the years since Aikenhead moved to Salmon Arm, he has been an active volunteer at the Okanagan Science Centre in Vernon, BC, where he helped set up its space and astronomy section.

After his involvement with the legendary Avro Arrow and his introduction to human space flight with NASA starting in 1959, Aikenhead worked for more than a quarter century in Canada's space program before the creation of the CSA.

He worked for the NRC and the Communications Research Centre, whose space operations became part of CSA when it was formed in 1989. He was also employed by two pioneering space enterprises in Canada, RCA Canada and Spar Aerospace, as well as CAE Inc., which is still a world leader in its field. And he took part in HARP, whose promise of using cannons to gain access to space has yet to be fulfilled. Aikenhead was involved in the creation of Canada's first generation of scientific satellites and in Canada's ground breaking communications satellite program. Canadian astronauts he helped select and train, and Canadarm2, the successor to the Shuttle RMS he helped create, have been integral parts of the International Space Station. In addition to the various parts of the Canadian space program Aikenhead touched, his career embodies the international cooperation that lies at the heart of Canada's space program.

"Bruce's career has touched almost everything," said Canadian astronaut Bob Thirsk. "He's the quintessential space worker. We're all visionaries and we're all optimists, but we have to pay attention to detail. Bruce showed us [astronauts] the importance of paying attention to detail."

"He has done an amazing string of things as a Canadian," astronaut Chris Hadfield told a celebration of Aikenhead's 90th birthday in October 2013.

> He is competent. He is highly educated. He's extremely experienced. He's done good things and he's devoted his life to the things that are important to him. It's as if he rode the wave of cutting edge of technology for decades as exciting things were happening in Canada's technological advancement.[10]

"He is one of the most unassuming people I have ever met," said Canada's first astronaut Marc Garneau, who is now a Member of Parliament.

> His accomplishments in both Canada's and NASA's space programs are truly impressive and yet, because of his inherent modesty, you have to draw it out of him to really understand the major impact he has had on both countries' space programs. What is also striking about Bruce is his extremely methodical approach to everything he does. I have seldom met such a well-organized and thorough person. Every detail is important and of course, in the Space business, attention to detail is paramount. That's why he was so good.[11]

"I was lucky to always have an interesting job, usually working in a program that had never existed before," Aikenhead reflected in an interview in 1995. "There was always some element of pioneering involved, or there were engineering problems where there were no solutions readily available."

References and Notes

[1] A great deal of biographical information on Aikenhead has been posted at "Bruce Aikenhead: A Canadian Space Pioneer," http://www.museevirtuel-virtualmuseum.ca/Search.do?R=VE_2382&lang=en&ex=on Accessed August 24, 2014. Helen Aikenhead passed away in 2005.

[2] For more on the Avro Arrow, see Chris Gainor, *Who Killed the Avro Arrow?* (Edmonton: Folklore Publishing, 2007).

[3] The story of the Avro engineers who joined NASA is told in Chris Gainor, *Arrows to the Moon: Avro's Engineers and the Space Race* (Burlington, ON: Apogee Books, 2001).

[4] All quotes from Bruce Aikenhead in this article are taken from an interview conducted by the author on September 25, 1995, in Salmon Arm, B.C. Much of the other biographical information in this article was provided to the author by Aikenhead in correspondence from 1994 to 2014.

[5] Finbarr O'Reilly, "Honoring a Quiet Canadian," *The Vancouver Sun*, July 12, 1997, C10.

[6] A technical description of the High Altitude Research Program is contained in J. H. Chapman, P. A. Forsyth, P. A. Lapp and G. N. Patterson, *Upper Atmosphere and Space Programs in Canada* (Ottawa: The Queen's Printer, 1967). For more on Bull, see William Lowther, *Arms and the Man: Dr. Gerald Bull, Iraq and the Supergun* (Toronto: Seal Books, 1991), and Grant Dale, *Wilderness of Mirrors: The Life of Gerald Bull* (Scarborough: Prentice-Hall Canada Ltd., 1991).

[7] For more on the history of Canada's space program, see Christopher Gainor, "The Chapman Report and the Development of Canada's Space Program," *Quest: The History of Spaceflight Quarterly*, Vol. 10, No. 4, 2003, 3–19.

[8] More details on the Canadarm and the Canadian Astronaut Program, and Aikenhead's role in these programs, can be found in Lydia Dotto, *Canada in Space* (Toronto: Irwin Publishing, 1987) and Lydia Dotto, *The Astronauts: Canada's Voyageurs in Space* (Toronto: Stoddart Publishing, 1993).

[9] Bob Thirsk, telephone interview with the author, July 30, 2014.

[10] Video of Hadfield speech available at "Bruce Aikenhead: A Canadian Space Pioneer," http://www.museevirtuel-virtualmuseum.ca/Search.do?R=VE_2382&lang=en&ex=on Accessed August 24, 2014.

[11] Marc Garneau, email communication with the author, August 11, 2014.