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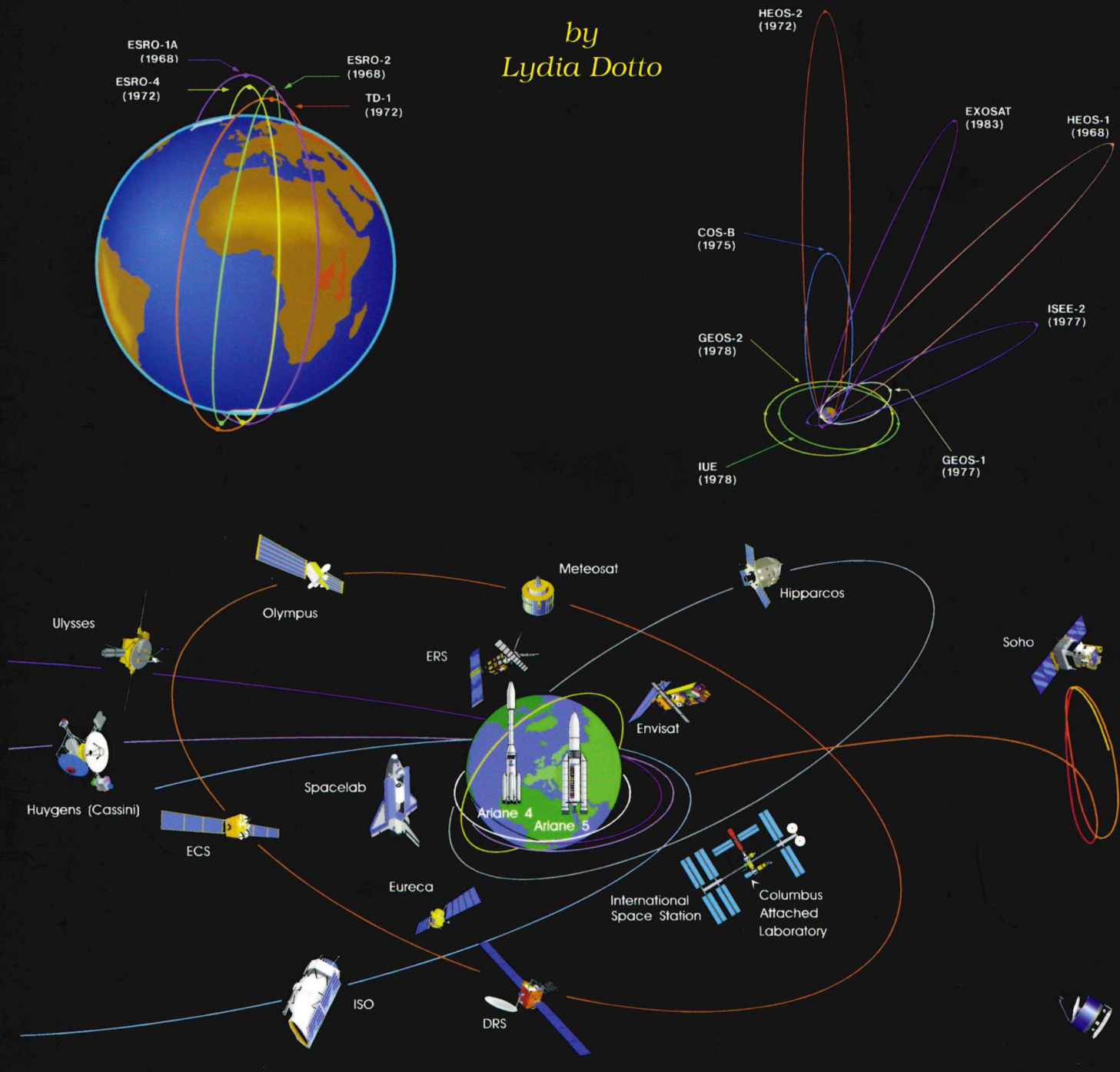
Three Decades of Cooperation

by
Lydia Dotto



European Space Agency
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Living next to you is in some ways like sleeping with an elephant:
No matter how friendly and even-tempered the beast,
one is affected by every twitch and grunt.

Canadian Prime Minister Pierre Elliott Trudeau,
on Canada's relationship with the United States,
to an American audience at the National Press Club,
Washington, D.C., March 25, 1969

The Third Option

Pierre Elliott Trudeau, who was first elected Canada's Prime Minister in 1968, was fond of comparing the United States to an elephant whose every move had repercussions for Canada. During his administration, the relationship with the US was tense and troubled – President Richard Nixon once referred to Trudeau in derogatory terms, to which Trudeau retorted: "I've been called worse things by better people." In a 1972 visit to Ottawa, Nixon announced that the special relationship between the two countries was as good as dead, emphasising their "very separate identities [and] significant differences." With ongoing disagreements over trade, military, foreign policy and cultural issues, Trudeau began searching for ways to reduce Canada's economic dependence on its neighbour and its vulnerability to US policies.

A paper by Secretary of State for External Affairs Mitchell Sharp laid out three choices: 1) maintaining the status quo; 2) forging even closer ties or 3) seeking relationships with other countries. The first did not appear to be possible and the second was not attractive to many Canadians, so Trudeau adopted what became known as the Third Option. As a result, in the mid-1970s Canada began actively seeking closer ties with Europe.

This was the context that led to discussions on Canadian participation in the European Space Research Organisation (ESRO), a precursor to the European Space Agency. Canada's Space Policy of 1974 "restated the basic strategy of cooperating with, but not relying wholly on, the USA in the field of space," according to a 1976 report by Colin Franklin, then Director-General of Space Programs in the Department of Communications (DOC). The theme was echoed in a memorandum prepared by John Chapman, DOC Assistant Deputy Minister (Research), for Communications Minister Jeanne Sauvé prior to a meeting with ESA officials in May 1976. Chapman noted that Canada's interest in a relationship with ESA "stems from our intention to develop the Third Option in our Foreign Policy. ESA is the only European agency actively soliciting Canada's participation at this time."

Canada had no national space agency at the time – its space affairs were managed by an Interdepartmental Committee on Space (ICS) – but it did have an active and growing space programme with a major focus on communications and remote sensing. In 1962, Canada became the third country in space by launching its first science satellite, Alouette-1, to study the upper atmosphere. In 1969, the government created Telesat Canada to manage its communications satellite programme and in 1972, Telesat launched Anik A-1, the first domestic communication satellite in geostationary orbit.

In addition, Canada's need to manage its 320-kilometre offshore economic zone had fuelled interest in all-weather remote sensing satellites. The Canada Centre for Remote Sensing (CCRS) was established in 1971 and the following year, a Canadian ground station received the first images from the Landsat-1 satellite. Canada's fledgling space robotics programme was also underway; in 1974, NASA awarded

Canada the contract to build the Space Shuttle's remote manipulator system, providing a pathway toward increased Canadian involvement in human space flight.

Chapman's memo noted, however, that Canada was not self-sufficient in space technology and lacked a launch capability, so it needed a partner. Although the USA was the obvious candidate, the problem of living with the elephant that beset Canada generally applied equally in the microcosm of the space programme. As Chapman's memo put it: "Canada's natural partner is the USA, but we are overwhelmed by the size and depth of the US program, while the European program is comparable (relative to GNP) to the effort Canada is putting forward in space."

"Around this time, John Chapman tried to get some sort of ongoing relationship with NASA but NASA was not interested," said Mac Evans, recently-retired president of the Canadian Space Agency. "They said they worked on a project-by-project basis and don't have long-term cooperative agreements, so he wasn't able to accomplish what he wanted."

"NASA was so huge compared with us, we had no chance of modifying or influencing the scope of a NASA program," added Colin Franklin. "We thought that with Europe, we would be dealing with a smaller outfit more our size. If we could participate in program definition studies, we'd have a better chance of affecting or modifying the design of programs to meet Canadian needs."

As a foreign policy, the Third Option never had much chance of success. Inevitably, Canada's economic entanglement with the USA continued to grow, as did the relationship between the two countries' space programmes. However, at least in space activities, Canada achieved a measure of influence, if not equality, that might have surprised Chapman. Over the strenuous objections of some US companies and politicians, Canada won the contract to build the remote manipulator arm for the US Space Shuttle; the "Canadarm" first flew in 1981 and has worked flawlessly since. Its success led directly to Canada's becoming a partner in the International Space Station (ISS) programme in 1985 with a mandate to build the Station's manipulator arm. Canadarm2, which is essential to the construction and maintenance of the Station, was installed by Canadian astronaut Chris Hadfield in April 2001.

The astronaut programmes of the two countries have also become more closely integrated. Marc Garneau became the first Canadian astronaut to fly aboard the Shuttle in 1984; today, Canada's astronauts are members of NASA's mission specialist corps at the Johnson Space Center with major responsibilities not only during space flights but also on the ground. (Hadfield is currently NASA's director of operations at Star City in Russia and was for several years chief of the astronauts who serve as *capcoms* in Mission Control during Shuttle flights. Dave Williams, a Canadian astronaut and medical doctor, is head of NASA's Microgravity and Life Sciences Directorate.)

At the same time, the unique partnership that Canada forged with ESA during the Third Option era did prove successful and continues to flourish today. The fruits of this partnership include not only building satellites and other space technologies, but using them to produce benefits on the ground, such as fighting forest fires in British Columbia, monitoring the safety of pipelines in Alberta, using robots for deep mining in Ontario and delivering telemedicine and tele-education services to remote communities in Newfoundland. These and other projects have produced some 500 contracts for Canadian companies, worth more than C$300-million (about €200-million).

In June 2000, when the Canada-ESA relationship was renewed for the fourth time, Canadian Prime Minister Jean Chrétien described it as "one that will continue to drive innovation, the sharing of knowledge and expertise, and the creation of partnership between countries, agencies and space-based industries to meet the needs of future generations all over the world."

It must be said, however, that forging a working partnership was not accomplished without doubts, frustrations and hurdles on both sides of the Atlantic.

Forging a Partnership

Canada's collaboration with Europe in space activities predated both the European Space Agency and the Canadian Space Agency. From 1968, Canada held observer status in the European Space Conference (ESC), a ministerial-level organisation set up to determine future European space activities, and it continued in this limited role after ESA was created in 1975. The Canadian government felt observer status was a useful first step toward eventual participation in European space activities, which it believed could provide economic and scientific as well as political benefits, but it wanted to wait until ESA was fully operational before pursuing more formal ties.

There were other areas of collaboration as well. Canada was a member of an ESC working group dealing with the peaceful uses of outer space and its ESA successor, the International Relations Advisory Group. In the early 1970s, Canada worked with ESRO (later merged with the European Launcher Development Organisation to form ESA) on the Communications Technology Satellite (CTS), a joint Canada/US project to test technologies for direct broadcasting from satellites to small, lower-cost ground receivers. ESRO provided blankets and associated solar cells for a lightweight extendible solar array as well as travelling-wave-tube amplifiers and a low-noise preamplifier for CTS, making it the most powerful communications satellite of its time.

This project was viewed as a success on both sides of the Atlantic; the contribution of several European-built components reduced Canada's costs, established useful contacts and provided insights into European technical capabilities. ESRO's participation in a flight programme provided valuable operational experience in developing future European communications satellites. "We had a very good experience with ESRO on the CTS program," said Franklin. "We got to know our opposite numbers in Europe. That encouraged us to think we should be pursuing the relationship."

In 1974, Canada, the USA and ESRO also agreed to collaborate on Aerosat, an experimental satellite network for transatlantic air traffic control, but the project was later cancelled. The possibility of cooperating in the development of an all-weather remote sensing capability was also broached by ESA in late 1975. Around the same time, there were discussions about possible Canadian participation in developing payloads for the European launcher, Ariane, and cooperation in developing science experiments to be flown aboard the European-built Spacelab module for the Space Shuttle.

By 1976, the Canadian government was ready to consider seeking a more formal relationship with ESA. Franklin's report, commissioned by DOC to examine Canada's options, presented three possibilities, each entailing higher costs and more significant cooperation. One issue, which would remain contentious for both sides over the next two decades, concerned Canada's financial contribution to ESA's General Budget, which included fixed common costs for internal management and administration (e.g. salaries, office and travel expenses, infrastructure, etc.) This was distinct from Canada's participation in and contribution to optional activities – specific space applications projects such as those in the telecommunications and remote sensing areas.

The options presented by Franklin included:

- *Retaining observer status*: This would involve "negligible costs" and give Canada an understanding of ESA's procedures and programmes but it wouldn't provide "meaningful access to technical knowledge." It would be possible for Canada to participate in optional programmes, but this would still require a contribution to the General Budget. Canada would not have guaranteed access to studies on the requirements for projects or ESA's long-term plans. It would be free to pursue space projects on its own or with other countries without consulting ESA.

  Franklin noted that observer status was "considered a temporary arrangement by ESA Council, and a prelude to associate or full membership…ESA clearly hopes that Canada's observer status is a step towards becoming an associate or full member." However, he also suggested that "semi-

permanent observer status may be possible for non-European countries such as Canada and Australia."

- *Associate Membership:* This would cost Canada up to C$3-million per year (1976 dollars) for mandatory activities. Canada could participate in optional programmes with a guaranteed minimum industrial return of 80%. (Industrial return referred to the amount of money that would come back to Canadian companies in contracts.) Canada would have voting rights when its financial interests were involved; it could also participate in scientific and technical research studies and receive the results of ESA studies. It might also be required to consult ESA before undertaking non-ESA-related space projects. (In 1976, there were no associate members of ESA and the terms of reference had not yet been fully spelled out.)
- *Full Membership:* Franklin was not certain this option was even open; in any event, it was expensive – an estimated C$12- to $17-million per year for mandatory activities. To make this investment worthwhile, another C$40- to $50-million would be needed for optional programmes and a "significant Canadian office" would have to be set up in Europe.

Full membership was "a total non-starter – nobody took it seriously," Franklin said in an interview. "When you looked at the price tag, that was not on." In addition, he said, "the Europeans would have none of it. Canada was on the wrong continent; they did not want Canadians, Australians, non-European countries as members."

Associate membership did, however, seem feasible and it's clear this is what Chapman had in mind. A 1974 letter to Chapman from Roy Gibson, then Acting Director-General of ESRO (and subsequently Director-General of ESA) referred to "our recent discussions…with regard to the question of associate membership of the European Space Agency." In a report written for the Canadian government after he left ESA, Gibson stated: "When, in 1977, Canada first started to show an interest in co-operating more closely and formally with ESA, the aim was associate membership."

The rationale behind Canada's interest, said Franklin, was that closer cooperation with ESA would give Canada greater influence than observer status and privileged access to European space technology. It would also promote "commercial contacts with European firms that stood a good chance of paying off." This view was elaborated in Chapman's memorandum for Communications Minister Jeanne Sauvé's meeting with ESA officials:

> *Canadian industry sees a benefit to themselves through participation by Canada in ESA, since the rules of "fair return" requires that at least 80% of a country's cash contribution comes back in the form of contracts to their industry. Secondly, Canadian firms believe that the development of Canadian sources of new space products, through ESA contracts, will lead to Canadian firms having a preferred position for the supply of these new products in all European spacecraft. It appears impossible to make a similar arrangement with US industry or the US government.*

The memo also suggested that ESA would derive several benefits from Canadian participation: "To Europe, Canada represents a very important market for space products; Canada has space technology as advanced as any country; Canada has a close and easy working relationship with NASA and the leading US aerospace companies; and finally, Canada's cash contribution…would be a welcome addition to the ESA program."

"We had a well-respected space program with a good history of success," said Leon Bronstein, an Ottawa consultant who was Canada's counsellor for European space affairs in the mid-1980s and worked in Canada's remote sensing programme. "We had a small but capable space industry with good scientists and technology labs. They felt we could bring something to the table technologically that would help their program."

However, in both Canada and Europe, there were doubts and even outright opposition to the idea of Canada becoming more deeply involved with ESA. The benefits were "by no means self evident to a lot of people," said Franklin. "There was a lot of criticism at the time." Some in Canada felt Europe was a "second-string operation" and too far away compared with the USA "They felt it wasn't going to be all that easy for Canadian firms to develop contacts, that the Europeans would be very Eurocentric," said Franklin. There was also concern that Europeans would regard Canada with suspicion, believing it might provide the USA with unauthorised, back-door access to European technology.

According to Gilles Leclerc, CSA's acting director for technology management, who is responsible for the Agency's ESA programmes, there was also concern in Canada about what the deal would do to the privileged relationship afforded by proximity with the USA "Too-close cooperation with Europe was perceived as a threat to promoting closer cooperation with the US"

Some critics balked at the idea of spending part of Canada's small space budget on ESA's overhead costs – a complaint that would echo through all the years of Canada/ESA cooperation. "The annual membership fee contribution to the General Budget is the thing that upset some people," commented Franklin. "That was money going into a budget for which they could see little in the way of return. Quite a lot of people thought it was a total waste of money, that we were simply not going to get our money's worth out of that involvement."

As Leclerc put it, although Canada could get contracts under the General Budget, many were not suitable for a country an ocean away. "We were not going for contracts to supply paper clips."

However, there were others who thought the investment was justified. "I felt the experience of playing on a bigger playing field was well worth the relatively small percentage of the Canadian space budget that went to ESA over the years," said John MacDonald, a founder of MacDonald Dettwiler and Associates Ltd., one of Canada's major space companies.

There was scepticism in Europe as well. The simple fact that Canada was not part of Europe was one objection; some felt it was too far away to make close cooperation successful. Gibson's report noted that Canada's original goal of associate membership "failed at least overtly because some Member States considered that Canada's geographical location disbarred it from even associate membership in a European regional organisation." Indeed, it said that Canada's association with ESA was viewed by some people on both sides of the Atlantic as "unnatural." There were also concerns about allowing Canadian companies to compete for contracts with European firms.

France, in particular, opposed Canada's entry from the outset. Besides the practical and economic objections, Gibson wrote, there were two "underlying fears" – first, that Australia and New Zealand might follow in Canada's footsteps, potentially creating "a powerful Anglo-Saxon bloc" within ESA and, second, that Canada was so tied to the USA that it could not truly become a loyal member of a European organisation (which seemed to validate fears in Canada that they would be viewed with suspicion.)

France was also concerned that Canada would not support its Ariane launcher programme. "Ariane was enormously important to France," said Franklin. "They were extremely concerned about making sure it was commercially successful and back then, it was not obvious it would be. France considered that a loyal participant in ESA would surely be obliged to give first priority to Ariane for domestic launches." Chapman's memo to Sauvé's noted: "France continues to place emphasis on Europe having an independent satellite launch capability, but Canada has in the past been satisfied that dependence on the USA for launches has not been an unreasonable burden."

In the end, Canada's choice was essentially "none of the above". It carved out a unique niche by becoming a cooperating member – what Franklin describes as "observer plus," an enhanced version of observer status. Canada was allowed to participate in optional programmes; it also had to contribute to the General Budget but not as much as associate membership would have entailed. This status was unique at the time and remains so today.

Although the contentious issues were resolved sufficiently to allow Canada and ESA to sign a cooperative agreement, they did not go away; indeed, the same arguments would be resurrected with every renewal of the agreement.

The Cooperation Agreements – Thirty Years Of Partnership

The first agreement: 1979-1983

The first five-year cooperation agreement between Canada and ESA came into effect in January 1979. It required Canada to participate in and contribute financially to "general studies concerning future projects which are part of the Agency's basic activities." In addition, Canada could choose to participate in optional programmes. Its General Budget contribution was set at 1 percent annually with the proviso that this would increase as participation in ESA activities evolved.

The agreement stated that ESA would "endeavour to ensure a fair industrial return to Canada, to the same extent as provided to Member States, with respect to the geographical distribution of work relating to the activities and programmes in which Canada participates."

In 1980, Canada embarked on its first projects within ESA. It joined the Olympus programme, a large communications satellite that extended the work begun with the CTS and Anik satellites. (See "Success Stories: Canada's Participation In ESA Projects" for more details of cooperative projects.) Canada took an 11 percent share in Olympus, supplying solar panels and other components and supporting the assembly, integration and testing of the satellite at its recently created David Florida Laboratory.

Canada also got involved in the development of ESA's first Earth observation satellite, the European Remote Sensing Satellite (ERS-1), contributing about 6 percent of the budget. In addition to providing microwave hardware for the satellite, it adapted its ground stations to receive ERS data.

ERS carried an all-weather radar known as Synthetic Aperture Radar (SAR). A Canadian company, MacDonald Dettwiler and Associates Ltd. (MDA), had pioneered digital processing of SAR data (a significant improvement over existing optical processing) and it was chosen as ESA's prime contractor for the ground segment, providing the equipment needed to control the satellite and to receive and process data from it.

Its growing involvement in ESA activities prompted Canada to appoint its first counsellor for European space affairs in 1982. Jocelyn Ghent Mallett said her role was to "protect our investment in European space programs, protect our related industrial interests to make sure we got our share of the contracts, to protect our technological and policy interests." She noted that Canada contributed more to the Olympus and ERS-1 programmes than most of the eleven ESA member countries and significantly influenced the development of these programmes. For example, Canada fought to have a large radar put on the ERS satellite when others suggested putting on a smaller one.

"In those days, we were able to shape things technologically, but it required a constant presence. We had to be there all the time," said Mallett, who attended many meetings of ESA committees, programme boards and working groups. "There were many "hard-fought battles." While Canada had its allies, it was perceived by some ESA members, particularly France and Spain, as an interloper. "We did have, in some respects, a bit of an adversarial relationship," Mallet said.

As a result, renewing the cooperation agreement was a tough prospect. The issue of General Budget contributions was a serious a point of contention; some ESA members believed that Canada wanted to reap the benefits of participating in optional projects without contributing to overhead costs – an approach described as "cherry-picking."

"The negotiations were extremely complex," said Mallett, noting that it was necessary to hold discussions with France and Spain separately, as well as ESA itself. "They wanted us to be paying a lot more. We were becoming a significant player and as far as the French and Spanish were concerned, we weren't paying our share. They accused us of cherry picking." Their resistance was a potentially serious political obstacle because renewing the agreement required unanimous approval by all eleven Member States.

(At times over the years, this requirement for unanimous approval left Canada vulnerable to being held for ransom on unrelated issues. One recent example was a demand that Canada support Europe's position in international negotiations concerning the allocation of frequencies for communications satellites. "They even wanted to have clauses in the agreement about supporting European positions in international discussions," said Bronstein. Political interventions were necessary to resist these pressures.)

Because Canada could not increase its financial contribution enough to appease these concerns, "we had to do it through persuasion," said Mallet, who described her job as an intensely personal one that required developing relationships with key players in ESA. For example, she established a rapport with some members of the French delegation who then took up Canada's cause with their compatriots.

On the positive side, Canada was perceived as having valuable technology and experience. "There were few countries with our experience in telecommunications and we were getting there with remote sensing," Mallet said. Canadian companies were also seen as "more aggressive and entrepreneurial, more like US companies. In the end, we earned their respect. They probably still think we're cheap, though."

The second agreement: 1984-1988

The second five-year agreement ran from January 1984 to December 1988. Much of the language was the same, with some notable exceptions. The agreement outlined the "outputs" of the General Budget in which Canada was required to participate, including studies on future projects and fixed common costs." But Canada was excluded from ESA's Technology Research Programme (TRP), which many ESA member countries viewed as the key to developing innovative new technologies.

Canada's contribution to the General Budget was set at 3 percent annually for the first three years, subsequently to be reviewed. The language on industrial return was identical, saying that ESA would "endeavour to ensure" a fair return. The agreement also laid out the conditions under which Canada could participate in ESA's decision-making bodies and its voting rights.

The Gibson Report

Not long after the second agreement was signed, Canada examined its future with ESA. The Ministry of State for Science and Technology (MOSST) commissioned a British company, General Technology Systems Ltd., to evaluate European perceptions of the Canada/ESA relationship as input into its deliberations on updating Canada's national space policy. The 1985 report, "A European Assessment of Canadian Opportunities and Future Options for Association with European Space Activities," was compiled by Roy Gibson, a former Director-General of ESA who was then working for GTS. The study reviewed existing and planned ESA programmes "with a view to assessing not only Canadian interest, but also the possible likelihood of the ESA Member States agreeing to Canadian participation." (The authors noted they were frank in their comments and that the report at times departs from "standard diplomatic practice….")

Gibson reported that the attitude of ESA members toward association with other countries was hardening and "further expansion of the ESA family is not favoured." Partly this was because of a growing insistence that all participants pay a fair share of common costs. "Member States consider that newcomers…must make more than a symbolic contribution to the cost of building up the ESA

infrastructure." Some members insisted that only European countries be allowed to join. "It is difficult to avoid the impression that most Member States simply want to pull up the draw-bridge and stand by to repel would-be boarders, and that they are desperately seeking arguments to justify this restrictive attitude."

He noted that, while many member countries would regret it if Canada withdrew, they wouldn't fight it with "heroic acts of bravery." Even the United Kingdom, though "naturally disposed" to assist Canada, was unlikely to "walk through fire to support Canada in the ESA Council." As for the French delegation, it had fought Canada's entry from the start and "there are no signs that this opposition has diminished," the report stated. Noting that the French had persuaded others to their point of view, it observed that "in some cases French-manufactured bullets have been fired from foreign rifles."

The report distinguished between the attitude of individual Member States and that of the ESA executive and staff, which, it said, favoured enlarging ESA's membership. This group generally had a "thoroughly positive attitude to Canada's association with ESA, and an appreciation of the overall competence of Canada's aerospace industry…."

There were some reservations about Canadian industry, however. ESA staff were asked to evaluate Canada's contribution in the telecommunications and Earth observation programmes. On the first, their comments suggest they were less impressed with Canada's technical prowess than Canadians were. They felt ESA's telecommunications programme had benefited from Canada's financial contribution and the "widening of the political horizon" but could not identify a major technical advantage from the association. "Canadian industry had perhaps hoped to find via ESA an open door for sales to Europe and the rest of the world," the report says. "But the hardware it offers is not reckoned to be either better or cheaper than can be obtained in Europe. For very sophisticated hardware one goes to USA."

The assessment was more positive regarding the Earth observation programme. Canadian participation in ERS was viewed as "a major asset" primarily because of the role of the Canada Centre for Remote Sensing. CCRS was described as "the leading body in remote sensing. It had a good team, the necessary resources and long experience." The report also noted that MDA, which had been awarded the prime contract for data processing and equipping ground receiving stations, had become a leader in the field – a fact that had, in fact, put some noses out of joint within ESA and was "in danger of poisoning the atmosphere."

The report also considered how Canada's aerospace industry was perceived within ESA and reviewed the ever-troublesome issue of Canada's industrial return. It pointed out that Canadian firms felt discriminated against when they weren't chosen for contracts even though Canada's financial contribution was small (it was paying less than would be expected on a GNP basis). "Some industrial companies have delusions of grandeur and believe they are in the same league as European main contractors." Finally, the report stated that "it has been difficult to communicate with Canadian companies because of their distance from Europe."

Aware that their blunt language might provoke wrath in Canada, the authors cautioned that the comments from ESA officials involved in the programmes could not be assumed to represent ESA's official stance. In fact, they said, the comments were not intended to discourage Canadian participation and were not unlike what might be expected in respect to any ESA member country. "A seasoned observer would in fact find these distinctly mild compared with those directed at other industries."

The report also analysed the likelihood that Canadian companies would receive contracts from European countries without being part of ESA and concluded that such direct industry-to-industry agreements were unlikely – again, because Canadian companies did not offer "such an advantage in technical quality or price to break the basic tendency to buy European…Many Canadian aerospace companies appreciate the 'door opening' nature of the ESA connection and would wish for an even wider participation in ESA programmes and a generally higher Canadian profile."

Finally, the report noted that working relations between the Canadian and European industries were troubled, with dissatisfaction apparent on both sides; it suggested that fence mending was needed.

Notwithstanding concerns in Europe about competition from Canadian companies, the report noted that Canada's industrial return at the time – about 88 percent – was "not entirely satisfactory" by the standards applied to member states. ESA had raised that standard from 80 percent to 100 percent – an unrealistic goal, the report suggested but said it was not unreasonable to expect a return in the range of 95 percent.

The narrowness of Canada's participation in ESA programmes was cited as the major reason why the industrial return was poor. There was a "distinct reluctance" to award studies on future programmes to Canada because of the perceived risk that Canada would not carry through in developing the programme. In fact, Canada was seen to be trying to do too much with too little money and there were fears this could result in a rapid reduction in Canadian space activities.

The report also addressed the influence on European thinking of Canada's relationship with NASA. Given the successful collaboration between the two North American countries, many in Europe felt that Canada should be content to be considered a US satellite in aerospace matters. It noted that NASA sometimes had difficulty understanding why Canada "is not satisfied just to follow the NASA line…In this complex situation, it seems that Canada often gets the worst of both worlds; neither the US nor Europe is satisfied with Canada's attitude in the space arena. Both have a tendency to think that Canada should choose between them…."

The authors suggested this problem stemmed partly from the lack of a formally-declared national space policy and the lack of a "single focal point" for developing this policy – a reference to Canada's lack of a national space agency. In fact, Canada had released its first national space plan in March 1985, focussing on Canada's commitment to the International Space Station and its intention to develop MSAT, a mobile communications satellite. However, in 1985, the Canadian space programme was still being managed by the Interdepartmental Committee on Space, comprised of representatives from various government departments. John Chapman had recommended the creation of a space agency as early as 1967 but this would not be accomplished until 1989.

As a result, according to the Gibson report, there was, within ESA, great uncertainty about who, exactly, made Canadian space policy. Visits to Europe by a succession of different Canadian ministers did little to reduce the confusion. The report suggested that establishing a central body responsible for setting forth a defined space policy would improve relations with both ESA and NASA, providing everyone with a clearly understood rationale for Canadian decisions. "Good relations with NASA cannot be considered a handicap to close cooperation with ESA, but both must be visible and understandable within a sustained national policy, rather than leaving all concerned to 'read the tea-leaves' in an attempt to interpret the significance of each individual action."

The report concluded that Canada had negotiated a favourable agreement with ESA, considering it was paying less, relative to GNP, than member countries, yet was significantly involved in two advanced satellite programmes, Olympus and ERS. "Several delegations believe, indeed, that Canada has picked the cherries out of the cake. This is probably as unjust as to believe that Canada has been wasting its money."

Finally, the report suggested that Canada's continued involvement in ESA would make sense only if it increased the budget and scope of activities devoted to ESA programmes. "The present scale of participation to ESA appears to be below the threshold for obtaining a satisfactory return." The report suggested that even a modest increase would be worthwhile; in any event, the existing arrangement could not be continued indefinitely. Because Canada's funding level was too low and its participation too narrow, it lacked "presence" and was not perceived in Europe as a "major entity in space." In short, "there is a mismatch between funding and aspirations" and a continuation of this situation would only result in further dissatisfaction.

Nor was withdrawal from ESA or falling back on bilateral or industry-to-industry agreements likely to provide satisfactory results. “This road would probably lead to a decline of the Canadian aerospace industry.” There was no realistic possibility that Canada would be allowed to become a full member, even if it wanted to, but the report urged Canada to improve its situation by negotiating an agreement with a ten-year term instead of five, and increasing its level of participation.

The report made special mention of technology research programmes funded under the General Budget which were intended to prepare critical technologies important for ESA’s future activities. Under the second agreement, Canada was barred from participating in these programmes (they were not specifically mentioned in the first agreement) and many in Canada viewed this as a serious handicap. It was, in fact, “the juiciest bone of contention,” the report notes, adding that Canada could try to gain access to the TRP in future negotiations but the chances of success were not good. “Member States have a somewhat exaggerated idea of the value of this programme and have become overly protective.”

However, Canada was not prohibited from participating in technology research programmes associated with the applications programmes in which it participated (i.e. the telecommunications or Earth observation programmes) and the report urged Canada to press hard to be included in these.

Finally, the authors noted that their report did not intend to imply, as some thought, that “ESA did not need Canada, and that Canada would have to take or leave the conditions handed down by ESA.” ESA had much to gain from cooperating with Canada but “the present climate in Member States is not such as to allow Canada – or indeed any other non-Member State – to dictate its own terms.” Negotiations on a new agreement would thus be difficult, because in space activities, Europe was going through “a period of consolidation not conducive to expanding international cooperation.”

According to Colin Franklin, the Gibson report was “dead right” in its assessment that Canada was spreading itself too thin. Ironically, this view was echoed in Canada, especially among those who still believed Canada should be spending those limited space dollars at home. Some put forth the view that the cooperative arrangement should be allowed to lapse after expiry of the second agreement in 1988 because they couldn’t see any major programmes in the future. The Olympus and ERS programmes were winding down and there were no major ESA programmes which Canada had identified as candidates for participation. “There were a number of people in the bureaucracy who thought it was not good value and some preferred to have all our involvement in the USA. On the other hand, some Canadian companies felt that their successes in market penetration were critically dependent on having this relationship.”

Ultimately, the arguments in favour of continued association won out.

The third agreement: 1989-1999

In May 1989, the cooperative agreement was renewed for the third time, this time for 10 years, as Gibson had recommended. (Interestingly, it was just two months earlier that the Canadian Space Agency was created, addressing the issue of Canada’s lack of a “single focal point” for developing space policy.)

Much of the language was similar to that in previous agreements, but there were refinements relating to persistently sensitive issues such as General Budget financing, the Technology Research Programme and industrial return. The contribution to the General Budget rose again; it was set at 4.22 percent in the first year and 4.86 in the second. After that, Canada’s payment was to progressively rise to half of what full ESA members states paid to the General Budget based on GNP.

As Gibson predicted, Canada was again banned from the basic Technology Research Programme, but it was allowed to participate in technological research related to the optional programmes in which it participated. The language concerning industrial return remained unchanged.

Economic Benefits

The question of what economic benefits Canada derived from cooperation with Europe was a continuing preoccupation in Canada. In fact, during the decade covered by the third agreement, no fewer than three studies were done to address these questions. They included a 1989 study by researchers at University Louis-Pasteur (Strasbourg) and École des Hautes Études Commerciales (Montreal), a second by Louis-Pasteur and Simon Fraser University (Vancouver); and a third by the Hickling Corporation.

The first two studies focussed on the indirect economic effects of the ESA relationship. Indirect benefits were measured in terms of product sales, reduced costs and the development of a critical mass of space technology specialists.

The 1989 study, which covered 1979 to 1988 for contracts and 1979 to 1993 for indirect effects flowing from those contracts, concluded that there was "irrefutable proof" that ESA contracts had generated indirect benefits for Canadian contractors. For every dollar ESA invested in Canada, the indirect benefits amounted to $3.50. These results were comparable to those in Europe, demonstrating that "the Canadian space industry behaves in the same way as its European counterpart, despite Canada's recent entry and its special status within ESA." The report noted this was remarkable because ESA contracts account for a relatively small portion of Canadian space activity, unlike in many European countries where the proportion is much higher.

There were differences in the return attributable to the four categories of indirect effects. The technological effects (i.e. sales of products incorporating space technologies developed under ESA contracts) accounted for most of the benefit – 40.5 percent. Indirect benefits related to labour (maintaining a critical mass of space technology specialists) came second at 23.7 percent. Commercial effects (sales from ESA references, new markets etc.) contributed 18 percent, while organisational effects (reduced production costs) contributed 17.8 percent.

The technological indirect effects comprised such a large percentage because "Canadian space firms are used by ESA in only a few technological specialties where they are already doing well, which allows them to strengthen their capabilities," according to the report. It noted that Canada's efforts to build a space industry focused on telecommunications and remote sensing is reflected in the indirect technological benefits but this had resulted in weak links with Canada's aeronautics industry, so the indirect benefits did not extend to them.

The effects related to quality management and project management (organisational effects) were "relatively weak" because Canadian space companies were already familiar with the rigorous specifications related to space projects as a result of their involvement in Canadian and NASA programmes. The indirect effects in the commercial category "confirm the hypothesis that participation in the ESA programmes serves Canadian firms as a means to enter European markets."

The study was unable to quantify the indirect benefits to the entire Canadian economy and, since ESA contracts made up only a small fraction of Canadian space activity, it was difficult to extrapolate the results even to the entire space industry. However, it said the data "lead us to think that the results would not be radically different if we took into account all space programmes in which Canadian firms participate."

The subsequent study, completed in 1994, covered the periods of 1988 to 1992 for ESA contracts and 1988 to 1997 for indirect spin-off benefits resulting from those contracts. The indirect return was higher this time – $4.20 for every dollar ESA invested, compared with $3.50 earlier. These results suggest that "the benefits derived by the Canadian economy would seem to have increased and Canadian contractors' performance in terms of the spill-over effects of ESA contracts would appear to have improved." But it cautioned that the results of both studies might have been skewed by the "outstanding performance of a few firms, given the limited number of Canadian companies contracting with ESA and their different specialties."

This study found that the indirect benefits were almost entirely (96.9 percent) concentrated in the space industry and most of them (91.4%) came from export sales to Europe, the United States and Asia. It attributed this to the smallness of the Canadian space market and the fact that Canadian firms were highly specialised.

The returns in different categories of indirect benefits were dramatically different from the previous study. Commercial effects had made a huge jump to more than half of the total, while technological effects were close behind with 45.5 percent, also an increase. This came at the expense of the benefits in the organisational category (down to just 0.3 percent) and labour/critical mass (3.1 percent.)

Commenting on these changes, the report noted that Canadian firms had gained considerable experience working with NASA and ESA and "have already served their apprenticeship in organisation and methods." And, since Canada was selling more space products worldwide, ESA contracts were becoming less important in maintaining a critical mass of space workers. The report attributed the dramatic improvement in commercial spin-off benefits almost entirely to the fact that ESA contractors have a good reputation that helps them sell products to other customers. "The reliability and performance requirements of ESA contracts have given Canadian contractors opportunities to sell ESA products to other customers, sell improved versions of their own existing products by incorporating ESA technology into them and penetrate new markets by using the ESA reference."

In 1996, with the end of the third agreement approaching, the Canadian Space Agency commissioned the Hickling Corporation to conduct an independent evaluation of the Canada/ESA partnership. One important aspect of the report was its analysis of the industrial return that Canada had received from the ESA agreements. At the end of 1996, Canada had achieved an overall return of 90 percent but there was a significant disparity between the return from optional application programmes (100 percent) versus that from the General Budget (50 percent.) In fact, the return from the General Budget had been steadily declining from a high of nearly 100 percent in 1988 to 50 percent in 1996.

Among the optional programmes, the remote sensing sector was the star performer, returning well over 100 percent most years and reaching the range of 130 percent or more in the mid-1990s. The telecommunications programme was also in positive territory, though just barely.

The report concluded that cooperation with ESA continued to be relevant to Canadian industry and that "Canadian companies have profited in the past from the association and continue to do so." It noted, however, that the value of the relationship was increasingly being questioned as Canadian companies shifted their focus from technology development to more commercial objectives. Consequently, there was a feeling that "the ESA arrangement as currently structured may have run its course." As for smaller companies, they had been unable to benefit much from the ESA association because of the high cost of bidding on ESA programmes.

An examination of the industrial, technological and political objectives of the ESA agreement resulted in the conclusion that these objectives had been only partially met. Following is a brief summary of the findings that led to this conclusion:

Technological objectives: The association with ESA had improved the reputation and capabilities of Canadian companies, which had acquired expertise they might not otherwise have achieved. There was little technology transfer between Europe and Canada, but the relationship allowed Canada to reinforce its expertise in niche technologies and market them around the world.

The report noted that Canada was, in a sense, paying a price for its contribution to ESA programmes. In the beginning, the technology Canada brought to the relationship was superior in a number of areas, but European countries had improved in fields once dominated by Canada. As a result, Canadian companies were finding it more difficult to win contracts because of increased competition within Europe.

Industrial and economic objectives: Industrial benefits in the form of product sales and spin-offs related to ESA contracts were "disappointing." The Canadian industry did not benefit from the ESA programmes as much as it did from other government-sponsored technology development programmes or to the same extent that ESA member countries did. ESA's General Budget was the primary source of the low return. Both Canada and ESA were making efforts to provide increased opportunities for small companies to participate in the cooperative programme.

Political benefits: Canada was viewed as an important partner by ESA and its involvement added value to ESA programmes in terms of management skills, technology and finances. Canada was able to influence the direction of ESA programmes in which it participated, but overall its influence had been limited. Withdrawal from ESA could hurt the ability of Canadian companies to partner with European firms, but technical competence and pricing had become more important factors in creating such alliances.

The report also addressed issues of management and cost effectiveness, saying that Canada did not have a well developed structure or mechanism for managing its participation in ESA programmes and establishing priorities for selecting ESA projects in which to participate. (It noted that this problem was being addressed by CSA). It also cited the lack of an industrial strategy for space activities as a factor that put Canadian industry at a disadvantage.

The plight of smaller space companies (known as SMEs or Small and Medium Enterprises) was highlighted. Many appeared to lack awareness of the opportunities in Europe but, in any event, the costs associated with making bids and operating an ESA contract had proved to be a considerable burden. (In fact, even larger companies found the effort to prepare proposals "onerous.") Consequently, smaller companies did not view the ESA association as cost effective. They would have to forge closer ties with larger Canadian companies in order to gain entry to ESA programmes in the future.

The report made a number of recommendations including:

- establishing a group within the Canadian Space Agency to keep Canadian industry informed about ESA opportunities and help them secure contracts;
- more active lobbying on behalf of Canadian companies;
- increasing support for SMEs, including improving information on ESA opportunities and encouraging larger companies to include SMEs in their contracts.
- developing an industrial strategy to define Canadian priorities for technology and market development in space activities

Finally, the report recommended that an increased emphasis on Earth observation programmes would be to Canada's advantage, given its strengths in this field and the likelihood of continued government involvement. This was in contrast to the telecommunications field which is increasingly commercial and driven by industry priorities. The report said Canada should remain open to participating in telecommunications projects, as well as space robotics and space science projects on a case-by-case basis, but should focus mainly on Earth observation. Among other benefits, this would result in "a stronger and more balanced cooperation between Canada and ESA [that] could bring progress to both which they would not be able to afford individually."

CSA followed up on the recommendation to establish a better management structure to handle the ESA relationship. CSA is still a relatively new agency and it had to pull together all the threads of Canada's space programme that were spread out over several government departments and agencies. "It took some time for the responsibilities of the various departments to be centralised and transferred to CSA. It took three or four years before that was really in place," said Leclerc. "The management of the ESA program was only centralised last year."

Mac Evans said that with this management group in place, CSA has become more proactive in helping Canadian industry take advantage of the ESA association. “We do have an industrial strategy in the sense that we sit down with our companies, make them aware of ESA opportunities, orchestrate ESA coming over here and talking to our industry. It’s new, and time will tell whether it’s more effective.”

It should be noted that these evaluations of the ESA relationship were taking place at the same time as Canada embarked on a growing and highly visible relationship with NASA that included signing on as a partner in the International Space Station programme and increased participation in NASA’s human spaceflight programme. During the 1990s, there were more than half a dozen flights by Canadian astronauts aboard the Space Shuttle, several of which involved visits to ISS and the Russian space station Mir. The culmination was the April 2001 mission of Chris Hadfield, who installed Canadarm2 on ISS. High-profile events like these consumed most of the attention the Canadian media and public paid to space activities and there was little, if any, awareness of the ESA relationship outside of the space community.

In June 1994, Canada’s second long term space plan was released. It allocated funding of C$2.7-billion over ten years and provided for Canada’s contribution to the space station, upgraded Radarsat facilities, an advanced communications programme, development of space technologies in partnership with industry and with other space agencies; more funding for space sciences (mainly atmospheric and microgravity sciences), and astronaut flights on the Shuttle. In February 1999, the federal budget earmarked an additional C$430-million over three years for space activities, to be followed by stable funding of C$300-million a year for CSA. A new space plan was approved to take into account the increased funding. “This decision gives the Agency, for the first time, the financial flexibility to plan and manage aggressive space programs in today's rapidly changing environment,” CSA noted in its performance report of March, 2000

The fourth agreement: 2000-2010

The fourth agreement came into force in January 2000 for ten years. Once again, Canada was excluded from the General Budget’s basic Technology Research Programme. Its contribution level was similar to that established in the previous agreement (i.e., half the contribution of a full member on a GNP basis.) At present, this amounts to 3.1 percent of the General Budget (lower in percentage terms than during the previous agreement owing to an increase in ESA membership.) In dollar terms, that amounts to about C$25-million, C$5-million for the General Budget and C$20-million for optional programmes. One new feature is that ESA is now allowed to participate in Canadian programmes.

The language regarding the Technology Research Programme was simpler, reverting to the straightforward statement that Canada would not participate and making no mention of research related to optional programmes. Although the door had been left open to such participation in the previous agreement, “in practice it never worked,” according to Gilles Leclerc, who described the process as fraught with difficulties and hurdles. “It wasn’t worth the trouble. Our priorities were in remote sensing and telecommunications and the basic technologies had been mastered in Canada. During the last negotiations, we decided to drop that in exchange for better guarantees for industrial returns in the programs in which we participate. We decided to put the emphasis on the industrial return which had always been a difficult issue, much more difficult than the TRP.”

The language concerning industrial return was changed in a seemingly small but fairly significant way. Instead of saying that ESA would “endeavour to ensure” a fair return, it stated that ESA *shall* “ensure a fair return to Canada for activities under the General Budget, excluding the technological research programme” and, in the optional programmes, apply the same standards for industrial return to Canada as it does for ESA member countries. This return has been “a moving target”, Leclerc said; in the early days it was set at 80 percent but by the 1990s, it had risen to around 96 to 98 percent and may change again.

For Canada, industrial return was the single most important issue to be addressed in negotiating a renewal of the cooperation agreement in 2000. Even this far along in the partnership, there are still doubters who question why Canadian tax dollars are being sent to Europe, says Leclerc. "Even within CSA, some people wonder why we give ESA 8 to 10 percent of our budget. It is something we always have to fight; we had a tough time renewing the last agreement. We worked hard to demonstrate the benefits."

Each renewal also required mustering support from Canadian industry. Bronstein said some companies felt they could compete internationally on their own if Ottawa gave them the money that was going to ESA. While that might be true for some, he said that "a lot of companies don't have the wherewithal or exposure. Without international agreements, they wouldn't have a hope in hell of working internationally."

Before each renegotiation, focus groups involving industry representatives and space-based government departments were set up to ensure that all players were acquainted with proposals and opportunities. The goal was to "make sure they were on-side and ready to lobby to support renewal," said Bronstein. "What sold the ESA programme was the success the major space companies had, particularly in Earth observation and satellite communications. Their world position in the marketplace, the affiliations developed with European companies – these did happen and Canada did have a stronger visibility, certainly in Europe."

It's not surprising, therefore, that industrial return remained one of Canada's priorities. In 1995, a task force was set up to find ways to improve the return, not only for the programme overall, but also in the General Budget, where it stood at only 50 percent. The task force was successful, Leclerc said, because it included key ESA representatives with responsibility for contracts. "It was not easy to see what we could get under General Budget, so it was important having the people who see all the contracts come and go and who could tell us what the opportunities were for Canada. That turned the tide."

The solution came in the form of two large projects. One involved a C$23-million contract to SED Systems of Saskatoon to build a large telemetry, tracking and command antenna for ESA's deep space tracking facility in Perth, Australia. This antenna will be used to track a spacecraft (Rosetta) that will be launched in 2003 to rendezvous with Comet Wirtanen and two asteroids. The antenna will also be used for future Mars missions. This was the largest contract ever let under ESA's General Budget.

The second project, called the Harsh Environment Initiative (HEI), involves applying space technologies to solving problems associated with operating in harsh environments on Earth. (See "Success Stories" below.) ESA funding for this project also came from the General Budget. The result was that by the end of 1999, Canada's industrial return had climbed to about 97 percent overall and its return from the General Budget was enormously improved at 140 percent.

Success Stories: Canada's Participation in ESA Projects

Documenting the complex evolution of Canada's cooperation with ESA, with its ongoing disputes about the value of the partnership, might leave the reader with the impression that the relationship was highly troubled and perceived to be of little value by both sides. However, for many people directly involved this is not the case; they seem to regard the disputes as an inevitable and not abnormal consequence of running a complex technological programme over international boundaries and they point to a range of successful projects as confirmation that the partnership has been productive on both sides of the Atlantic.

These projects helped to advance the development of new technologies, provided the partners with valuable operational experience that carried forward into future programmes, and allowed aerospace companies to enhance their capabilities and develop wider markets for their products. Their success is reflected in the simple fact that the cooperation agreement was renewed four times, and for increasingly longer terms, despite the difficulties that arose in the interim.

From the start, Canada's participation was primarily focussed on the two fields in which it had already established a considerable expertise on its own – satellite telecommunications and remote sensing.

Satellite Telecommunications Programmes

Olympus

Olympus, one of the largest telecommunications satellite ever built, was an experimental satellite designed to test advanced technologies to enhance the power and transmission capabilities of future commercial communications satellites. Initiated in 1978, it built on the work done on the CTS/Hermes satellite and Canada's Anik-B satellite.

In 1980, Canada joined the project, becoming the third largest participant with an 11 percent share of the budget. Canadian companies supplied several components, including solar panels and amplifiers. The primary Canadian participants were COM DEV Ltd., Spar Aerospace Ltd. and the government's Communications Research Centre.

Assembly, integration and testing of the C$1-billion satellite was done at the David Florida Laboratory, an experience that proved invaluable for DFL. "That was something new for us," said Colin Franklin. "Now DFL has contracts all over the world."

Olympus was launched in 1989 and operated for four years. During that time, the satellite was used for experimental programmes in satellite newsgathering and broadcasting, distance learning and telescience.

Advanced Research in Telecommunications (ARTES)

ESA's ARTES-3 Multimedia Programme, established in 1997, is designed to help industry and service providers compete in the global market for multimedia satellite services, projected to exceed US$120-billion by the end of the decade. It focuses on developing new applications for broadband interactive services using communications satellites, emphasising practical benefits to enhance everyday life. Early trials included delivering Internet web content via multicasting (single point to multi-point delivery) and digital distribution of music files 100 times faster than conventional land-based Internet systems. This e-commerce application can also be used to distribute video products, computer games and other software.

The ARTES programme will also promote development of satellite-based tele-education and telehealth applications, a field in which Canada, with its many remote communities, already has considerable experience. Three Canadian demonstration projects are part of the ARTES programme:

• **Remote Communities Services Telecentre (RCST):** Starting in 1998, Telesat Canada and the Canadian Space Agency established satellite telecentres in nine remote rural communities in Newfoundland and Labrador that linked them to urban centres. This enabled the use of high-speed Internet access, videoconferencing and digital imaging to deliver health, education and government services.

• **Integrated Emergency Medicine Network (IEMN):** Building on the RCST infrastructure, this project was started in 1999 to provide high-speed communications to aid emergency workers treating patients in remote locations by providing real-time links with medical experts in urban centres. The service has been used to provide cardiac care and to send X-ray images to be interpreted by specialists. It also enables doctors to remotely monitor patients' vital signs while they are being transported by land or air ambulances. A network like this could also be used to treat people in disaster situations.

• **Marine Interactive Satellite Technologies (MIST):** This project, started in 2001, extends satellite-based communications to marine vessels in Canadian waters. High-speed terminals will link patients or the ships' medical staff with doctors on shore. The terminals can also be used by passengers for non-

medical purposes, such as accessing email. Announcing the launch of this service, Canada's Industry Minister, Brian Tobin, who is responsible for the Canadian Space Agency, remarked that "innovations in leading-edge satellite technology are rapidly bridging the gap between urban and remote regions of Canada."

Abdul Lakhani, Telesat's senior specialist in applications and networks, said IEMN is scheduled to end by the end of 2001, but it may be continued under the MIST project.

ESA provided up to 50 percent of the funding for these projects; the rest came from Telesat, CSA and other partners from government, industry and universities. Lakhani noted that there are many similar projects in Europe and all participants share their results and experience. "All member countries benefit."

Lakhani said the concept of community telecentres developed under RSCT is being recognised as a solution for remote, underserved areas of Canada because it allows a single infrastructure to deliver a wide range of services. "Reducing the cost of infrastructure is important for remote communities because their economic base is very small." In 2000, Industry Canada funded a C$60-million three-year project to expand the community centre concept to 28 new sites in Labrador and in 2001 Telesat signed an agreement with Canada's First Nations to provide broadband connections to 622 communities by 2004. Lakhani said this initiative is based on work done during the demonstration projects and "it would have been a slower process without ESA."

Galileo (ARTES-9)

Galileo is a proposed civilian global satellite navigation system currently in the development and validation phase, with the goal of starting operations around 2008/2009. The network will comprise several satellites in medium Earth orbit and a ground infrastructure to provide GPS-compatible global coverage. The system could be used to support a variety of applications including search and rescue, travel and tourism, shipping, ground vehicle traffic management, crime prevention, mineral exploration and infrastructure planning.

Several Canadian companies are involved in the definition phase, including EMS Technologies Canada, COM DEV and CAE Ltd. In January 2000, Calgary-based NovAtel Inc. was awarded a C$190,000 contract to work on the definition phase, providing input on signal validation and receiver performance, development requirements and costs.

Artemis

Artemis is an experimental satellite designed to test new telecommunications services that will improve mobile voice and data communications services for vehicles on Earth, improve global navigation services and allow direct satellite-to-satellite communications.

This project is intended to improve the flow of data from remote sensing satellites, which now depend on ground receiving stations to relay the information they gather. Artemis carries advanced technology, including a unique relay system that uses lasers, which will permit these satellites to talk directly to each other. It's expected this will improve the efficiency of delivering environmental data to end users. Two Canadian companies, COM DEV and EG&G Canada Ltd., are participating.

Artemis was launched in July 2001. A rocket malfunction caused the satellite to be placed in the wrong orbit; however ground controllers were able to gain control and put the satellite into a safe parking orbit.

Real Time Emergency Management via Satellite (REMSAT)

REMSAT is a project that combines several types of satellites – telecommunications, navigation and remote sensing – to fight forest fires. In 1998, ESA gave a C$1.6-million contract to MDA and the British Columbia Forest Service to run tests demonstrating the use of satellites for emergency planning and managing forests fires in B.C., which experiences about 2800 wildfires a year. The project was proposed to ESA by MDA and BCFS in response to ESA's call for projects that could showcase the value of using space-based technologies to deal with disaster situations.

The REMSAT system can provide telephone, fax and Internet access in remote locations, as well as near real-time remote sensing images, weather and land use data, topographical models and GPS navigation. This enables fire-fighters to more accurately map the perimeter of the fire, predict how it will spread and how much damage it will cause and decide where fire fighting resources can be most effectively deployed. "The major difficulty when fighting a forest fire is lack of communication and information," says Stanley Wu, REMSAT project manager for MDA. "The incident commander needs to know instantly where his people and supplies are."

The location of fire-fighters and their equipment is determined by the navigation satellites and relayed by communications satellites. Fire-fighters on the ground use hand-held terminals that precisely pinpoint their location to exchange information with command centres, reducing demands on radio communications. (In some remote regions, radio communications may not even be possible.) Images from Earth observation satellites provide geographic data, such as the location of roads, power lines, rivers and lakes, tree types and topographic information.

Two demonstrations were run in May 2000; scenarios based on real fires were enacted to determine whether the space technologies could help fire-fighters do their job more effectively. During the summer, the prototype system was used to fight two real fires; fire-fighters were able to set up operations eight kilometres from one fireline in just six hours and redeploy to the other in three hours.

The container housing the equipment, including a satellite receiving dish, is moved in by truck or large helicopter. The B.C. Forest service plans to develop a lighter version that can be packaged in aluminium cases and transported by light helicopters.

The project was funded under ESA's applications programme, designed to develop practical uses for space technologies. "Demonstration projects such as REMSAT bridge the gap between space technologies and users," said Emmanuel Rammos, REMSAT project manager for ESA. The goal is to develop a generic system that can be used wherever disaster strikes – not just for forest fires, but also for earthquakes, floods, toxic spills or any other kind of natural or manmade disaster. MDA is now working to supply disaster management systems to emergency agencies in Canada, the U.S., Mexico and Europe.

Gilles Leclerc said the importance of these Earth observation projects has increased because of ESA's growing interest in promoting space technologies as a public good that can be used to improve the lives of European citizens. There is particular interest in the REMSAT technology in European countries that have experienced natural disasters likes floods, earthquakes and volcanic eruptions.

Earth Observation Programmes

ERS

With its vast land mass and lengthy coastline, Canada has a long-standing interest in using space systems for environmental monitoring. Given that large regions of the country are often shrouded by bad weather and, in the North, by lengthy periods of darkness, Canada has made a priority of developing all-weather

radar, known as Synthetic Aperture Radar (SAR), that can penetrate clouds, rain and fog and can also "see" at night.

In 1978, NASA launched an oceanography satellite called Seasat that carried a SAR. Canada immediately established an interdepartmental programme called Sursat to make use of the radar images. "We put out requests for proposals to the science community for experiments to assess the value of SAR," said Ed Langham, one of the Sursat managers. At the time, the government was particularly interested in mapping sea ice because of concerns about shipping oil out of the Arctic but most of the scientists who responded focussed on terrestrial applications. "We had an enormous response, but three quarters of the proposals were for land things. We went along with it and found the land applications were every bit as important as the sea applications."

Unfortunately, Seasat only lasted a few months but it was enough to "make the case for Canada to get into the Earth observation satellite business and to use SAR," said Langham. "It produced an insane amount of data," said Ralph Baker, a former deputy director-general of CCRS. By 1980, CCRS was proposing to the Canadian government to develop an advanced Canadian remote sensing satellite called Radarsat.

Seasat had another significant impact: it led to the development of digital processing techniques for SAR data. At the time, said Baker, no one thought SAR data could be processed by computers. "There was a debate about whether such a thing was feasible. We happened to have a couple of first class people at CCRS who did see how to do that." The result was that a Canadian company, MDA, became the first to develop a digital SAR processor. "MDA cut their teeth on Seasat," said Leon Bronstein. The experience stood them in good stead when Canada sought to join Europe's remote sensing programme in the mid-1970s.

At the time, ESA was developing its first European Remote Sensing Satellite (ERS-1),. a SAR-equipped environmental monitoring satellite. It was an experimental system, designed to demonstrate the performance of the technology. It was also conceived as a "pre-operational" system that would provide useful data for scientists, particularly those working in ocean- and ice-related disciplines. And, finally, it was intended as a "market-opener," preparing users and suppliers alike for future operational remote sensing satellite projects.

ERS-1 was launched in July 1991 and for six years produced data used by 3500 scientists around the world who studied the Earth's atmosphere and oceans, sea ice, glaciers and snow, as well as geological processes on land. Governments and industry also used ERS data for activities ranging from agriculture and resource management to ice monitoring and shipping.

When ERS-1 was shut down in 1996, it had already been backed up by ERS-2, which was launched in 1995, allowing the two satellite to operate in tandem. A major addition on ERS-2 was an instrument to measure the ozone layer, which protects the Earth's surface from harmful solar ultraviolet radiation.

Canada got involved in the ERS programme starting with the preparatory programme in 1980. Capitalising on its Seasat experience, MDA was able to win a C$34-million prime contract to provide the technology needed to control the ERS satellite from the ground and to receive and process ERS data at ground stations in Sweden and Italy. Under contract to CCRS, it also provided data processing equipment for two Canadian ground stations in Quebec and Saskatchewan. MDA equipped the ground stations with its unique digital SAR data processing system, which placed them in an advantageous position to supply similar equipment to ground stations in many other countries that wished to receive and process ERS data.

John MacDonald of MDA described winning the contract for the ground segment as "a coup" that was "critical to the company becoming a world player in this business. Doing that ground segment was a very important achievement for the company and it gave us a lot of credibility. Because the ERS-1 ground segment was so successful, MDA went around the world and built ground stations for ERS-1 all over the place. We actually ended up making money. There's no question that it was a major factor in MDA becoming a dominant company in remote sensing."

Just as working on Seasat had prepared Canada to contribute to ERS, so too did the experience gained on ERS provide a training ground for the Radarsat project, which was already in the planning stages while Canada was participating in ERS. "Our experience with ERS helped our industry to get its feet wet in building a Canadian remote sensing satellite," said Bronstein. "We hadn't built a remote sensing satellite before and it was quite a bit different from a communications satellite. It's a completely different animal." Not only are remote sensing satellites in different orbits than communications satellites, their functions are quite distinct. Whereas communications satellites just relay signals, remote sensing satellites have sensors on board to collect data and then downlink them to Earth.

He said working on ERS gave Canadians much needed experience in defining and developing such a satellite to meet Canadian needs. In addition, Canada learned about the operational aspects of managing such a programme. Radarsat was intended to be a commercial satellite and one of the challenges for Canada was making the transition from operating an experimental satellite that primarily served the scientific community to one that could reliably deliver products to paying customers day in and day out.

Ed Langham, who was the Canadian delegate on ESA's Earth Observation working group for eight years, said the ERS project helped Canada financially, technically and scientifically. "The extensive involvement of our scientists helped in developing applications and it helped our industry get up to speed for the job we wanted to do with Radarsat." In fact, ESA provided direct technical support for Radarsat-1 starting in 1990.

"I don't think we would be as strong in Radarsat if we had not been involved in all the precursors," agreed Ralph Baker of CCRS, who participated in ESA planning boards. "If you sit on the ground and think about what you want to have up in space, you're going to make a hundred mistakes. If you have experience with all the precursors, you're going to make fewer mistakes."

However, John MacDonald pointed out that, while ERS did provide a base of experience that helped with Radarsat, it was not the case that Canada couldn't or wouldn't have built Radarsat without it. "We had the capability. ERS was part of the story; it's role in Canada going for Radarsat was not negligible but I don't agree that if we hadn't done it, we wouldn't have done Radarsat. The decision to go down the road toward Radarsat predates the launch of ERS-1 by five years."

Radarsat

Launched in 1995, Radarsat-1 was the world's first operational commercial SAR satellite. It provides images for customers around the world day and night and in all kinds of weather. These data have been used for a wide range of applications including mapping, ice tracking, monitoring forests, maritime surveillance and disaster relief. With Radarsat images as the mainstay, the Canadian remote sensing industry has captured about 12 percent of the world's market for Earth observation data.

The Canadian Space Agency and MDA are spending more than C$300-million developing Radarsat-2, which is scheduled for launch in 2003. MDA was awarded the prime contract for the satellite, which it will ultimately own and operate. Lighter and cheaper than its predecessor, Radarsat-2 is more technologically advanced and carries a more sophisticated SAR system. It will produce very high-resolution images, pinpointing features on the ground as small as three metres, more than twice the resolution of Radarsat-1 images.

This enhancement created a serious problem when the US military became concerned about the potential accessibility of high-resolution images of sensitive sites. Even though Canada offered to restrict the use of the satellite over such sites, the US government in early 1999 refused MDA the necessary agreements to buy the satellite bus from their US parent company, Orbital Sciences Corporation. Around the same time, NASA withdrew its offer of a free launch in exchange for access to the data as it had done with

Radarsat-1. These events threw the Radarsat programme into upheaval, delaying the programme by more than a year and causing serious cost increases.

Canada turned to Europe for the satellite bus, negotiating a C$74-million agreement with Alenia Aerospazio of Italy. Some observers in Canada felt that the long-standing relationship between Canada and Europe made this process easier. “I think the ESA involvement over the years was rather helpful in getting that,” said Colin Franklin.

“Because of the 25-year relationship with Europe, we simply ran an RFP and got one in Europe,” said John MacDonald. He pointed out that MDA had worked previously with Alenia so “it wasn’t as though we were strangers. It certainly made it easier that we had had a very long relationship by that time.”

The Radarsat programme is not out the woods, however; Canada still has to make up about C$100-million in launch costs as a result of NASA’s withdrawal. It recently sought European partnerships and financial support for a tandem mission involving Radarsat-2 and its planned follow-on, Radarsat-3. ESA’s director-general, Antonio Rodotà did offer ESA’s help shortly after the collapse of the NASA agreement, but at ministerial meetings in November 2001, Canada was unable to obtain the funding it hoped for from ESA member states.

Proposing that the Radarsat project become part of ESA’s Earth Watch environmental programme, Canada was seeking about €100-million (about C$140-million). Instead, it was offered only €15-million, which was a “big surprise” and a tremendous disappointment to the Canadian delegation, said Leclerc. One of the reasons for this outcome may have been that, while the project offered access to Radarsat data and a share of the world market for that data, there were few opportunities for European companies to win space hardware contracts and some member states would have preferred to conclude bilateral deals for access to the data.

Envisat

Envisat, the follow-on to ERS-1 and ERS-2, is an Earth observation satellite that carries advanced instruments to provide enhanced remote sensing data to aid studies of the Earth’s climate and atmosphere, ozone layer, oceans and ice sheets. It was launched in March 2002.

Several Canadian companies are participating, including MDA, COM DEV, Bomem Inc. and EMS Technologies. They are also participating in ESA’s Earth Observation Preparatory Programme (EOPP) which funds concept and development studies related to future projects that will be part Europe’s Earth Explorer and Earth Watch missions. These missions are an integral part of ESA’s Living Planet Strategy, which has three objectives: to develop knowledge of the Earth; to preserve the Earth and its environment; and to manage life on Earth in a more efficient way. Explorer missions will focus on scientific issues in areas of public concern; the first mission, scheduled for 2005, will study ocean circulation. Earth Watch missions will focus on the long-term provision of data to customers; they will be undertaken in partnership with industry, commercial entities or public entities, with primarily private funding.

Other Projects

Harsh Environment Initiative

As a northern country with the world’s longest coastline, Canada has more than its share of harsh environments – cold oceans, Arctic terrain, underground mines and undersea regions – and a long-standing interest in developing technology to cope with them. In 1997, with C$1.3-million in funding from ESA’s Technology Transfer Programme, Canada’s Centre for Cold Ocean Resources Engineering (C-CORE) established the Harsh Environment Initiative (HEI) to explore ways in which technologies developed for the space programme could be used to solve problems associated with operating in harsh

terrestrial and marine environments. C-CORE is an independent engineering research and development corporation affiliated with Memorial University in Newfoundland.

According to HEI director Bob Robinson, industry comes to C-CORE with a list of their needs and "we go to the space sector and say, 'The mining industry needs to do to this; is there someone within your space agencies, prime contractors or SMEs who have developed this type of hardware or software or capability?' "

Working with dozens of Canadian and European companies, C-CORE has conducted several demonstration projects to evaluate the use of communications and remote sensing satellites, smart robotics and sensors and advanced materials in ground-based applications. In 2001 ESA contributed another $C1.7-million for the second phase of the project.

In addition to solving operational problems in harsh environments, the goal of HEI is to help companies become more innovative and competitive in world markets by developing new products adapted from space technologies. Thus, the criteria for HEI projects included gaining the support of a "receptor industry" as an end-user of the technology, raising industry funding equal to or greater than the ESA seed funding, and the potential for commercialisation. (C-CORE succeeded in attracting funding from industry, levering ESA's seed funding by a ratio of 1.81 to 1.)

Projects undertaken so far have focussed on the oil and gas and the mining industries. They include:

- monitoring of ground motion near pipelines using radar satellite data
- enhancing helicopter operations in harsh environments.
- using smart telerobotics to automate mining operations
- anti-icing of communications antennas
- real-time sensing of conditions at a drill head
- identification of gas hazards in seabeds related to oil and gas operations

According to Robinson, the pipeline study is a good example of how well the programme is working. In Canada, there are tens of thousands of kilometres of oil and gas pipelines, most traversing rough and inaccessible terrain. Protecting pipes from damage caused by either natural events or human encroachment is difficult and expensive. The HEI demonstration project looked into the potential for using satellite images to detect changes that signal trouble so that remedial or preventative action can be taken before damage to the pipeline occurs.

Ground motion is particularly hazardous, said Robinson. "Even relatively small movements can cause a pipeline to be damaged or ruptured." So they put European-built solar-powered radar transponders on critical sections of the pipeline, which transmit data to a satellite on the position of the pipeline. "They can measure very small ground motions – less than a centimetre in length," Robinson said. "With this system, you're alerted to an incident when the tolerance is breached and you can dispatch a crew right to the spot."

He said the concept proved to be accurate and reliable within the first few years of demonstration testing. "The pipeline companies are sold on it; they believe this is the way to go." Numerous pipeline companies have contracted to use the system and Robinson said they have plans to adapt the technology for use on dams and reservoirs.

The concept of HEI originated in Canada – "the Canadian Space Agency really sold the idea to ESA," says Robinson – but he credits ESA for a large part of its success. "Without ESA, there would not be an HEI. They not only talked about technology transfer, they put the money and people in place to do this."

New satellite technologies

Canada and ESA are collaborating on the development of new technologies to improve satellites. These include new antennas that will improve the energy efficiency of satellites; advanced techniques for transmitting signals that will increase the data capacity of satellites; and optical inter-satellite links that will allow for high-speed transfers of data between satellites in geostationary orbits. These links are considered essential to improving the ability of satellites to handle the transfers of huge amounts of information required for multimedia communications and will help satellite systems compete with ground-based fibre-optic networks.

Conclusion

The long list of collaborative projects between Canada and Europe is testimony to the fact that cooperation has provided benefits sufficient to keep both sides in the game for at least another decade. For Canada, the fundamental driving force behind this association has changed to some extent from the early days. Distancing itself from the U.S., so prominent in the 1970s, is no longer an issue. Yet, while it's true that Canada is more closely tied to the US space programme than ever before, the same is also true of its relationship with Europe thanks to the cooperation agreement.

The commitment to ESA, rather than being viewed as an effort to balance the relationship with NASA, is now seen as complimentary, says Leclerc. "The reasons why we are in ESA are different from the reasons why European states think of joining ESA. We already have our own space program and our objectives are industrial, economic, scientific and technological."

He noted that one of the strongest arguments for continuing cooperation is the conviction that if Canada were to abandon the relationship, "we'd never be able to get back in the game." This is strong evidence that the benefits already achieved are considered to be worth preserving. Leclerc noted that during the 1980s and 1990s, when Canada had to cut membership in other international organisations, "we didn't do that with ESA. This was a significant indication that it was important."

What hasn't changed for Canada over the years is the need to diversify its space activities and, especially, to share the risks and costs associated with them. As both the cost and value of space technology increase, the need for partnership grows. Given the limitations of its budget, going it alone has never been an option for Canada. But then, given the enormous costs of conquering space, going it alone is not really an option for any individual country these days.

In a document entitled "Europe and Canada: Partners in Space," CSA notes that "Canada and the countries of Europe share a conviction that, while space offers unlimited prospects for the future, to obtain the maximum leverage from their investments in space, they recognise the fundamental need to spread risk and financial burdens as widely as possible…This is a high-risk venture, where not all ideas succeed. Because there is considerable financial risk attached to the development of these emerging technologies and systems, co-operation and the pooling of resources between Canada, Europe and their respective industries helps share this risk and maximises the potential to make real and substantive progress…Co-operation that has brought substantial socio-economic benefits to both sides of the Atlantic and strengthened the bonds between Canada and Europe in critical areas of science and technology."

Many of the people who were down in the trenches, so to speak, also believe that, in the end, cooperation has rewarded both ESA and Canada. "Overall, yes, it has been very beneficial," says Jocelyn Ghent Mallett. "Every time the concept of cooperation comes up for review, the evaluation comes back that it's something important to do."

Leclerc says that while the doubts of the early years were understandable, times have changed and the advent of globalised trade has made it increasingly important for Canada's space industry to seek

international markets. “ESA opened new markets for Canadian companies. The money flowing into ESA has served us very well.” He adds that ESA is a model for the creation of a worldwide space agency in the future. “ESA was a co-operative of various nations wanting to build a space program. It was a pioneer – the only international space agency.”

John MacDonald points out that the ESA relationship enabled Canada to become a relatively prominent player in international space activities. “Canada is a small economy and there are few other economies of our size that participate in space at this highly sophisticated level. I think the ESA connection over the last 20 or so years has been a big factor in Canada being recognised as one of the international players that makes a contribution.” This would not have been possible if our only relationship was with the U.S., he said. “When you deal with the Americans, you’re always being told what to do.”

“The cooperation agreement with ESA is different from anything we have with NASA,” said Leclerc. “With ESA, we are more integrated into the whole program.”

In the end, said Mac Evans, the ESA relationship helped Canada achieve what John Chapman had been looking for all those year before – a long-term relationship in which Canada could be an equal partner. “We had a chance to participate in much larger programs than we could do by ourselves and that can be altered to meet our needs.”

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Agence spatiale européenne

Contact: ESA Publications Division
c/o ESTEC, PO Box 299, 2200 AG Noordwijk, The Netherlands
Tel (31) 71 565 3400 - Fax (31) 71 565 5433