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Draft

PROGRAM FOR THE DEVELOPMENT OF SPACE SUBSYSTEMS AND COMPONENTS

AN EVALUATION

DEPARTMENT OF COMMUNICATIONS

Canada

Project No. 2-3939
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PROGRAM FOR THE DEVELOPMENT OF SPACE SUBSYSTEMS AND COMPONENTS AN EVALUATION

DEPARTMENT OF COMMUNICATIONS

Industry Comments on the DSSC Program

"From a market point of view, because the application is small, there is more room for a small organization, (and) the market is big enough (that) a small company can focus more effort on such advanced technology."

E.A. Tromanhauser
President, Eidetic Systems Corporation

"The business that has developed bears little resemblance to the original CRC funding. However, without this funding, we would never have been positioned to enter this market. Current employment.... exceeds 50, of whom 20 - 25 are engineering related."

E.W. Muffitt
General Manager (Marketing) Electrohome Electronics

"It appears that the Canadian federal government does not have... funds to support research projects which will improve the reliability of components and therefore... give an advantage to the whole electronics industry and in particular to the space sector, where reliability is a major concern.

Dr. S.P. Bellier
QRL Analysis Corporation

"As a general comment regarding the DSSC (ICF) Program, I trust it will continue essentially in its present form... the elapsed time between submission of our Unsolicited Proposal and contract award was very short, which is in sharp contrast to our experience with other programs. The result of comparing notes with friends in other companies is that DOC CRC has a very good track record in contracting out to industry."

R.E. Mooney
Vice-President, Sparton of Canada Limited

EXECUTIVE SUMMARY

This report contains a description, findings and recommendations relating to the evaluation of the Department of Communications' program for the Development of Space Subsystems and Components (DSSC). The evaluation study was carried out within the Comptroller General's guidelines using a general survey, interviews and case studies for information collection.

The program provides funding support to industry for advanced space subsystem and component development projects. It is aimed at strengthening the Canadian space industry and making available to Canadian purchasers space products and technology appropriate to their future needs.

The study shows that there continues to exist a strong mandate from Cabinet and a need within industry for this type of support. The program is found to be viable and appropriately structured, both as an instrument of space industry development and to encourage the availability of appropriate technology. The effects of the program are found to be broad ranging, and to include, in varying degrees:

- domestic and foreign sales of resultant products and technology,
- improvement of the level of technical capability within industry and at DOC, and development of new product lines in certain companies,
- increased employment and an improved balance of trade,
- improved credibility of Canadian industry in pursuing international bids on R&D work
- higher Canadian content in Canadian space systems.

Two factors which currently limit the effectiveness of the program are identified. The first is the lack of complementary programs available to the Canadian space industry as a whole and addressing the Research and Development life cycle on either side of the DSSC program, at the advanced research and product development phases. This is a structural problem with the overall Space Program in DOC, and it is not appropriate to undertake major changes in the DSSC program without first improving the framework in which it operates.

The second area is one which can be addressed immediately. The DSSC program has never been planned and managed actively as a program; rather, it has been operated in a reactive fashion, responding to industry and the particular needs of different directorates within DOC. The impact of the program can be strengthened by implementation of an orderly and regular program planning process which takes advantage of planning, marketing, and industrial development skills available within DOC and other departments.

Several other recommendations of a less significant nature but which will contribute to increased effectiveness are also contained in the report.

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I. INTRODUCTION

In October 1983, the Department of Communications contracted with the Bureau of Management Consulting to carry out an evaluation assessment of the program for the Development of Space Subsystems and Components (DSSC). In January 1983, an evaluation study was started to address the questions and issues identified during the evaluation assessment.

The study was undertaken for several reasons. First, program responsibility for DSSC was tranferred in January 1982 from the Direction of Space Applications and Industrial Programs (DGSPA) at DOC headquarters, where it had resided since its inception, to the Communications Research Centre under the Director General, Space Technology and Applications (DGSTA). This transfer took place as part of a reorganization of Space Sector activities. The ADM(Space Program) originated the request for an evaluation in January 1982 to help clarify and resolve several points of discussion about the objectives, direction and operation of the program.

Also, the DSSC program has funding approval currently valid only to the end of FY 1983/84. Originally conceived as a six-year program (starting in FY 1976/77), it had been extended once and appears to be successful and useful enough to warrant continuation. An evaluation study would provide an objective means of supporting or refuting this assumption.

Finally, it was envisioned that this study might provide some insight and possibly a starting point for proceeding with evaluation of other elements of the space program.

At the time of preparation of this report, it was apparent that a restructuring of the space sector organization was likely in the near future. No information on the nature of this reorganization was available to the study team, and it has not been accounted for in this report. However, the findings and recommendations herein are largely program based and would find application irrespective of the organizational structure in which the program operates. Planned organizational changes are therefore not expected to compromise the usefulness of the study.

Throughout this report we employ several commonly used non-technical abbreviations. These include:

- CRC Communication's Research Centre (Shirley's Bay)
- DOC Department of Communications
- DSSC Development of Space Subsystems and Components program
- SSC Supply and Services Canada
- TB Treasury Board
- UP Unsolicited Proposal

Other abbreviations are explained in context, non-technical terms in the body of the report and technical terms in the project summary and case study annexes.

The main body of this report contains a description of the program, an overview of how the evaluation was carried out and a chapter of detailed findings and recommendations as they relate to the questions/issues identified in the evaluation assessment.

The annexes contain detailed and summary descriptions from several points of view of the projects thus far undertaken under the program, and detailed write-ups of the case studies.

II SUMMARY OF FINDINGS AND RECOMMENDATIONS

The purpose of this chapter is to provide a summary of the findings and recommendations which are discussed in detail later in this report.

As a result of the investigation carried out during this project, it was found that:

1. The program retains a strong mandate derived from the 1974 Cabinet Policy on Space and reinforced regularly in policy since then.

2. The space industry still needs assistance, since the companies are not large enough, nor are the markets for space subsystems and components strong and regular enough, to fully support the level of R&D in industry required to maintain technological currency and a competitive position.

3. The DSSC program does not overlap with other programs within or outside the department; in fact, DSSC would be made more effective through development of a framework of complementary programs.

4. The boundaries of the DSSC program have legitimately had some flexibility owing to the variety of participants, types of projects and the absence of complementary programs.

5. The DSSC program has resulted in significant Canadian and offshore sales of space subsystems, components and services, as well as sales of spinoff technologies, with attendant benefits in terms of employment and balance of payments.

6. The program has resulted in substantially improved expertise in industry and DOC in the specific technological areas covered by DSSC projects, and in some related areas.

7. Some firms would have undertaken projects related to those funded by DSSC even in the absence of the program, but at a cost in terms of timeliness and relevance to DOC mission needs.

8. The program has provided some companies with the technology base to develop new product lines and/or to move away from an R&D stance to more of a manufacturing base.

9. The greatest substantive returns in terms of sales have been from companies with a strong manufacturing capability and an aggressive marketing stance in relation to the project technology.

10. The structure of the Canadian space industry has not been substantially affected by the DSSC program.

11. Project objectives have been generally consistent with program objectives.

12. There has been a high level of success in achieving technical objectives of individual projects.

13. The DSSC program has achieved a reasonable level of industrial development, especially when the broader objectives of DSSC are taken into account.

14. The Canadian content in Canadian satellite systems has risen as a result of the DSSC program.

15. The DSSC program has been operated in a reactive fashion, taking its direction from industry and individual directorates without benefitting from a central program planning process.

16. "Appropriate" funding levels cannot be determined for the program in isolation from a framework of other complementary programs which would address on an industry wide basis the advanced re- search and product development phases of the R&D cycle.

17. Joint ventures with other government departments and the private sector, and use of the SSC Unsolicited Proposal Fund have given effective leverage on DSSC funds.

18. Industry finds the DSSC program to be convenient and timely but considers current policy on rights in intellectual property to be an impediment to use of the program.

19. There has been no formal process for planning of the DSSC program at the program level.

20. There have been no standards for management, documentation or administration of DSSC projects except those normally demanded by the contracting process.

Analysis of the above findings led to formulation of the recommendations that:

1. The statements of objectives and scope of the DSSC program not be changed in the short term.

2. Projects supporting development of the infrastructure of the Canadian space industry be specifically excluded from eligibility within DSSC, but that another means of support be found.

3. DSSC contracts be awarded to firms with the verifiable capability of producing the target product or technology on a commercial scale.

4. DSSC funding be focussed on development of new technologies rather than further development of technologies within an existing market.

5. The availability and specifics of the DSSC program be more widely publicized within the space industry.

6. Relevance to Canadian requirements be formally recognized as the primary concern of the DSSC program, and the equality of technological development and industrial development objectives emphasized.

7. The list and relative weights of criteria for choice of projects be reviewed annually, before project proposals are solicited, updated to reflect current management views, and the revised lists communicated to project sponsors and members of the selection committee.

8. The list of criteria for evaluating proposals for DSSC funding be limited to factors relating directly to compliance with stated program objectives and the ability of firms to perform the required work.

9. Formal provision be made for participation in the project selection process by persons or organizations with expertise in evaluating the capabilities of firms in the space industry from a business and manufacturing viewpoint.

10. Formal provision be made for participation in the project selection process by representatives of space sector planning (DGSCP).

11. Strategic directions developed in the DSSC program planning process be communicated to selection committee members and to firms invited to or likely to make proposals for funding under the program.

12. Current funding levels for the DSSC program be maintained with appropriate allowances for inflation until such time as the overall space program is adjusted to provide a more balanced distribution of R&D funds, or the scope of the DSSC program is changed.

13. Providing DSSC program (and other funding program) objectives are satisfied, joint funding arrangements and the SSC Unsolicited Proposal Fund continue to be used where possible.

14. Proposals for funding of terrestrial and space activities continue to be considered within the same program framework, but some appropriate mechanism be established to take into account the different characteristics and requirements of R&D in each area of technology.

15. Companies be encouraged in all cases to participate directly in project funding or to arrange other non-government participation.

16. A maximum of 100% of costs be paid for each project, with no profit.

17. Rights in intellectual property be vested in the company in cases where the company makes a significant contribution to the cost of the project.

18. Limits be placed on the total funding available to any given project over its entire life, and to a single company over one fiscal year.

19. The DSSC program be funded for a further period of five years and an evaluation of program impacts and effects carried out after four years.

20. DOC retain responsibility for management and operation of the DSSC program.

21. A formal program planning mechanism be instituted to provide direction for proposals and the annual project selection process.

22. The DSSC project selection committee meet at least once during the fiscal year to consider changes in direction, progress of approved projects and allocation of available funds.

23. A mechanism be established for following up DSSC projects to ensure the products or technology developed are being used to best advantage within government.

24. A set of standards for project management within DSSC be developed and implemented without delay.

25. A project manager be specifically appointed to manage each DSSC project.

III DESCRIPTIVE OVERVIEW

The purpose of this chapter is to set the factual stage for the following discussions and observations. The DSSC program is described in detail, along with the environment in which it operates and the industrial sector at which it is aimed.

THE PROGRAM

Legal Mandate and Funding History

In 1974, Cabinet Document 230-74 covering "A Canadian Policy for Space" was submitted by the Minister of State for Science and Technology. The policy was developed in recognition of the fact that Canada would become a greater user of space systems to achieve national goals and was aimed at rationalizing and clarifying an overall approach to space activities.

In the policy, it was recognized that in order "to make effective use of space applications systems to achieve national objectives, Canada requires:

a. Appropriate knowledge of space science and technology;

b. Ability to acquire and operate effective and economic space systems; and,

c. Ability to have space hardware launched and positioned into orbit."

In order to develop the appropriate knowledge, it was noted that departments and agencies should initiate research programs commensurate with their individual needs "to understand the properties of space, the potentialities of space systems, and the search for potential applications".

As regards the acquisition of space system hardware, the strategy recognized that Canada required technological programs to develop the necessary industrial capability. These programs would build on previous government-space industry initiatives, by:

> "moving government space research and development activities into industry in accordance with the Make or Buy policy, and by an enlightened policy of purchasing Canada's space research, development and production systems from Canadian industry supplemented by technological programs relevant and necessary to develop the industrial capability essential for future operational space systems."

Specifically, these programs would be "designed to develop advanced technology relevant to actual needs".

The strategy recommended in the Cabinet document, and subsequently approved, called for the development of such programs as the central thrust of Canadian space activities, and for the use of foreign launch vehicles and services to place Canadian satellites in orbit.

Guidance to the space program as a whole, and specific direction to the Minister of Communications were provided in the Cabinet Document through endorsement of the following policies:

1. "...Canada's ability to use space shall be furthered by the support of...technology programs to develop the industrial capability essential to meeting future requirements for operational space systems."

2. "...a Canadian industrial capability to design and build space systems to meet Canadian needs is to be maintained and improved..."

3. "...the necessary Canadian industrial capability be maintained by moving government space research and development activities into industry in accordance with the Make or Buy policy, and by purchasing policies which encourage the establishment of research, development and manufacturing capabilities leading to international trade and economic benefit to Canada."

4. "...the Minister of Communications...(is to) bring forward suitable plans and procedures to provide that, to the optimum extent, Canada's satellite systems are designed, developed and constructed in industry:...

   b. under procurement policies and procedures which will progressively increase the utilization of Canadian sources; and,

   c. with an increasing proportion of space qualified components from Canadian sources."

Based on this direction, the Department of Communications made a submission to Treasury Board (TB 740025) in November 1975 for funding of a program for "Development of Space Subsystems and Components". This program was intended to "increase the Canadian content of satellite systems by increasing the level of contracting in industry by the Department of Communications for the design and development of selected subsystems and components".

The program was approved to start in FY 1976/77 and continue to FY 1981/82. A condition was put on this approval, however: that "continuation of the program beyond the initial three years will be contingent on a satisfactory evaluation at that time". Criteria for this evaluation were to be included in the 1977/78 program forecast. This requirement was complied with by DOC, the evaluation taking the form of an aggregation of comments by industry users of the DSSC which were submitted in response to a questionnaire.

Treasury Board was apparently not satisfied that the industrial benefits thus identified had been sufficiently large or convincingly justified to warrant continued funding of the program at planned levels. In 1978, Treasury Board notified DOC that the originally planned $1 million increment from FY 1978/79 ($2.0 million planned expenditure) to FY 1979/80 ($3.0 million planned expenditure) was not included in the proposed 1979/80 budget and would be subject to a separate TB Submission for possible adjustment at Main Estimates. The required Submission (TB 760864, November 30, 1978) was made by DOC, supported by its review of the program to date. Approval was given for continuation of the program, but at the $2.0 million level, without the proposed increase.

As a result of Cabinet Decision 59-81RD (April 2, 1981), additional funds were allotted from the Economic Development Policy Reserve to the Canadian Space Program: Five-Year Plan (81/82-85/86). These funds included a supplement for the DSSC Program for FY 1981/82 and extended the program to FY 1983/84. Treasury Board approval of the increases was given in July, 1981 (TB 778298).

The most recent Cabinet Decision on "Strategic Options for the Canadian Space Program" (463-81RD) provided for slightly reduced funding in 1982/83 and 1983/84 to partially compensate for increased spending on other space programs.

Table 1 provides a historical summary of the Cabinet and Treasury Board decisions affecting the DSSC, and Table 2 gives a summary of program funding.

Program Resources

The DSSC program falls within the Communication/Information Technology (Space) element of the Communications Program. The funding allotted to the DSSC is shown in Table 2 and has been discussed previously. It should be noted, however, that no person year (PY) resources have been assigned specifically to this program for program or project management, or for technical advice to the projects. This support is provided mainly from the "A" base resources within CRC at the present time.

The figures shown can be compared to an overall budget for the Space Applications Activity of $63,781,000 (1983/84 estimates).

Projects are sometimes supported by SSC bridge funds, other departments, and/or by contractor investment in addition to funding provided under DSSC.

Program Objective and Scope

The DSSC program's objective was stated in the original Treasury Board Submission and again in the 1978 Submission as follows:

> "To promote a strong and independent Canadian capability for the design, development and manufacture of future satellites for Canadian requirements as well as for export to other countries, through contracting out for advanced development work in the anticipation of procurement of hardware".

Table 1. History of DSSC

1974:	Cabinet, as a result of document 230-74, directs the Minister of Communications, in consultation with other Ministers, "to bring forward suitable plans and procedures to provide that, to the optimum extent, Canada's satellite systems are designed, developed and constructed in industry...with an increasing proportion of space qualified components from Canadian sources".
November 1975:	TB Submission (TB 740025) proposing a six year space industry support program.
December 1975:	Program approved.
April 1976:	Program initiated.
September 1976:	Mid-life evaluation criteria included in DOC 1977/78 program forecast.
June 1978:	Letter from TB to DOC asking for separate TB Submission to cover originally planned $1 million increment for FY 1979/80.
November 1978:	TB Submission (TB 760864) proposing approval of originally planned $1 million increment. Submission accompanied by DOC mid-life evaluation report. Program approved to continue, but without planned increment.
April 1981:	Cabinet Decision 59-81RD allots additional funds to Space Program.
July 1981:	TB Submission (TB 778298) approved to increase 1981/82 DSSC funding and extend the program to 1983/84.
1981:	Cabinet Decision 463-81RD provides for slightly reduced funding in 1982-/83 and 1983/84.
January 1982:	Program management responsibility transferred from Director of Space Applications and Industrial Programs (DGSPA) at DOC headquarters to Director General, Space Technology and Applications at CRC.
December 1982:	Program guidelines published by DGSTA

DOC Vote 1	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
TB 740025	0.5	1.0	2.0	3.0	3.0	3.0	-	-	-	-	-
Amendments per 1979/80 1980,81, 1981/82 Program Forecasts:	-	-	-	2.0	2.0	2.15	-	-	-	-	-
Supplement/Extension per TB 778298:	-	-	-	-	-	1.02	3.27	3.64	-	-	-
Reduction per Cab. Doc. 463-81RD:	-	-	-	-	-	-	(0.5)	(0.8)	-	-	-
Present approved level:	0.5	1.0	2.0	2.0	2.0	3.17	2.77	2.84	-	-	-
Proposed in 1983/84 Operational Plan:	-	-	-	-	-	-	-	-	3.0	3.0	3.0
Actual expenditures to date:	0.41	0.46	1.47	1.84	1.78	2.49	-	-	-	-	-

Table 2. DSSC Resources

This was stated slightly differently in the 1981 TB Submission (TB 778298):

> "To promote a strong, independent Canadian capability for the design, development and manufacture of satellite systems, equipment, and components for Canadian requirements, as well as for export to other countries, through contracting for advanced development work in anticipation of procurement of hardware".

The change made it clear that the program was not aimed just at space qualified subsystems and components, but also at those comprising the terrestrial portions of space systems. This was consistent with the definition of space activities provided in the original Cabinet Decision (230-74) which served as the direction for the creation of the DSSC program:

> "space activities are defined to include the use of satellites for research and operational purposes,...and the earth based facilities needed to support these activities".

A similar but potentially more controversial evolution has taken place in the statements of scope supplied in the 1975, 1978 and 1981 TB submissions.

In 1975, the scope of the program was defined to cover:

> "contracts to industry to design and develop specific components and subsystems which have a high probability of being required in future Canadian satellite systems, and which are required by DOC to fulfill its mission. A major objective of the program will be to maximize the Canadian content in future Canadian satellite systems."

These two sentences were restated virtually exactly in the 1978 submission, except that the underlined phrase was added:

> "... in future Canadian Satellite systems, and to increase competitiveness of the Canadian space industry in domestic and export markets."

In the 1981 submission, the introduction of offshore considerations into the statement of scope was made complete:

> "This program will continue to support contracts to Canadian industry for the purpose of developing specific space subsystems and components which have a high probability of being required in future Canadian and foreign satellite systems, and which are required by DOC to fulfil its mission."

This evolution may have its origins in the assumption that an industry which is competitive internationally will be in a better position to satisfy national requirements. While this is reasonable, the original policy foundations of the program clearly point it squarely at Canadian satellite systems, making this the primary consideration. The question of interpretation of program objectives and scope is covered in Chapter V of this report.

Organization

Until January 1982, DSSC program management responsibility was assigned to the Director of Space Industry Development (DSA), under the Director General, Space Programs and Industrial Development (DGSPA). The DSA role consists primarily of management of industrial development and support programs within the space sector. Coordination of the DSSC was carried out by a Special Projects Officer who reported directly to DSA. Because of their specialized technical nature, a Scientific Authority responsible for monitoring technical aspects was assigned to each project. The Scientific Authorities were drawn almost exclusively from the Director General, Space Technology and Applications (DGSTA) organization at CRC.

In January 1982, responsibility for management of the DSSC program was transferred to DGSTA, whose focus is on technical research and development related to DOC space sector activities. The individuals assigned to the Scientific Authority roles are also relied on to be project managers for most projects. The Coordinator, Space Technology Development (reporting to DGSTA) acts in a program level coordination role.

Program Description

The DSSC program consists entirely of contracts to the Canadian space industry. From its start in 1976 to the end of FY 1982/83, the program has awarded 101 contracts to 29 companies.

The projects which have been funded show a range of characteristics with respect to:

- deliverables (from technology studies to specific hardware)
- expected payoff time (several months to several years)
- time to complete (a few months to more than 6 years)
- cost ($4 thousand to several hundred thousand)
- level of sophistication (stamped metal reflectors to complex state of the art electronic components)
- application area (satellite bus or payload to terrestrial subsystems).

In short, the program has addressed itself to a very wide variety of technical problems.

The main families of equipment covered by the program to date include:

- integrated attitude sensing and control systems (IASCS)
- battery management systems
- solar array deployment and power transfer assembly (SADAPTA)
- heat pipes
- power dividers and combining networks
- low cost terminals for TV and two way telephone
- time division multiple access (TDMA) equipment
- L-Band transmitters.

More recent projects reflect newer developments in space technology as funding has been provided for software development and microprocessor based subsystems.

Where DSSC is the only source of funds to a project, full funding is permitted, including a profit component. DSSC funds are also used to carry the DOC share of eligible jointly funded projects to which industry, other line departments, or more commonly, the Department of Supply and Services' Unsolicited Proposal (UP) Fund also contributed.

Delivery System

The projects funded under the DSSC can theoretically originate with any organization, but in practise have come from industry in the form of unsolicited proposals or from within DOC (mainly from CRC). For FY 1983/84, a number of organizations within DOC were invited to submit proposals for consideration.

Shortly before the start of the fiscal year, a list of proposed projects was prepared and circulated to members of a DSSC selection committee. The use of a selection committee as the mechanism for reviewing and discussing proposals for funding has been consistent through the life of the program. In the past, the selection committee has had varying membership, sometimes including representatives from DOC planning and IT&C in addition to DSA and DGSTA. The 1983 selection committee was comprised of representatives from CRC (DGSTA) and Space Planning (DGSCP). No DSA (Space Industry Development) representative was present, although they were invited to participate.

The project proposals were presented, discussed and given a weighted scoring against a list of established criteria. These criteria have been derived by the program managers from the program's objectives. The project proposals were then ranked according to score and submitted for consideration by DGSTA. A final list was prepared, taking into account the available budgetted resources and considering existing carryover commitments.

Contracting with industry is carried out through the normal DSS procurement mechanisms, using directed contracts or the competitive process, as appropriate.

Depending on the progress of approved projects over the course of the year, other projects may be added if funding is becoming available. These additional projects have been identified on an ad hoc basis and have not always been subjected to the process of formal proposal, discussion and committee evaluation.

Changes in scope or direction of approved projects are raised through the assigned Scientific Authorities and approved by the responsible Directors. The Scientific Authority has been the prime point of contact between DOC and the company during the execution of the contract.

RELATIONSHIP TO OTHER PROGRAMS

There are several programs in DOC and other departments which address similar, but not identical, concerns to DSSC. Some complement DSSC activities, and others help define the limits of the DSSC program. These associated programs are described below.

Other DOC Programs:

1. "A" Base R&D Activities:

   Limited funding is provided within the CRC base budget for research and development projects related to in-house work. These projects are generally small, support a particular research direction, and do not necessarily have an industrial development component. For the most part, they also cover the types of activities which fall early in the research and development cycle.

   Full profit is paid on these contracts.

2. DGSPA Administered Programs:

   a. Accelerated Research and Development (ARAD): The objective of this program is to support the development of SPAR Aerospace as the prime contractor for satellites in Canada. In theory, this does not restrict other companies from receiving funds (providing the project supports the program objective), but in practise only SPAR has benefitted from the program. This will probably continue to be the case in the foreseeable future.

      The program consists of grants, contributions to and contracting for communications satellite payload subsystem R&D projects which are likely to meet SPAR's near term needs (i.e., less than 5 years). In instances where earth station design is considered to influence significantly communications satellite payload design, related development may also be supported.

      The majority of projects are proposed by industry and accepted by government as projects that the industry would fund themselves if sufficient company discretionary funds were available.

Companies may contribute to the cost of projects in which cases profit will not be paid. In cases where contracts are awarded to satisfy government requirements, profit may be paid.

b. Subsystem Development Program (SSD): The objective of this program is to support exclusively the development and enhanced competitiveness of the satellite and satellite payload subsystem manufacturing capability of the Ste-Anne-de-Bellevue plant of SPAR Aerospace.

This is achieved by grants, contributions to or contracting with SPAR for satellite and satellite payload subsystem development projects related to both domestic and export markets. Projects are agreed on after joint discussion between SPAR and the government, represented by DOC and MOSST.

The company may contribute to the cost of projects, in which case profit will not be paid. In cases where contracts are awarded to satisfy government requirements, profit may be paid.

It should be noted that both the SSD and ARAD programs can provide sources of further funding to initiatives started within the DSSC program.

c. International Bid Support: As the name implies, funds are available to the space industry at large through this program to support international bids on space projects. It is not primarily an R&D program (although related activities may be carried out using the funds), and it does not consider the DOC space mission (other than general space industry development aspects).

3. Specific Mission Programs (e.g., MSAT):

These programs are individually evolved and approved in pursuit of a particular set of objectives. They are large, costly, complex and time consuming. Support to industry is not a primary objective, although the research directions may be aimed at proving technologies which will benefit Canadian manufacturers as well as supporting other goals.

These missions can be considered more as clients of the DSSC program, in that they will be among the prime users of technology developed under DSSC. DSSC program planning takes into account the expected procurement requirements of these missions, as far as they are known.

4. Planned Programs:

At the time of preparation of this report, preliminary discussions have taken place within DOC about the possibility of establishing two additional programs which would affect DSSC. One would complement DSSC by addressing an earlier (and more uncertain) stage in the product/technology development cycle, while the other would specifically support development of earth station technology. While few details on these programs are available, it is clear that they could affect the DSSC program to some extent. This is discussed in Chapter V of this report.

Non-DOC Space Programs

1. NRC Space Activities:

NRC carries out a range of activities in the space sector, from large one-off research and development projects (e.g., CANADARM) to general scientific investigation programs like those administered through the Canada Centre for Space Science. Like the specific mission programs which are managed by DOC, these activities can be regarded as users of the technology or products developed under DSSC. Historically, there has been limited interaction between DSSC and NRC space programs since DSSC specifically supports the communications applications area.

2. Other Government Department Space Programs:

These activities take the form of one-off projects which are designed to satisfy a particular departmental mission objective like remote sensing (EMR/RADARSAT) or search and rescue (DND /SARSAT). Again, these programs are potential users of DSSC developed technology and products. Although there is generally heavy reliance on DOC technical support to such programs, DSSC funding would theoretically be assigned to related projects only when DOC mission objectives coincide with those of the responsible department.

Other Non-DOC Programs

1. EDP--Enterprise Development Program (ITC/DREE):

The objective of EDP is to help the growth of the manufacturing and processing sectors of the Canadian economy by providing assistance to selected firms to make them more viable and internationally competitive. The projects supported are relatively high risk but viable, and promise an attractive rate of return.

Recipient companies fall in the small/medium business category and are required to contribute at least 25% of eligible costs. EDP provides these firms with loan guarantees and grants for product and process design and development, among other things.

EDP is different from DSSC primarily in that its sole purpose is industrial development; there is no other mission support role implied, and projects are initiated by the recipient companies. It is also universal, forcing space sector industries seeking support to compete on an equal footing with companies in other sectors, including low technology firms and (sometimes) the service sector.

2. DIPP--Defence Industry Productivity Program (ITC/DREE):

Like DSSC, the DIP Program is aimed at promoting a viable advanced technology industry in support of a particular sector: in this case, defence. It does this in several ways, of which two relate to DSSC: research and development assistance, and source development assistance.

R&D assistance allows for contributions towards the cost of applied R&D of defence and defence-related products, including components, materials, and development support equipment such as computer aided design (CAD) systems.

Source establishment assistance aims to establish Canadian companies as acceptable suppliers of these products. Funds can be used to develop company facilities and for relevant studies.

Because of the defence market orientation, DIPP offers little conflict with the DSSC program.

3. IRAP--Industrial Research Assistance Program (NRC):

In the past, IRAP primarily provided financial assistance to manufacturing companies for applied research projects by paying part of the wage costs of researchers. The Program has recently been consolidated with the Technical Information Service to form a new six element program providing a range of services from contributions to research and development projects to technical assistance to industry. IRAP attempts to further economic development by increasing the calibre and range of industrial research and development in Canada and fostering the use of available technology.

IRAP is not specific to any industrial sector or government mission. Applicants for IRAP funding must therefore compete for limited resources with firms representing a variety of industrial sectors. As a result, the development of industrial capability within a particular sector like space would be limited.

Since projects are proposed by industry and are evaluated on their scientific merit, there will not necessarily be coincidence between the direction of a given project and the mission of a particular government department.

4. PILP-Program for Industry/Laboratory Projects (NRC):

PILP is designed to "assist Canadian companies to undertake projects that take advantage of technology in the form of scientific and engineering knowledge and resources existing within government laboratories". In short, it aims at transfer of technology to industry so that the technology will be exploited to the economic benefit of Canada.

PILP is a shared cost program which allows participating companies to retain the rights to new intellectual property developed by them during projects, and to license from the Crown any government owned rights.

As with IRAP, there is not necessarily any coincidence between company objectives and any government mission.

5. UP-Unsolicited Proposal Program (SSC):

The UP program was established as an adjunct to the Contracting Out Policy to "permit the government to respond promptly and consistently to sound and unique unsolicited proposals from the private sector in support of government science and technology missions. The aims of the program are to encourage industry to contribute to the accomplishment of government goals and to increase government's appreciation of Canadian industry capabilities" (from the UP information booklet).

Projects do not necessarily have to be research or development oriented, but they must clearly be consistent with a department's objectives. The UP Fund is available to provide bridge funding in cases where the sponsoring department does not have sufficient funds in its current budget to finance the proposed work. The DSSC program has taken advantage of this fund on several occasions.

6. SDF-Source Development Fund (SSC):

The SDF program aims to develop Canadian sources of supply in anticipation of future government purchases, usually about one year in the future. The program considers whether it is possible to develop a Canadian source of supply through incremental funding--in effect, by paying a "buy Canadian" premium. The SDF is used only where ITC or similar programs are unavailable or inappropriate.

Funding opportunities are identified by departments, by industrial firms who wish to supply particular items, or in relation to planned SSC purchases.

The SDF is not used to fund large projects, but is aimed at production type items. Nor is it aimed especially at research and development activities related to particular departmental missions. It is simply a mechanism for taking advantage of substitution possibilities to improve Canadian content in government procurement.

The SDF's relationship with the DSSC program, therefore, would be complementary and most likely to follow DSSC funding. No direct relationship has existed to date.

7. Federal R&D Tax Incentives:

Grants and industrial support programs are one major policy instrument for government support of R&D in industry. Tax incentives are the other. Currently, three tax measures are in place to encourage R&D:

a. an immediate income tax deduction of both current and capital expenditures on R&D in the year in which they are incurred;

b. a 50% additional allowance on current and capital expenditures on R&D in excess of the average of the three previous years;

c. a tax credit at a basic rate of 10% for both current and capital expenditures on R&D.

A discussion paper outlining proposed adjustments in the R&D tax system as part of the budget was published in April, 1983, and asked for comments from industry and other interested parties by the end of June, 1983. The discussion paper proposes two elements of change:

a. The existing provision allowing an additional tax deduction of 50% of increases in R&D expenditures would be replaced by an increase in the tax credit for all R&D expenditures of 10 percentage points.

b. As an aid to R&D financing and to increse accessibility of the incentives, corporations would be allowed to enter into an agreement with outside investors under which it would renounce the benefits of R&D tax deductions and credits it would otherwise be entitled to. Investors would be eligible for a special 50% tax credit in respect of the funds advanced to the R&D performer.

Whatever the specific structure, R&D tax incentives clearly have the simple objective of economic development and are not selective of the sector or mission to which the R&D activities are related. They are complementary to the DSSC program in that they provide additional incentive to industry to undertake a given project.

It is interesting to note that the four principles on which the discussion paper proposals are based can be adopted for use by the DSSC program in examining its relevance to the space industry development objective:

a. the private sector is in the best position to determine the amount and type of industrial R&D that it should undertake;

b. incentives should not be used, or set at a level, to promote R&D activities that do not conform to sound business practice;

c. as much as possible, tax incentives for R&D should be of immediate benefit to firms;

d. tax incentives for R&D should be as simple to understand and comply with and as certain in application as possible.

R&D tax incentives are discussed in Chapter V in relation to the question of funding levels to DSSC.

THE SPACE INDUSTRY

Overview

Some of the firms in the Canadian space industry were examined in detail as part of the case studies. The purpose of this section is to provide an overview of how the Canadian space industry as a whole has evolved in size and capability since the DSSC program was begun in 1976. There is no attempt to attribute all or any part of these changes to the effects of the DSSC program; this relationship will be explored later in this report. At this point, we wish only to set the industrial framework within which the DSSC operates.

For the purposes of this review, the primary Canadian space industry will be considered to be comprised of companies with the capability to both manufacture and perform R&D on space systems, subsystems and components. These include items with either or both terrestrial and flight application.

There are several substantial differences between space and ground sector activities within the space industry. In general, the ground sector activities have the following characteristics in relation to markets, companies and R&D activities:

1. they enjoy wider potential markets,

2. they enjoy more open (and less politicized) competition,

3. products have lower unit costs and large production volumes,

4. markets are somewhat more predictable,

5. firms are smaller and have lower capital requirements and less complex facilities (especially test equipment and assembly areas),

6. firms extend into lower technology areas than space firms (for example, metal stamping for antennas), and activities are often more labour intensive as a result,

7. there are several dozen companies with capabilities in terrestrial applications vs. three with the ability to produce space qualified components,

8. R&D in the ground applications is significantly faster, less complex, less risky and less expensive, and has a faster potential payoff to the company.

The DSSC program, because of its global mandate, must span the full range of these differences.

Table 3 shows the Canadian space-related sales and employment in the private space sector in Canada, with domestic and export sales identified. These figures were supplied by the Interdepartmental Committee on Space (ICS) and noted to be of questionable accuracy, since no historical data were available covering the whole industry either from government sources or through industry associations. The figures have been derived from a 1981 survey of the industry by the ICS, and interpreted from a variety of sources for earlier years. Despite their limitations, however, they do provide a general picture of the growth of the industry over the period in which the DSSC program has been active.

Table 4 shows the split between space and ground segment sales for the years 1981 to 1985, based on the industry responses to the ICS questionnaire.

The launch of CTS/Hermes in 1976 was the culmination of a development and procurement program which realized substantial changes in the capability of the Canadian space industry to design and build communications satellites. Since that time, the structure of the industry has remained relatively stable, evolving gradually as new products developed and new market requirements arose.

The major exception to this was the acquisition in 1977 by SPAR Aerospace of the space products interests of RCA Canada Limited and Northern Telecom Ltd. This consolidation allowed the government to recognize SPAR as the only Canadian firm which was in a position to assume the role of prime contractor for communications satellites, a

Table 3. Canadian Space-Related Sales and Employment in the Private Sector in Canada (Source: Interdepartmental Committee on Space)

YEAR	TOTAL SALES (in $M)	DOMESTIC SALES (in $M)	EXPORT SALES (in $M)	EMPLOYMENT (in PY)
1968	15	9	6	
1969	16	8	8	
1970	21	16	5	
1971	19	14	5	
1972	27	18	1	
1973	26	14	12	
1974	32	19	13	864
1975	30	21	9	
1976	43	36	7	
1977	60*	50*	10*	
1978	111	38	73	1903
1979	138	78	60	2242
1980	120*	60*	60*	
1981	123	54	69	2333
1982**	182	68	114	
1983***	290	86	204	
1984***	327	153	174	
1985***	380	195	185	

* Estimated (reliable data not available for that year)
** Projected
*** Forecast

Table 4. Space Segment vs Ground Segment Sales (Source: Interdepartmental Committee on Space)

YEAR	TOTAL SALES SPACE RELATED	SPACE SEGMENT SALES		GROUND SEGMENT SALES	
	$M	$M	%	$M	%
1981	123	73	59	50	41
1982	182	107	59	75	41
1983	290	166	57	124	43
1984	327	176	54	152	46
1985	380	212	56	169	44

role which continues to be supported financially and from a policy perspective. With the exception of this change, the same companies accounted for the great majority of the space industry's 1982 sales as accounted for most of the 1976 sales. In the interim, some have experienced growth resulting from successful product developments, while others have undergone little change. Examples of each can be found in the case study summaries later in this report.

The capabilities of the primary space industries have also remained stable. In the absence of major developmental efforts (with the possible exception of the technology associated with the CANADARM, which has relatively limited space applications potential), there has been a general concern with maintenance of a competitive level of expertise. The development of new (and profitable) products by some companies is more representative of the exploitation of existing capabilities than changes in industry directions.

Current Trends

There is evidence of two major current trends which will affect the way the space industry is perceived and therefore the way the DSSC program is used. The first concerns the nature of current technological developments, and the second, the way space technology is being and will be used.

As the use of microprocessors in space becomes more attractive and the applications and system architecture become more complex, there will be increasing demands for related skills to be available within the space industry. SPAR and other firms are developing these capabilities, but it is evident also that there is opportunity for companies without specific space backgrounds to develop mission critical and highly visible products (for example, software) for use in space applications. These types of complementary skills are likely to become more important as complexity and size of missions grow, and the boundaries of the space industry are therefore likely to become less clear. It is also evident that the potential for spinoffs of Space technology to applications in other areas is very high for these project.

The use of communications satellite technology is also changing the nature of the industry. The enormous growth to date and forecast for popular use of earth terminals for television reception and two way communications implies a shift in the balance of cost of a given satellite system between space and earth components. Both, it has been recognized earlier, are legitimately considered parts of space systems, but the respective market demands, technological complexity, and development lead times are substantially different. There is evidence that because of the market potential in the area of terrestrial applications, even companies whose major focus under this program has been space subsystems and components (SPAR, Com Dev) are increasing substantially their activities in the earth station market.

These developments are discussed in Chapter V of this report.

THE SPACE R&D ENVIRONMENT - SPECIAL CONSIDERATIONS

A conceptual view of the positioning of the DSSC program within an idealized research and development cycle is shown in figure 1. In the earliest stages of highest risk and most uncertainty, government involvement is highest, reducing as the cycle moves toward commercial exploitation of the product or technology.

The DSSC supports advanced development activities in a high technology area having limited markets. Most of the recipient companies are relatively small, are new, and have limited funds available to undertake R&D on their own. These considerations have a number of implications which are relevant to the observations and findings of this study:

a. Companies cannot afford to undertake all or even a significant part of this type of R&D without strong confidence in potential returns. Similarly, they cannot afford the additional development which is frequently required to carry the product or technology to the production stage.

b. The R&D projects are generally expensive to carry out and are simply beyond the financial capability of many companies, even where there is good potential for returns.

c. There is often a significant time lag between research and returns from sales of resulting products or technology. Again, most companies cannot afford to underwrite this waiting period.

d. There is some risk of technical failure in each project.

e. There is some risk that the product or technology will be obsolete before it is developed.

f. Market forecasts for products or technology are at best highly uncertain, particularly in the space segment (as the president of one highly successful company put it, development decisions are not even risky - they are "a gamble", implying that it is even impossible to reasonably assess a level of risk).

g. Specialist expertise is required for technical contract and project management (both in industry and in government).

h. Hi tech R&D projects are less predictable and controllable than those in other environments.

It must also be noted and strongly emphasized that because of the rate of change of technology in this environment, it is essential for industry to maintain continuous contact with the specific technologies in order to remain competitive and even competent.

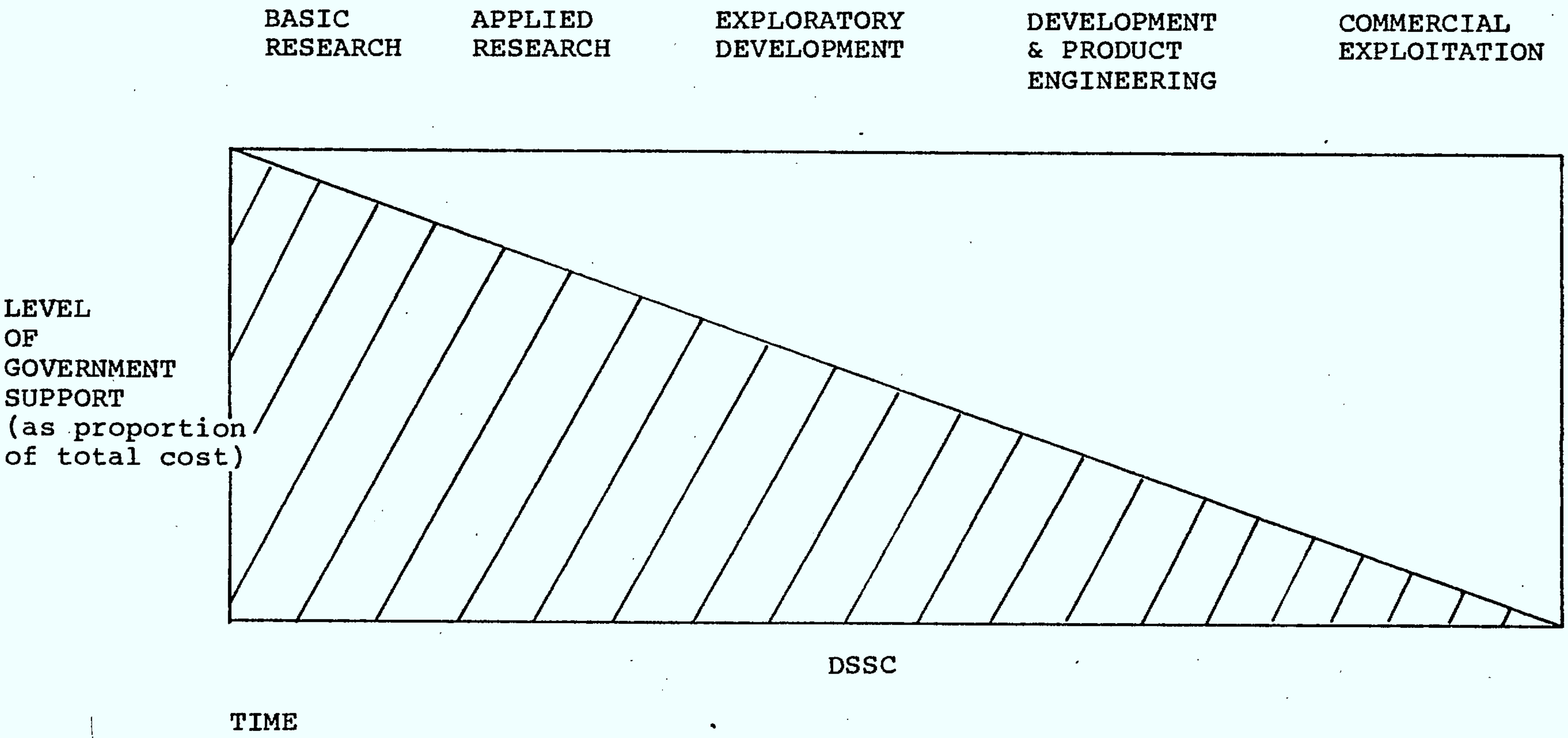


Fig. 1 Idealized Research and Development Cycle

In view of these considerations, it is evident that even after seven years of operation of the program an assessment of its benefits in terms of finished product or technology sales will be incomplete and potentially misleading. Some early projects are just now beginning to bring benefits to the companies, and the full extent of their potential is impossible to estimate. Hence, it is inappropriate to judge the value of the DSSC program solely on the basis of sales. Other effects will be identified in the later sections on impacts and effects of the program.

IV THE EVALUATION

The purpose of this chapter is to describe how the evaluation was carried out and why this approach was chosen.

METHODOLOGY AND APPROACH

The DSSC program evaluation was carried out within the framework defined by the Office of the Comptroller General. Several possibilities exist within this framework for collection and analysis of information, from controlled experimental design to examination of reported past results.

There are notes elsewhere in this report which describe the limited size of the program and the wide variations in characteristics of both companies and projects. In view of these differences, it would be impossible to develop an acceptable statistical base for analysis of the program's quantifiable characteristics.

A two-part approach was identified as the best alternative for collecting project based information in these circumstances. General information would be collected by means of questionnaires on all projects, covering costs, performance and effects on the participating companies. These data would be supplemented by detailed case studies representing as broad as possible a cross-section of firms and projects. The case studies would have three data collection components: review of available file information at DOC headquarters and CRC, interviews of the designated Scientific Authorities and of company representatives (at the company premises), and questionnaires to be completed by the Scientific Authorities and by the companies.

In addition, program files retained by the current and previous program coordinators as well as those held in DOC headquarters and CRC archives would be reviewed in detail. Further program level information would be gathered through a series of interviews with DOC and industry representatives.

DATA COLLECTION AND ANALYSIS

All the Scientific Authorities or responsible Directors at DOC were asked to complete one of two questionnaires on each project, depending on whether or not that project would be examined as a case study. The case study questionnaires asked for more detailed information on project performance and impacts.

Questionnaires were also sent to twenty-four of the participating firms, including separate copies to SPAR Montreal and SPAR Toronto. The other six firms were omitted from the mailing list for one of the following reasons:

a. the company was bankrupt (Digital Devices)

b. the company's first funding from DSSC was in FY 82/83, too recent to have had any impacts which could be objectively examined (ANTECH, Opto Electronics), or

c. the projects were very small, unique and gave no evidence of having affected the companies involved (Leigh, Lindsay, Parker).

Copies of each of the three questionnaires are included in Annex D to this report.

Of the twenty-four firms contacted, sixteen returned questionnaires covering eighty four projects. These projects accounted for 90.3% of total DSSC expenditures, or $10,700,000.00. Table 5 provides a summary of the industry questionnaire response statistics.

Ten major case studies were also identified, covering seven firms and some thirty-eight separate projects. The case study projects represented some $5,218.000 or 44.0% of total program expenditures. This information is also shown in table 5.

The case studies were selected to provide as wide a range of project and company characteristics as could reasonably be accounted for within the limits of the study. The firms range from SPAR, the industry leader (1982 revenue $178M, 2,000 employees) to Com Dev Ltd. (1982 revenue $9.4M, 160 employees).

Successful and unsuccessful projects are included, covering several of the technologies addressed by the program. The list of case study projects was derived from discussions with technical and DOC headquarters staff following an initial survey of the program.

Following a detailed review of information available at DOC, a site visit was made to each of the six main companies participating in the case study projects (the seventh was, in essence, a subcontractor for another firm), including:

a. SPAR (Montreal)
b. SPAR (Toronto)
c. Com Dev Ltd. (Cambridge)
d. Miller Communications Systems (Ottawa)
e. Canadian Astronautics Ltd. (Ottawa)
f. Canadian Chromalox Ltd. (Toronto)
g. SED Systems Ltd. (Saskatoon)

During these visits, questionnaire responses were reviewed and detailed interviews carried out with technical and managerial personnel. The Scientific Authority or responsible director in each case was also interviewed. The case study summary writeups are contained in Annex C to this report.

Table 5. Industry Questionnaire and Case Study Statistics

	Total Program	Questionnaires Distributed	Questionnaires Returned	Case Studies
No. of firms *	30*	24	16	7
No. of Projects	102	96	84	38
Total Funding	$11,858,000	$11,680,670	$10,708,270	$5,218,060
Funding as % of total program	100%	98.5%	90.3%	44.0%

*counts SPAR (Toronto) and SPAR (Montreal) separately

Historical and policy-related information was collected through a comprehensive review of documentation available within DOC and elsewhere, and by means of a lengthy series of interviews. The interviews covered over fifty managers in twenty different companies, agencies and departments and touched on subjects from economic development issues to technical and administrative concerns. A list of people interviewed is included as Annex E to this report.

Most of the quantitative analysis and record-keeping in support of this project was carried out using Visicalc on an Apple II Plus microcomputer.

LIMITATIONS ON DATA AND FINDINGS

A number of problems were encountered which impose limits on the amount and usefulness of data collected during this study.

Within DOC, the difficulties can be traced mainly to the historic lack of a central record keeping system. This factor and the absence of standards for maintenance of detailed project files made it a rare occurance for a complete set of documentation to be available for any given project. This limited the ability of the evaluators to fully determine the rationale and justification for projects and to understand problems encountered during the course of the projects. This type of information had to be collected largely by means of interviews, thus introducing perceptual biases depending on the source of the information.

The records which were available (including financial data) also often differed from one source to the next. Further, the older the project (and the more long term information available on impacts and effects), the poorer was the quality of historical information available. Most financial records had been archived and retrieval of this data from the central financial records on a project basis would have demanded a prohibitive amount of effort on the part of administration staff and the evaluation team. The evaluation team therefore relied on facts from the program coordinators' files, the company records and the Space Program Level I and Level II Management Reports to establish project financial records. This information was cross checked whereever possible with independent sources.

Similar problems were encountered in the companies contacted. Most firms were either unable to supply the requested data on sales resulting from each DSSC project or heavily qualified the information submitted. In many cases, funds were made available to the project from several sources, creating problems in attributing effects. In other instances, the company's perception of the project was different than that of DOC. This is especially true where an actual marketable product was produced. The companies recorded their (and other) funding contributions in relation to the entire development project, from research to production planning, and not in relation to the research and development cycle segment specifically addressed by the DSSC program.

Further complications are added by the inevitable unevenness between companies in their administrative and financial systems. The level of detail and degree of confidence in estimates of past sales, for example, was highly variable across the spectrum of companies contacted.

Forecasts of future sales are even more unreliable. The companies once again vary widely in degree of sophistication in their market forecasting and prediction approaches. The technology and markets change so quickly in any case, that forecasting is risky at best, an observation borne out by the large differences in sales figures predicted by the same firms in their responses to DOC's 1978 and 1979 forecasts. The comment of an industry spokesman about R&D in the space sector being more of a gamble than a risk has also been mentioned.

As with any evaluation study, the problem of determining incrementality (that the impacts and effects measured took place because of the program and not because of some other set of conditions or factors) is significant in this case. It has been noted that many projects enjoyed joint funding. Similarly, many of the companies involved were receiving money from other programs to assist with research on product development, areas not covered by the DSSC but obviously critical to the successful introduction of the subject product or technology to the marketplace. In most cases, company representatives were understandably reluctant to hypothesize about whether their firms would have undertaken the project in the absence of government funding. In at least two instances, however, the companies were clear that they would have proceeded without assistance from DSSC. They did indicate that compromises would have been necessary in scope, speed, or in other R&D projects to permit the work to be performed, and that the marketability of the resulting product or its relevance to DOC's requirements might therefore have been compromised. The latter point is a particular concern, since the program aims to develop appropriate technology as well as industry capability.

V. ANALYSIS, FINDINGS AND RECOMMENDATIONS

This section includes observations, analysis, findings received on the program as a whole. The chapter has two parts: a general analysis based mainly on quantifiable observations and information; and, interpretive analyses of the evaluation questions and other issues which became prominent during the course of the study. The latter section is organized by issue area and question as identified in the evaluation assessment study, with an added discussion on program objectives and scope.

Comments on individual projects are recorded in the Annex to this report as part of the project fact sheets or case study writings.

GENERAL FINDINGS AND ANALYSIS

Perceptions of the Program

It is of interest to review briefly the apparent perceptions of the program which are held by its various participants and users.

1. DOC Program Users: The views held by different DOC managers and their staffs are consistent in that the DSSC program is generally regarded as an extremely important means of extending their own activities in specific directions. This implies nothing incompatible with the basic objectives of the program, since these directions must be accounted for in the choice of projects for funding; rather, it is a recognition that the program has significant value within DOC in addition to its nominal industry and DOC mission objectives.

   There are, however, significant variations in other ways. In particular, the Space Electronics (DSE) and Space Mechanics (DSM) directorates at CRC both are more research oriented than the Space Communications (DSL) or Space Systems (DSS) directorates. DSS takes a system view of space activities, often in terms of specific programs. DSL's orientation, on the other hand, is user based, while the Director of Space Industry Development (DSA) at DOC headquarters focuses on industrial development concerns. This diversity of role produces a corresponding variety in the way the program is interpreted and used, and can result in considerable variation in the characteristics of the projects which comprise the DSSC.

   Again, this does not imply that one set of projects is more appropriately funded than another, since the selection process is intended to ensure that all projects fall within the guidelines for the program as a whole. It does, however, occassionally give rise to some differences in opinion over the validity of funding certain projects.

2. Industry: The industrial users of the DSSC program appear to find certain advantages in the way the program is operated, but do not have any particular concerns about the source of their funding. As might be expected, they do not aim to satisfy specific DSSC criteria. Instead, they will either submit unsolicited proposals (and simply allow the supporting DOC organization to locate the necessary funds), or respond to RFP's based on the attractiveness of each project from a business point of view.

   There were, however, several positive comments from industrial representatives on the relative ease of use of DSSC from the point of view of paperwork requirements, on the good relationships enjoyed between industry and CRC project teams, and on the fact that DSSC makes available full funding to most projects.

Funding Analysis: The distrubution of funding by company is shown in figure 2. The available DSSC funds have been divided in a way generally consistent with the relative sizes of the companies, with the exception of Miller Communications. This firm has received a relatively high level of support, mainly for the Slim Route TDMA project.

The total value of funding provided by the DSSC program for 101 contracts let between 1976 and 1983 is $11,855,660. The total value of these projects is considerably higher, however, since 38 of the projects were also funded by SSC through the Unsolicited Proposals Fund, by the companies themselves, and/or from other sources (RCA, Teleglobe, National Defense, etc.). Table 6 shows the number of projects which obtained funding outside DSSC, and figure 3 shows the level of funding from these sources as a proportion of overall project value. A detailed table of project funding by company is contained in Annex B to this report.

Source of Additional Funds	No of Projects
SSC only	13
Company only	15
"Other" only	1
SSC and Company	4
SSC and Other	2
Company and Other	3
	38

Table 6: DSSC Projects Also Funded From Other Sources

The proportions shown in figure 3 are significantly affected by the inclusion of SPAR project 780 (TDMA/DSI). This is by far the largest single project funded by DSSC ($1.5 million), and the DSSC contribution represents only one quarter of overall project value. A more representative distribution of funding sources for the large majority of projects is shown in figure 4, which excludes the SPAR TDMA/DSI project.

Fig. 2 Distribution of DSSC Funds by Company

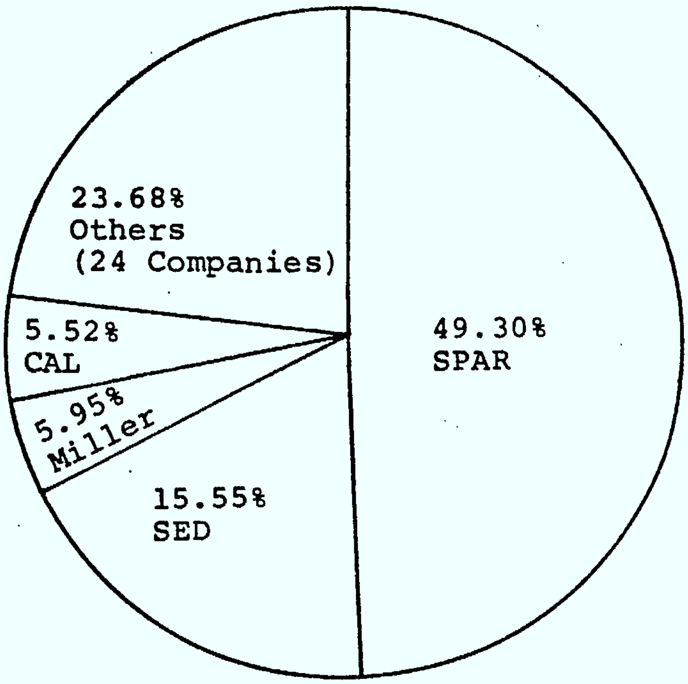
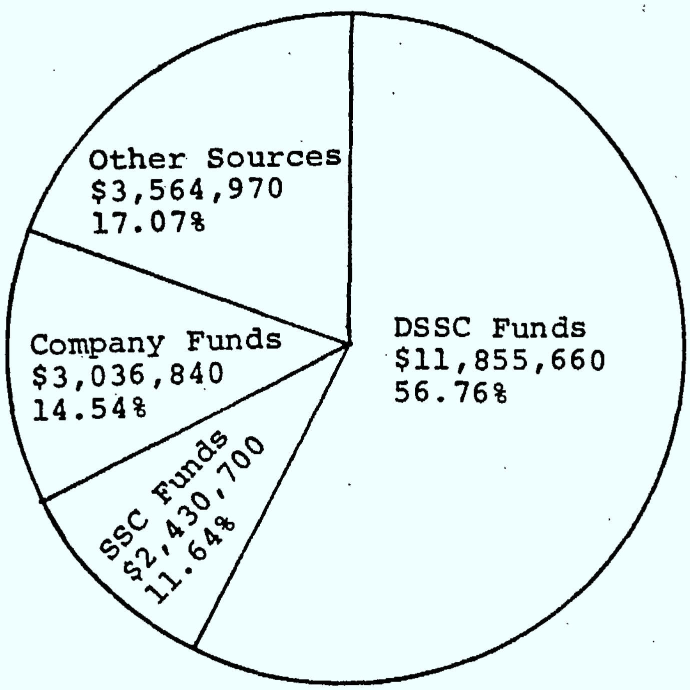
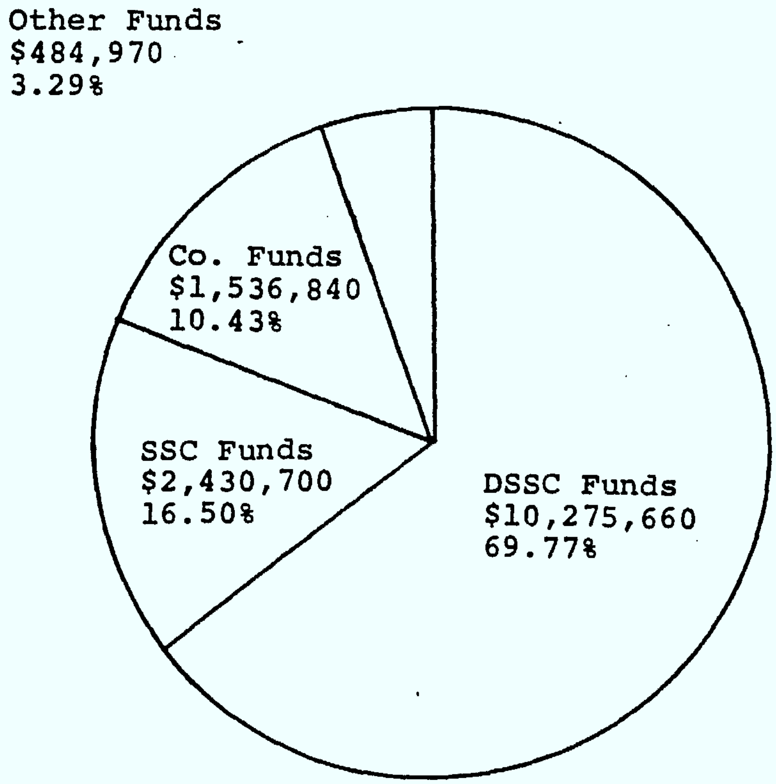


Fig. 3 Level of Project Funding by Source (including project #780)



Total Value of DSSC Supported Projects
= $20,888,170

Fig. 4 Level of Project Funding by Source (excluding project #780)



Total Value of Projects (excluding #780)
= $14,728,170

When project 780 is eliminated from the figures, the level of non-DSSC support shows some limited leverage of DOC's funds in achieving its objectives. The specific sources of additional funding are irrelevant to this observation, since DOC's only criteria for supporting a project are related to that department's mission and the program's objectives and goals.

It is interesting to note that company contributions were negotiated in only 5 of the 25 cases where the company also supported the project. The willingness on the part of the firms to put in their own money in the remaining 20 instances reflects one or both of two factors: a recognition of the value of the project to the company; or, an unwillingness to jeopardize future contracting opportunities by requesting support of overruns.

Table 7 shows the total number and total average values of DSSC projects undertaken each year from 1976/77 to 1982/83. Increases in the average values of projects can be accounted for by inflation over this period.

Figure 5 demonstrates how DSSC funds have been split between earth and space applications projects. The division of funds has been relatively even between the two. Again, it is clear that project No. 780 (TDMA/DSI) has a considerable effect on the calculations. The influence is especially obvious in the average values of projects in each sector, which are shown in Table 8.

Earth applications projects normally have a signficantly lower average cost than those with primary application in space. This relates directly to the greater complexity and more stringent requirements in development of hardware for the space environment.

It should be noted that certain projects result in hardware or technology which can be used in both space and terrestrial applications (e.g., the variable power divider (VPD) developed by ComDev). In the preceding analysis, the identification of each project application area was done on the basis of the original motivation for undertaking the project. The costs of the VPD project are therefore identified with space applications.

Contract Performance

Considering the nature of the projects, the performance of the participating companies with regard to time and cost has been generally good. (The extent to which technical objectives have been met will be discussed later in this chapter.) Of a total of 92 projects reviewed, there were 12 funding extensions approved by DOC to cover overruns which did not arise from a change in scope agreed to by DOC. The amounts were usually small in relation to overall contract values. A total of 50 of the 92 projects were late in relation to the contracted delivery date, but the large majority of these delays were minor (a few weeks to two months). The problems contributing

Table 7

Number and Value of Projects by Fiscal Year

Fiscal Year Contracts Started	No. of Contracts Started	Level of DSSC Funding ($000's)	Average DSSC Funding ($000's)	Total Project Value ($000's)	Average Tot. Proj. Value ($000's)
1976/77	9	$ 540.78	$ 60.09	$ 978.81	$108.76
1977/78	18	1,545.83	85.88	1,948.49	107.14
1978/79	11	1,066.43	96.95	1,311.78	119.25
1979/80	16	1,846.77	115.42	2,511.77	156.99
1980/81	13	1,464.58	112.66	2,227.48	171.34
1981/82	21	4,154.32	197.82	9,611.38	457.68
1981/82 (excluding project #780)	20	2,574.32	128.72	3,451.38	172.57
1982/83	13	1,239.30	95.33	2,334.79	179.60

Table 8: Average Project Values for Space and Earth Applications

	Average DSSC Funding ($000's)	Average Total Project Value ($000's)
Space Applications	$129.28	$181.70
Earth Applications	107.86	227.64
Earth Applications (excluding project 780)	81.10	119.78

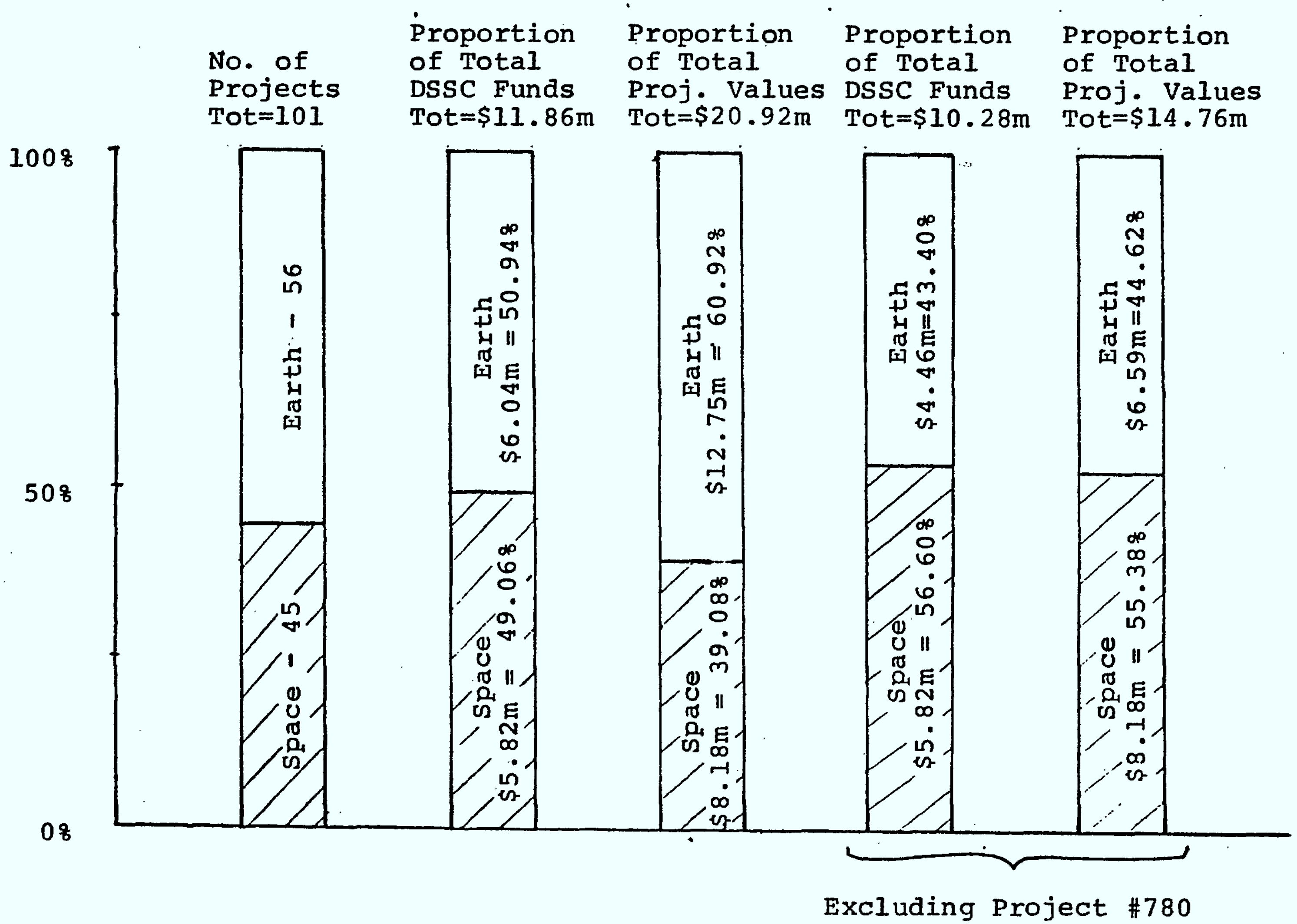


Fig. 5 DSSC Support to Earth and Space Applications

to significant delays were identified as late deliveries of components from subcontractors, late submission of final report, inexperience on the part of contractor staff, or inadequately staffed contractor project teams.

Unexpected technical difficulties accounted for the most signficant changes in delivery times and/or cost. These represent mainly problems of initially low estimates of the complexity and cost of the work by the companies, CRC, or both. These problems were relatively rare and are discussed further later in this chapter and in the case studies.

Four contracts were cancelled prior to completion because of unsatisfactory performance on the part of the contractor. In one case, no money was paid and in the others, the final settlement was negotiated depending on the amount of work performed by the firm. One of the four cancellations was initiated at the request of the company, whose management made a decision for market reasons that the firm was no longer interested in the technology represented by the project.

FINDINGS AND RECOMMENDATIONS BY ISSUE AREA

Program Rationale

Q1 DOES THE DSSC program still have a raison d'etre given

a. past and planned changes in the space program;

b. the existence of a more vertically structured and mature Canadian space industry than existed six years ago;

c. the availability of other industrial development and support programs, particularly within the department?

The derivation of the DSSC program was outlined in some detail in Chaper III. In summary, there was a recognition in 1974 by Cabinet that Canada would become a greater user of space systems to achieve national goals, and the resulting policy on space promoted a strategy of development and support to the space industry. The Minister of Communications was specifically directed to take a lead role in improving the Canadian content of Canadian satellite systems, and the original DSSC program submission to Treasury Board relied on this direction to substantiate the requested funding. Several other industrial support programs within DOC (mainly developed to assist SPAR as the Canadian prime contractor) have also employed this rationale.

The recognition of space systems as (a technology) important to Canada and the principle of strengthening the space industry have been reaffirmed several times since the 1974 document directly in policy statement and through various forms of support to the space industry.

The basic foundation of the DSSC program, therefore is unchanged from its 1976 position.

DOC space activities have three main thrusts: space technology development, space applications development and space industry development. The DSSC is considered to support the first and last, technology and industry development, about equally. As noted in the earlier discussion in Chapter III, there are presently no other programs within or outside DOC which specifically aid the space industry at large in medium range advanced development related to anticipated procurements. Further, the DSSC is in practise the only DOC program currently supporting the space industry as a whole. This places an enormous burden on DSSC in carrying out the direction of Cabinet.

The proposals for an industry wide advanced R&D and an earth terminal development program have been mentioned earlier. These programs are at this point in the preliminary development stages, and require substantial further definition before receiving formal approval. They are therefore considered here for information only.

Even considering these possible developments, there remains a substantial mandate derived from Cabinet policy which DSSC alone can satisfy. There is a signficant minimum level of funding which must be maintained for DSSC to be effective in this regard. The question of funding levels is discussed as part of the "Alternatives" section of this chapter.

The other consideration in determining whether DSSC should continue to exist is changes which have occurred in the space industry over the life of the program. It was earlier noted that the last seven years have seen no incremental changes in structure or capability of the industry. There has been a process of evolutionary development based on post-CTS/Hermes technology and some specialization in particular vertical markets (e.g., ComDev). Most companies have not grown or matured enough that they can risk large amounts of company money in R&D activities, even when there is convincing evidence of future payoff. Even a company the size of SPAR has some difficulty in this regard, as the TDMA/DSI project (No. 780) illustrates. It is one of two projects which together account for virtually all of the current SPAR Communications Systems Division R&D budget, and it is also heavily supported by ICF and other government funds. The company has indicated that it views the project as being pivotal to SPAR's participation in satellite earth station technology and crucial to future growth of the division.

Finally, although Canadian content in domestic satellite system procurements has increased because of this and other programs, there is nevertheless further room for improvement. This is particularly true when the rapid rate of change of technology and the resulting opportunities for new product development and sales are considered.

In summary, the rationale for the DSSC program was founded in two parts; to help ensure Canadian technology is used to the greatest extent possible in domestic satellite system procurements; and to support the development of the Canadian space industry. From both points of view, the rationale remains sound, despite the growth of related programs and changes in the space industry.

Discussion of Program Objectives and Scope

Given the conclusion that the DSSC program has a sound rationale, the objectives and scope of the program can be explored in detail. There was recurring evidence in the interviews undertaken of differing interpretations of what the program's objectives and scope really meant in terms of hard criteria for choosing projects to be funded. This issue was identified earlier in this chapter in the section on "Perceptions of the program".

Figure 1 located the DSSC program within a theoretical R&D cycle and showed how the level of responsibility assumed by industry could be expected to increase (and by government to decrease correspondingly) as the project progressed toward the commercial exploitation of the product or technology. This representation is appropriate in a mature industry with high volume markets, where firms have sufficient capital and potential sales to allow them to assume this increasing responsibility.

The space industry faces a different situation. It was earlier noted that the industry is relatively new and far from maturity, either in technical capabilities or in financial terms. Space research has a high level of associated risk, and the markets for space products are limited (even in the case of earth stations), and highly competitive and politicized internationally.

This implies that effective support to the industry by government must extend beyond that identified in the idealized case By contrast, the actual levels of funding provided are less than those required even for the idealized case. Limited funding is provided for small projects in basic and applied research through the CRC "A" Base budget, and the only product development support available to the space industry at large is through IT&C programs. The exception to this, of course, is certain parts of the funding provided to SPAR to assist its growth as the Canadian prime contractor.

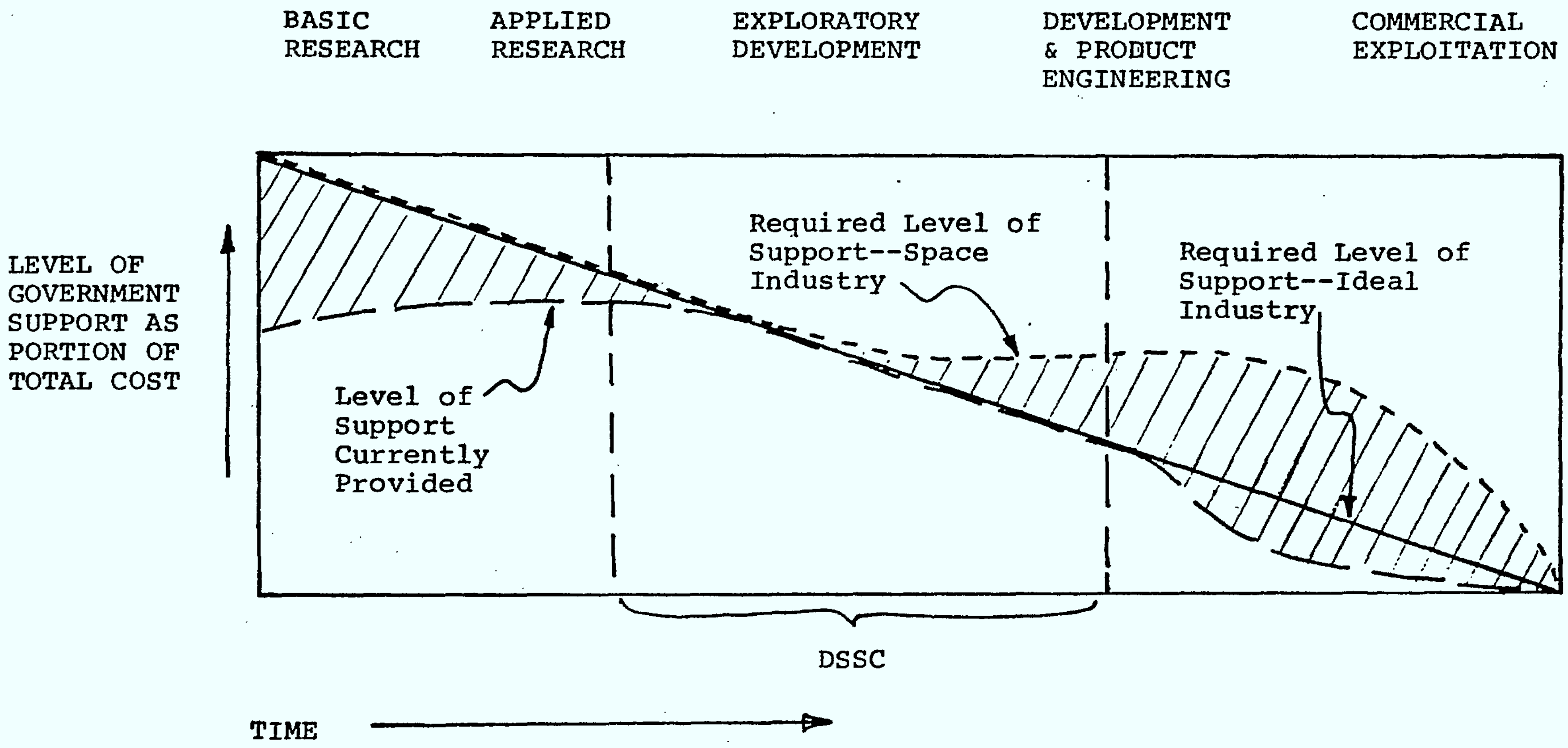


Fig. 6. Level of Support to Research and Development

Figure 6 illustrates the level of support required and provided for the Canadian space industry in relation to the phases of the R&D cycle. The cross hatched areas show the substantial gaps which exist. These gaps have the effect of stretching the boundaries of coverage of the DSSC program outward, since no agreement can be reached on a satisfactory definition of what the DSSC's target, "advanced development" projects, really represents.

It has also been noted in the previous section that the perceptions of the program vary, even within DOC, according to the primary focus of the individuals involved.

Until such time as the gaps in the set of space industry support programs are filled or the basic policy of support to the industry changes, it is inappropriate to make changes in the existing DSSC objective statements. The forces acting to influence the program's boundaries are strong enough and valid enough to argue for leaving considerable flexibility in those boundaries. As long as this flexibility exists, the program will be able to achieve an intuitive measure of support to the different phases of the R&D cycle.

> It is therefore recommended that
>
> The statements of objectives and scope of the DSSC program not be changed in the short term.

Any changes required should only be made in the context of an overall redefinition of how the space industry is supported throughout the R&D cycle. This is addressed further in the discussion of funding levels in question 12, below.

There is an urgent need, however, for formal clarification of uncertainty about the legitimacy of supporting projects relating to development of the infrastructure of the space industry.

In their present form, the program's objective statements allow for selection of projects which will "promote a Canadian capability" for "developing specific space subsystems and components", and not necessarily result directly in a product. Considerable advantage has been taken of this latitude by including projects relating not to specific space subsystems and components, but to the general ability of industry to work in certain areas. An example of this type of projects is the study of metallization of IC's.

Projects like these are important to the overall capabilities of the space industry in Canada, but are outside the scope of DSSC as it currently exists. One of three solutions may be pursued: to expand DSSC's scope to include these projects, to search for another vehicle elsewhere in the space program for providing such support, or to eliminate it altogether.

Impacts and Effects

General

The DSSC program has affected the Canadian space industry in the following ways:

1. It has directly resulted in domestic sales of specific items, with the attendant effects on employment;

2. It has directly resulted in offshore sales of specific items, with the attendant effects on employment and balance of payments;

3. It has directly resulted in sales of spinoff products and technology, both domestically and offshore;

4. It has directly resulted in the Canadian space industry's ability to maintain currency in special areas of interest to DOC's space program; and

5. It has directly resulted in an improved manufacturing capability in certain companies.

It is also evident that the program has had incremental effects on certain companies within the industry. In several cases this represents new products or technological directions, and in others it appears that the sales success resulting at least in part from this program has led to major growth in the company.

Most projects have at least some inherent value (whether or not they were technically successful) in improving the capabilities of the recipient company in the specific technology covered. In terms of sales directly resulting from the contract work or from spinoffs, there seem to be few mediocre performers - either there is little measurable payoff, or the results are spectacular. This indicates that the technical areas addressed by the program have at the least consistent potential for payoff in terms of sales. Sales success can often be linked to other factors whose effects cannot reasonably be measured, like the entrepreneurial skills, foresight and business abilities of the recipient company's management.

In one case study on the LSI Codec, the recipient of the DSSC funds (SED) has not benefitted as much as their subcontractor for manufacture of the component. Siltronics Ltd. has developed the design further and is selling the Codec chip under license from Canadian Patents and Development Ltd. (CPDL) to various customers. The component has very large potential sales if it proves to be attractive in audio scrambling of Pay-TV, and could become a major element in the company's range of products. This was the only case of this type identified, and is discussed in the case study writeup.

Aside from the direct support to the departmental mission which results from some degree of successful achievement of the program's objectives, DOC enjoys benefits in other areas:

1. DOC's programs aimed at development of a strong prime contractor who is supported by Canadian subcontractors with capabilities in particular areas have obviously benefitted from the DSSC program. Not only has SPAR been the recipient of a significant proportion of the available DSSC funds (49.3% of the overall total to date), but it is able to rely on Canadian suppliers of components and subsystems which SPAR itself is unable or uninterested in producing.

2. In some cases, it has been possible for DOC to explore new technological directions in addition to building industrial capability. DOC's internal research has been enhanced in that many of the DSSC projects fit directly into larger research thrusts and, as a result, enhanced their progress. For example, the heat pipes manufactured in the SPAR/Chromalox project are being used in a program of research into the behaviour of these components. When DOC is in a position to buy heat pipes for future missions, they will be in a much better position to effectively specify and evaluate these components as a result.

The evidence collected during this study clearly shows a high potential economic value can be placed on the projects in question and that they are very important to the needs of the Canadian space industry as a whole. Expanding the scope of DSSC, however, would compromise its effectiveness in dealing with an already large obligation with limited funds.

It is therefore recommended that:

Projects supporting development of the infrastructure of the Canadian space industry be specifically excluded from eligibility within DSSC, but that another means of support be found.

In view of the importance of some of these technologies to SPAR as a prime contractor, the programs aimed especially at supporting that firm might be one possible alternate source of funding.

A final comment can be made relating to the qualitative differences between the technological areas of concern to the CRC directorates which are closest to the program. These differences, covered earlier in this chapter, must be taken into account in the interpretation of program scope. Where satellite mechanical systems are concerned, for example, there are few standardized components, and single mission designs are the norm. The DSSC program's concern here would be with technology and design approaches. Earth terminal projects, on the other hand, can be more easily related to specific components.

Q2 TO WHAT EXTENT did projects result in eventual development of a saleable product or an improved capability which could lead to a saleable product?

It was possible to assess a total of 92 projects to determine their outcome in this regard. Of this number, 27 (29.3%) contributed directly to development of subsystems or components which have since been sold on a commercial basis, and which were the primary subject matter for the project. In 23 other cases, or (25.0%) of the projects assessed, the company has the capability to supply such a product but has not yet sold any on a commercial basis (e.g., Miller Communications Systems' TDMA). In the remaining projects the lack of directly related products or capabilities can be attributed to technical failure of the projects (i.e., the infeasibility of the technology under consideration), insufficient time or failure by the company to follow through in further development, obsolescence of the technology or the nature of the project itself precluding development of a specific subsystem or component (e.g., dynamic modelling).

For the projects which did not result in the primary product or capability being available, there were very few cases in which the companies did not identify a significant improvement in their capabilities as a direct consequence of having performed the work. Of a total of 74 projects covered by either company responses to the distributed questionnaires and/or case studies, in only 5 cases (3 companies) were no peripheral benfits identified for the projects. These projects were very small (total value $66,260) in relation to overall expenditure on the program. Spinoff products which have been sold commercially and which were developed directly as a result of DSSC work were identified in 18 (24.3%) of the 74 projects. In 44 cases (59.5%) the capability to produce spinoff products was identified as having been developed. In 25 (33.8%) cases, credibility in international markets and/or success in bidding on offshore R&D contracts was specifically mentioned.

It should be noted that although many of the spinoff products and technologies identified are used in space system applications, some were not. For example, Canadian Chromalox is currently testing heat pipes (developed from DSSC technology) for use in individual heat recovery systems.

The overall record of the DSSC program in making space system products or technology available is considered to be good, considering the risky nature of advanced development. When spinoff benefits are considered, the performance record is very good.

Q3 WHAT DOMESTIC AND export sales have been achieved of products developed directly as a result of this program, or products developed as a result of technological gains realized through this program? What future sales can be expected?

Not all participating firms replied to the distributed questionnaires, and sales data were not generally available elsewhere. The figures supplied by the respondent companies were largely incomplete and suspect to varying degrees. In several cases, sales could not be identified for specific products of interest. Some estimates were clearly of questionable accuracy because of the uncertainties of market forecasting in the DSSC environment and the time frames involved. Only in a few instances were sales provided by fiscal year, and these were mainly projections. Problems of attribution of sales arising from jointly funded projects caused further difficulty in identifying DSSC-specific sales achievements. Because of these factors, it has proven to be impossible to collect aggregate sales figures for the entire program.

The qualified information which was made available does, however, provide substantive evidence that the program has resulted in Canadian and offshore sales at a level high enough to warrant continuation of the program. The sales achieved are associated with spinoff products and technology as well as those resulting directly from the DSSC projects. Table 9 lists several of the most significant. Some further detail on sales can be found in the case studies.

Q4 TO WHAT EXTENT were projects undertaken only because funding was available under this program? How many projects received funding from other programs as well and how did this affect those projects?

The reluctance of the industry representatives interviewed to hypothesize on whether their firms would have undertaken projects in the absence of the DSSC program has been discussed in Chapter IV. The general (qualified) consensus was that without DSSC funding, most projects would not have been carried out. In three cases, the companies did have enough confidence in the potential marketability of the products that they indicated they would have performed the work in any case. However, the likelihood of compromises in scope and/or timing was seen as inevitable if alternate funding equivalent to that provided by DSSC could not be found. These compromises could affect marketability of the product and its relevance to DOC needs. No case could be identified where the same outcome would have occurred had DSSC resources not been available.

TABLE 9: Sales Outcomes from Specified DSSC Projects

SCO	COMPANY	TITLE	SALES OUTCOME
274	ComDev	14 GHz Combining Ntwk	$320K sales to date. Potential market is enormous.
521	ComDev	Variable Pwr Divider	GStar (RCA) - $3 million. Excellent potential for space and earth station applications.
832	DBC	TVRO Transmitters	$300K to date (TV Ontario). Expect further $300K in 1983. Expected FCC type approval and are marketing in USA. Spinoff products have wide market potential.
485 4590	Electro-home	Indoor Unit LCET LCET Tuner	Led to joint venture to form Gensat Communications. Company has $4.5 million in orders, potential for $30 million annually by 1985.
810 913	Intelli-tech	CAE I CAE II	$2,328,500 spinoff sales identified for 1983-85 time frame. Expect more related products after further development by company.
537 777	MAECL	14 GHz SS Pwr Amp I 14 GHz SS Pwr Amp II	Sales projection for 158 units in next 12 months at $8-10K each (total $1.2-1.6 million). Interest from two U.S. customers in 1328 additional units over next 5 years (value over $10 million).
310	SED	ODAP	SARSAT $25K.
383 483 589	SED SED SED	LCET I LCET II LCET III	$450K sales to date of redesigned receiver units, company now producing 3rd generation units. Sales of engineering services and royalty rights re: DBS LCET to General Instruments $2 million to date, additional royalties to come.
571	SED	Oscillator/Mult.	$500K sales to date.

248 381 535	SED/ Siltronics	LSI Codec	Estimated $70K sales next 12 months by Siltronics. Large sales potential in Pay-TV audio scrambling.
240	SPAR	L Band Transmitter	16 units sold to date, value approx. $2.8 million. Negotiating for additional 10 units, value approx. $2.0 million.
553 646 745	SPAR	LCTT I LCTT II LCTT III	SPARCom product line developed from LCTT activities. No significant sales to date, but products being actively marketed. Total market expected to be in $ tens of millions.
703 780	SPAR	TDMA/DSI	$3 million for Teleglobe Mill Village earth station. Project $70 million sales over next 10 years.
551 766	SPAR	SADAPTA	$300K (US) from Intelsat for further research. Expect to supply Intelsat VII, MSAT, RADARSAT.

A general analysis of the distribution of funds is contained in the first part of this chapter, and Annex B shows the project costs and sources of funding. According to these figures, the DSSC program has, through the expenditure of $11.9 million, obtained advanced development work relevant to its mission of an overall value of $20.9 million.

There is no evidence that shared cost projects are affected by the fact of funding from different sources. The one possible exception might be the case of negotiated company participation in funding, reflecting a greater commitment by the firm to pursue commercialization of the project or technology. Since these projects have generally been aimed at a marketable product, the company's willingness to participate has probably been as much a consequence of this fact as an indicator of the potential for successful exploitation.

<u>Q5</u> WHAT IMPACTS HAS the program had on firms overall (beyond direct sales or upgraded capabilities)? Has the program affected the ability of recipients to survive and/or grow substantially? Do impacts differ for different sizes and types of firms?

The DSSC program has made contributions to the Canadian space industry beyond support to the development of capability and salable products or technology.

In addition to developing specific corporate capabilities many projects were pointed out to have enabled the firm to maintain or evolve a high level of currency in the general area of technology covered. This competence is obviously crucial to the credibility of the Canadian space industry as a whole in the eyes of domestic and offshore purchasers of space products. In some cases, the fact of this competence has encouraged the companies to take initiatives in related areas, further expanding the technology base of the industry. Electrohome's participation in the development of 12GHz indoor units for TV reception is credited by the company with positioning the firm to enter the 4GHz receiver market, a venture which has proven to be highly successful.

Unexpected problems which arose during some projects resulted in solutions which were useful beyond the immediate project. Com Dev Ltd.'s approach to dealing with passive intermodulation (PIM) problems in the variable power divider project has been applied in other areas. SPAR's investigation of gear lubrication problems encountered in the SADAPTA projects enables that company to deal effectively with that aspect of any gear applications in space qualified systems.

Employment levels were (and will be) affected by the program as well. Although this question was not answered by most of the industry respondents, eight companies identified employment levels of professional and/or production staff as having increased (usually by an unspecified amount) as a result of the DSSC project. Two more indicated that they were able to maintain existing employment levels. In another case, the firm forecast an additional twenty engineering positions opening as the DSSC developed technology is brought into production.

Higher order effects on the structure and direction of some of the participating firms can be identified. The best example is ComDev Ltd. The product lines which were established from DSSC technology have contributed to very rapid growth (in excess of 40% annually for the past five years), an international customer base and a very large (75%) market share of all communications satellite microwave multiplexers. The firm expects the variable power divider and combining network related products to have great market potential in the near to mid-term future. SPAR's major Communications Systems Division (CSD) product lines of the near future have also been founded on two developmental thrusts initiated through DSSC - supported projects: low cost telephony terminals and TDMA/DSI earth stations. The company has make substantial contributions of research money and time to pursue these areas.

A different type of effect was identified by Miller Communications Ltd. At present an almost exclusively R&D company, the firm is attempting to move towards a greater proportion of production activities. It has used DSSC funding to support development of its slim route TDMA product which, if successful in the commercial market, will enable the company to move significantly in this direction.

Spinoff products and services in areas unrelated to space systems were also identified by several firms as having resulted from DSSC projects. Canadian Chromalox, for example, is currently testing space-type heat pipes for terrestrial application in industrial heat recuperation systems. This is regarded as having considerable commercial potential if successful.

Another commonly raised observation was related to the substantial improvement of a firm's credibility especially on an international scale. This was true even in cases where no product could be specifically identified. Several companies (e.g., Canadian Astronautics, SPAR, Miller Communications) demonstrated direct links between their successful bids on Intelsat R&D contracts and preceding development work under DSSC.

The effects of DSSC projects will of course be more visible on smaller companies. Market impacts in terms of sales or availability of expertise, however, appear to be basically unrelated to the size of the recipient company. A survey of the successful projects (in terms of direct and spinoff sales) leads to identification of one primary common element: commitment to commercialization. In the case of SPAR's successes, the process has been methodical and ordered, in keeping with the size and type of organization. For smaller companies with an obviously entrepreneurial orientation (like ComDev), the process is faster and more a matter of aggressive pursuit of a specialized market sector. This may reflect the size and complexity of the undertakings and the nature of the company, but in each case the company traded on its existing capabilities to develop a product, and followed through to bring it to a marketable stage.

It is also evident that the greatest substantive returns have been achieved by companies with a strong manufacturing capability. This is critical to the ability of the program to satisfy both its objectives. While awarding a development contract to a firm whose strength is in R&D may result in a good research product, it will be unlikely to contribute to the strength of the industry or the ability of Canadian users to buy Canadian.

<u>It is therefore recommended that:</u>

DSSC contracts be awarded to firms with the verifiable capability of producing the target product or technology on a commercial scale.

The level of sophistication of the manufacturing capability required would be a subjective judgement relating to the nature of the product or technology being investigated, but a clear capability for production in commercial quantities is essential.

<u>Q6</u> HAS THE STRUCTURE of the Canadian space industry been affected by this program? Has there been any concentration or specialization which can be attributed to DSSC?

The overall structure of the Canadian space industry has not been substantially affected by the DSSC. The only company which could be considered to have been newly introduced to the space industry through its DSSC contracts is Canadian Chomalox Ltd. Although Chromalox had some previous experience with heat pipe technology, it had never been exposed to space applications and in particular the special requirements of manufacturing to space qualification standards. Since there is still some question about whether the company is able or willing to undertake the manufacture of space qualified hardware, its position as a bona fide member of the Canadian space industry is at best uncertain. This is discussed in more detail as a case study.

From the point of view of the balance within the space industry population, the DSSC has had a greater but still minor impact. The support to ComDev Ltd., for example, has contributed to the more prominent position it now enjoys within the industry, and SPAR's ability to compete in the earth station market has been enhanced.

Any specialization attributable to the DSSC is a consequence of its support to specialized areas of expertise. The most successful projects, as noted earlier, have built on existing capabilities and reinforced them.

The whole issue of intervention in the industry is one which bears more detailed discussion since every DSSC project is, in a sense, an intervention. In its industrial development role, the DSSC aims to support the space industry as a whole. When the target technology of a specific project is one which is not already available in Canada (e.g., heatpipes), the choice of contractor is potentially less controversial than if a competitive situation exists (e.g. for telephony earth terminals).

In those cases where the market is more mature and there are several possible suppliers of a given technology, there are some options open to DOC to minimize any perceptions of arbitrary intervention. The most obvious is avoidance of potential conflicts by foregoing involvement in competitive technologies. This is not as impractical as it first appears; a strong argument can be made that a segment of the industry which is mature enough to engender a competitive supply situation should also be able to support research and development in response to market needs and without participation of the government.

> It is therefore recommended that:
>
> DSSC funding be focussed on development of new technolgies rather than further development of technologies within an existing market.

This implies a willingness to pursue projects with a higher level of risk and a lower payoff in terms of sales achievements. This is, however, an appropriate stance for DOC as a leader in innovation and development in a new technological area.

There will, however, be occasions when either the scale or speed of product or technology development required to remain competitive with offshore suppliers will warrant support from the DSSC program. In other cases, the development required may be in a new area of technology, but several competing firms may have the capability to perform the work. In these instances, the competitive contracting process must be strictly adhered to and particular attention paid to the ability of a potential supplier to commercialize any resulting product or technology.

It is essential in all aspects of the program that DOC be seen to be equitable in its treatment of the industry by ensuring that potential suppliers are made aware of requirements and that availability of the program is made known to the industry at large. Publicizing the program has some disadvantages, in that it would likely increase the administrative workload. However, this must be traded off against the development opportunities which are being foregone because companies are unaware of the existence of the DSSC, in some cases even firms which have received funding in the past. One company contacted about the effects of a DSSC contract indicated a high degree of success in commercializing the resulting product and stated that another project was being started using the previously developed technology. They identified foreign sales potential as well as Canadian, but stated that they had limited funds. Because their previous support was never identified with an ongoing program (DSSC), they were not aware of the possible availability of funds from the same source.

Achievement of Objectives

General

In general, the DSSC program has been successful in promoting the strength and capabilities of the Canadian space industry. The degree to which program objectives have been achieved relates in part to the consistency of project objectives with those of the program, and to the degree of success in achieving technical objectives in each project.

It is also evident that even in the case of technically successful projects, there are a variety of other factors outside DOC's control which will determine whether the end users will eventually have access to the product or technology developed. These include:

1. The company's willingness to bring the product or technology to market;

2. The availability of resources to help bring the product or technology to a marketable point;

3. The company's market strategy, pricing, and general entrepreneurial ability;

4. Changing market conditions and growth of competing offshore (or Canadian) suppliers;

5. The legislative and policy environment (e.g., development of direct broadcast earth station antennas which were illegal for general use).

These can be accounted for to some extent by building compensatory mechanisms into the program structure and collecting as much intelligence as possible. Even so, there will always exist a signficant level of uncontrollability in the results of each project.

Project objectives were found to be generally consistent with those of the program, with a few exceptions. The projects which were considered inappropriate to have been undertaken within DSSC were of the following types:

1. Those related to supporting a bid by the company on another contract,

2. Those covering improvements to an existing product,

3. Those addressing the infrastructure of the industry rather than specific subsystems or components,

4. Those aimed at producing a piece of hardware for CRC's use.

Table 10 lists projects which were judged to have been primarily aimed at these types of objectives rather than those specified for DSSC. The total DSSC funding for them was $1,025,830. In several cases, the formal DSSC objectives were addressed to some extent but appeared not to have been the primary consideration in originally undertaking the project. The list does not reflect a lack of worth for these projects, since several have had positive results. In some cases, a need not covered by other parts of the space program (e.g., infrastructure development) is addressed. This question was covered earlier in this chapter.

The degree of success in achieving technical objectives of each project is high, especially considering the nature of R&D in a high technology area, and is heavily dependant on the company's having had previous experience in the specific area of technology covered by the project.

Sales success and its dependance on the commitment and ability of the company to carry the product to a marketable stage were covered in the previous section.

<u>It is therefore recommended that:</u>

The availability and specifics of the DSSC program be more widely publicized with the space industry.

		SCO NO.	COMPANY	TITLE
Type 1.	Bid Support	718	Miller	TDMA Modem and Codec
		866	Raytheon	Dual Antenna
Type 2.	Product Improvement	512	Miscellaneous	Antenna Fabrication
		614		Techniques
		615		
Type 3.	Infrastructure	259	SED	Shuttle Tests
	Development	310	SED	ODAP
		508	SED	ODAP
		775	Dynacon	Dynamic Modelling and Control System
		9233	Dynacon	Dynamic Modelling and Control System
		810	Intellitech	CAE Tools Ph I
		913	Intellitech	CAE Tools Ph II
		888	QRL	IC Metallization
Type 4	Manufacturing	236	Miller	6/4 GHz Test Translator

Table 10. Inappropriately Funded Projects

Q7 HAVE THE CRITERIA and methods for choosing projects to be funded adequately reflected program objectives and priorities? Are current criteria and methods adequate?

The two objectives of the program have been repeatedly noted in this report. In the 1983/84 departmental estimates, the allocation of the TB approved DSSC funding level was divided in equal amounts between the Space Technology Development and Space Industry Development activities. Comments were also made during the interview program by several senior DOC managers that the original intent was to achieve an equal balance between these two sides of the program.

At a less obvious level, however, there are signs that point to a historical emphasis on the industrial development objective. At least in part, this derives from the (relative) ease with which saleability of a product can be determined, compared with the uncertainties which exist in regard to the direction of the Canadian space program.

The increasing concern with development of foreign sales in the statements of scope contained in the successive TB submissions is one example of the emphasis on industrial development. The assumption from which this evolution was probably derived (and which is completely reasonable) is that an industry which is competitive internationally will be in a better position to serve Canadian requirements. Even so, the purpose of the program as derived from the original policy foundation is not to build a Canadian export capability, but to address specific Canadian requirements. Should there also be export possibilities, so much the better, but this is not a primary concern of the program.

The danger arises in establishing criteria for choosing projects for funding. If relevance to Canadian needs (and of course the DOC mission, specifically) is covered in the same breath as offshore sales, projects leading to development of products or technology with a high degree of marketability may be selected over other projects with lower potential for resulting sales but greater relevance to Canadian needs. The relevance to Canadian requirements must be considered a primary concern, and the degree of relevance determined. The simple fact of relevance by itself is not enough to ensure that the Canadian technology development objectives will be adequately balanced with industrial development objectives.

<u>It is therefore recommended that:</u>

Relevance to Canadian requirements be formally recognized as the primary concern of the DSSC program, and the equality of technological development and industrial development objectives emphasized.

The method of project selection has been described in Chapter III under "Delivery System". Once per year, a committee has been established to review and evaluate proposals raised by industry or opportunities identified within DOC (usually CRC) in relation to a set of weighted criteria. In principle, this process should act to ensure strong links between project and program objectives and priorities. In practise, the strength of these links is only as good as the adequacy of the criteria and the representation on the committee.

The criteria should serve two main purposes:

- to guide the screening and initial examination of the project proposals before they are brought to the committee's attention, and

- to assist the committee in assessing the relative merits of each proposal in relation to all others.

They have not been, nor should they be, the absolute basis on which projects are selected.

Similar comments apply in relation to the consideration of the needs of other departmental missions (e.g. RADARSAT). Consideration of DOC mission must take priority over the possibility of using a technology or product to support other space activities. Further, the original TB submission demands that the product be <u>required</u> to support the DOC mission, not just <u>useable</u> in that regard. This implies a program planning process, discussed later in this chapter.

Uncertainties about the criteria arise from two sources:

- the criteria statements themselves are a reflection of the current program management's perceptions of the program objectives and scope, and it has been noted that perceptions vary considerably, and

- the relative weighting of each criterion is arbitrary and could change substantially depending on a number of factors, including the current management direction of the space program as a whole.

These uncertainties can at least be reduced by ensuring that management's current concerns are taken into account.

It is therefore recommended that:

The list and relative weights of criteria for choice of projects be reviewed annually, before project proposals are solicited, updated to reflect current management views, and the revised lists communicated to project sponsors and members of the selection committee.

The list of criteria also contains one factor related to whether the proposed project supports the Government's regional economic/linguistic policies, this consideration being weighted the same as the potential for "Canadian Value Added" in space products.

The regional/linguistic factor is one which has been accounted for in government policy covering the location of Canada's prime contractor capability. It is also often considered in the procurement process when equivalent proposals are submitted by different companies. It is not appropriate for it to be further considered in an examination of the scientific, technical and industrial development merits of projects proposed for funding under the DSSC program.

It is therefore recommended that:

The list of criteria for evaluating proposals for DSSC funding be limited to factors relating directly to compliance with stated program objectives and the ability of firms to perform the required work.

The DSSC selection committee's membership is the other factor affecting the adequacy of the selection method. Until 1981, an IT&C representative participated in the DSSC project selection process. In the 1983/84 selection, there was not even a representative from the Space Industry Development Directorate of DOC. Since industrial development is one main thrust of the program, it is appropriate that there at least be strong representation from organizations within the department with the capability and ongoing contacts to provide information on:

- the structure and status of the industry as a whole, and

- the interests and capabilities of individual companies from points of view other than in relation to their research and development capabilities.

There is frequent contact between CRC engineers and scientists and the space industry, but these are generally at a working level and related to specific technical issues. Especially with companies who are not part of the primary space industry, this does not allow for an adequate understanding of corporate financial stability, commitments to particular technical directions or capabilities, for example, with respect to marketing or manufacturing. As the Chromalox/heat pipe case study illustrates, the interests and enthusiasm of a relatively isolated R&D group in the company were not necessarily coincident with those of a conservative corporate management, and it is still uncertain whether any increased Canadian content in related systems will be realized in the future as a result of this project. In this example there was also a failure on the part of both CRC and the company to anticipate the difficulties with the manufacturing process itself. The expertise needed for an appropriate assessment of a company is outside the skills and mandate of CRC scientific staff.

It is therefore recommended that:

Formal provision be made for participation in the project selection process by persons or organizations with expertise in evaluating the capabilities of firms in the space industry from a business and manufacturing viewpoint.

Such participation an be achieved in several ways: by using IT&C in a consultative fashion to undertake specific investigations, by getting regular overviews from IT&C of the space industry as a whole, by involving DSA on a similar basis, and by requiring DSA participation in the selection committee meetings. The particular means chosen will depend on the individual circumstances, since not all proposals will require the same level of detailed investigation.

One other type of information is essential to the selection process. Since the second thrust of DSSC is to make technology and/or products available in anticipation of future procurements, there must be formal consideration of what these procurements can be expected to be. This should be accomplished in two ways:

- as part of the DSSC program planning process (discussed in the section on program management later in this chapter), and

- by involving space sector planners in project selection.

It is therefore recommended that:

Formal provision be made for participation in the project selection process by representatives of space sector planning (DGSCP).

Q8 TO WHAT EXTENT did projects achieve their stated objectives?

The assessments of success in achieving technical objectives by the companies who responded generally coincided with those of the scientific authorities. Table 11 shows the ratings assigned to the projects by CRC and company staff.

	Company	CRC
Total number of projects rated	74	91
Ratings with respect to technical objectives:		
. Exceeded	4	11
. Met	61	56
. Partly Met	5	17
. Did not Meet	4	7

Table 11. Ratings of DSSC Projects Performance on Technical Objectives

There were twenty cases where company and DOC assessments disagreed: in seven cases the projects were ranked higher by the scientific authorities, and in twelve cases by the firms. The apparent emphasis by DOC at the lower performance end only reflects a lack of comment on many of these projects by the companies involved and the natural tendency of the company to be slightly less critical of the results obtained. Most of the failures to fully meet project technical objectives were recognized to be the result of unforseen technical difficulties, a common problem in the R&D environment. On this note, the overall success rate of nearly 75% (by DOC's assessment) is high, indicating that DOC's ability to choose projects which are technically feasible and to shepherd them to a positive conclusion is more than adequate.

Four projects were judged to be failures resulting from non-performance by the companies involved and cancelled by DOC prior to completion. In one of these cases, termination was initiated by the company based on a business decision that the firm should not be working in the technology area under development.

Q9 TO WHAT EXTENT has a "strong and independent Canadian capability" been promoted by this program? Have the industrial benefits resulting from this program been reasonable in relation to other industrial support programs and considering the broader objectives of the DSSC program?

The impacts and effects of the DSSC program on the Canadian space industry have been recorded previously. In view of the sales achieved of DSSC related products in both the domestic and offshore markets, the number of products which would not otherwise be available from Canadian sources and the improved capabilities of the industry as a whole, the program can be considered to have effectively promoted a strong and independent Canadian capability. The extent to which this has occurred can be related directly to the level of funding available through the program.

The program has supported the industry through development of specialized products and technologies which have related specifically to anticipated Canadian needs and which frequently have been salable to other countries. In cases where no new product or technology has been produced, the experience gained by the company undertaking the project has helped to develop or maintain a high level of currency in the firm.

As a consequence of the limitations in sales figures available from participating companies, it is impossible to calculate with any confidence the "leverage ratio" (ratio of sales achieved to DSSC funds contributed) for the program. However, using only those sales figures supplied with confidence by respondents to the company questionnaires and using total program expenditures to date and reducing sales in proportion to funding from other sources, a minimum ratio of past and forecast sales to total DSSC expenditures can be calculated as follows:

Program cost	$11,858,000
Sales to date	11,635,200
Sales forecast with confidence	18,813,000
Total sales	30,448,200
Minimum ratio of sales to cost	2.57

It should be noted that none of the figures on which this calculation is based have been discounted to present value.

Several companies identified total markets for their products, without forecasting a market share. Overall, these markets are valued at a minimum of $139 million, in areas where Canadian products (like the SADAPTA made by SPAR, for example) are recognized to be competitive. The minimum payoff ratio calculated above would be revised upwards according to the overall market share achieved, as follows:

Market Share	Payoff Ratio
10%	3.74
20%	4.91
30%	6.09
40%	7.27
50%	8.45

No forecast of likely market share is possible, although some companies indicated they felt capture of up to 75% of their particular markets was possible.

The figures used in the above calculations do not include any sales forecasts for the 22 projects which are considered to have resulted in development of a capability within the recipient company, but for which no product which has been brought to market. Nor do they cover products which will almost certainly bring income to the companies in future, but for which the firms were unwilling or unable to make a forecast.

The ratios calculated are therefore very conservative. Nonetheless, they reflect a significant payoff in terms of sales resulting from the DSSC investment. When it is further considered that the DSSC program is also satisfying a second objective, the return on funds invested through DSSC can be seen to be very favourable in relation to other programs with economic development objectives.

Q10 WHAT INCREASE IN Canadian content in Canadian satellite systems procurement has been achieved as a result of this program?

While the inaccuracies and missing information in sales data supplied by the firms preclude calculation of a representative figure, several examples of past or potential substitution of Canadian for offshore technology can be identified from case study interviews and company responses to the questionnaires. These demonstrate that a significant level of substitution has been achieved in the specific product and technology areas covered by the program to date. The examples which follow are listed by company.

ANCON Space Technology Corporation: Spacecraft inertial sensing system for use in communications and remote sensing satellite systems. No sales estimates identified.

Canadian Astronautics Limited: Whole or partial battery management subsystems (including battery charge controllers, battery discharge regulators, etc.) for use in future Canadian satellites. Potential sales of $2.9 million per year estimated.

Com Dev Ltd.: Multiplexers, filters and ferrite devices in ANIK C and D series spacecraft. Supplier of microwave components and subsystems for earth stations. Canadian sales not specifically identified.

Delta Benco Cascade Ltd.: Canadian sales of 20 W UHF transmitters of $300,000 this year to date, with an additional $300,000 (Canadian) forecast to year end. Future sales not quoted. Follow on products under development also identified to have Canadian sales potential.

Miller Communications Systems Ltd.: Potential light route TDMA sales to CN/CP Telecommunications. Value not specified.

SED Systems: Low Noise Amplifier (LNA) sales to Telesat. SARSAT orbit determination programs ($25,000). Phase Locked Oscillator sales to Microtel Pacific Research for use in Space Phone products. Siltronics Ltd. sales of LSI codec $70,000 to date, with broad market potential identified.

SPAR Aerospace Limited: $3 million sale to Teleglobe Canada for TDMA/DSI terminal at Mill Village and related future sales. Potential for small telephony earth terminal and related product sales is judged to be good. Use of Canadian attitude sensing system and SADAPTA are tentatively planned in operational MSAT designs. L Band transmitter used for ANIK D telemetry. SADAPTA will be used in MSAT demo project (as part of the LSAT bus).

One other form of substitution which is not quantifiable but also important to Canadian satellite systems procurement is the expertise developed through DSSC contracts. An example of this type of benefit is the knowledge which SPAR has gained of heat-pipe technology through its association with Canadian Chromalox on the heat pipe project. As a result of this project, SPAR is now in a position to advise its customers directly and in detail on related requirements, something which no Canadian company could previously have done.

These increases in Canadian content have secondary benefits in relation to the balance of payments, both in terms of substitution of Canadian products and services for those previously purchased offshore, and in relation to direct export sales of components to other countries.

Alternatives

Q11 TO WHAT EXTENT does the department wish to be directive or reactive to industry in using this program? Should the projects be suggested to industry (based on strategic plans of the department) or by industry based on potential profitability, specific capabilities, etc.)

Throughout its life, the direction of the DSSC program has been determined in a basically reactive and opportunistic way. Even projects originating within CRC or DOC HQ have been pro- posed first in response to a particular perceived need or opportunity, and only incidentally, if at all, in the context of an identified strategic direction. There has, in fact, been limited organized strategic input to the program; it has not been planned on a program basis. This has consistently been the case since 1976, the first indication of the need to plan a new year's funding generally taking the form of a call for project proposals to DOC/CRC directorates, with no supplementary information being provided.

Had the DSSC simply industrial development objectives, a purely reactive stance would be appropriate. The fact that it has an equally important objective to serve DOC and other buyers of Canadian space systems, subsystems and components imposed an obligation of strategic direction and program planning on the management of the program. Even where funding proposals originate in industry, the selection committee must be in a position to put the projects into a planning context. In this regard, it is appropriate to keep both selection committee members and industry informed of the program's current directions.

At one point, proposals for funding were solicited from a number of companies without specific guidance on the types of projects and the program objectives being given. The result was submission of several inappropriate proposals and, therefore, wasted effort on the part of the firms. Without appropriate information on program directions (as well as basic objectives and guidelines), a similar situation could arise.

It is therefore recommended that:

Strategic directions developed in the DSSC program planning process be communicated to selection committee members and to firms invited to or likely to make proposals for funding under the program.

The timing and form of these communications will be determined by the availability of the information. The program planning process is discussed below in the section addressing Program Management.

Q12 HAVE FUNDING LEVELS been sufficient to support program objectives? What would be the effect of changing funding levels? Can project funding be effectively extended in any way (e.g., by involving other departments like EMR or DND in joint ventures?)

Based on the program's impacts and effects discussed earlier, the levels of funding provided to date have been sufficient to support the program's objectives. However, there is no "right" level of funding which can be identified in relation to this or any other R&D program. As long as there are projects to be undertaken, careful analysis and management of R&D resources will result in payoffs for the investment. Comments on DSSC funding levels can best be made in reference to the program's position in the framework of related programs.

An important principle can be stated at the outset: the DSSC program, addressing a particular stage in the R&D cycle as it does, is most effective if it encourages at that stage a level of activity which is in balance with the basic research and product development stages on either side.

It has already been observed that, with the exception of the relatively small level of contracting which supports basic research at CRC, there is no other program available from DOC to the space industry at large. Nor are there R&D or product development programs available specifically to the space industry through other departments. This situation has been a major influence in the stretching of the program's boundaries, which has been described elsewhere.

In light of this situation, it would be more effective to develop a balanced framework of fully complementary programs than to increase funding of the current program. This could be achieved by creating new programs around DSSC or by broadening the scope of DSSC. In the latter case, it would be the obligation of program management (possibly through the selection committee), to ensure that an appropriately balanced distribution of funds was achieved within the program.

On the other hand, any significant reduction in the current level of DSSC funding would be inappropriate and counterproductive: inappropriate because it would directly reduce DOC's ability to respond to Cabinet direction in supporting the space industry at large, and counterproductive because it would reduce the positive economic and technical benefits it has been demonstrated DSSC projects have brought to the space program. It has also been noted that even projects considered technical failures have had some positive effect in imparting knowledge and experience to DOC and company technical staff. Any loss of funds will therefore cause a corresponding delay in the acquisition of technology by Canada's space sector.

No allowance has been made in the past for inflation, which tends to be higher in high technology sectors than other parts of the economy. The analysis of program funding earlier in this chapter reflects steady increases in the average values of projects undertaken, an increase which can be at least partly attributed to inflationary tendencies. The result is an effective reduction in the size of the program which should be taken into account in determining funding levels.

> <u>It is therefore recommended that:</u>
>
> Current funding levels for the DSSC program be maintained with appropriate allowances for inflation until such time as the overall space program is adjusted to provide a more balanced distrubtion of R&D funds, or the scope of the DSSC program is changed.

At the time of preparation of this report, preliminary discussions have taken place within DOC about the possibility of establishing two additional programs which would affect DSSC. One would be aimed at directly supporting the contracting of advanced R&D activities to the space industry at large, and the other supporting the development of earth station technology.

The former would complement DSSC by addressing an earlier (and more uncertain) stage in the product/technology development cycle. The funding for a basic research program should not affect that provided for the DSSC. Indeed, they would enjoy a complementary relationship in that advanced research is not currently covered by any industry programs, and DSSC is sometimes considered for funding of such projects. The existence of such a program therefore, would theoretically clarify some of the controversy about the limits of coverage of DSSC. In fact, it is probable that there would be some overlap between the two unless very clear guidelines were provided for each.

A medium range development program for earth stations, on the other hand, would require a major reorganization of DSSC funding since a signficant number of DSSC projects are currently directed at development of earth station technologies. The degree of overlap of these programs would have to be determined by examining the stated objectives and redistribution of funds carried out on that basis.

One cautionary note must be recorded here. Should a set of complementary programs be developed in the future, it is imperative that they be tightly linked from a management point of view and their <u>aggregate</u> effects and value to the space program, the space industry, and the economy monitored on an ongoing basis. Although individually the programs may have positive effects, the maximum benefit will be obtained through a coordinated effort. Analysis on this aggregate basis is also the only means by which the real premium being paid to develop a particular tehnology or product in Canada can be assessed and a true benefit/cost picture determined.

It has been noted that joint ventures with other government departments and agencies and with the private sector, as well as use of the SSC Unsolicited Proposal Fund, have in several cases supplemented funding provided through DSSC. This has given some effective leverage in use of DSSC funds in these cases.

> <u>It is therefore recommended that:</u>
>
> Providing DSSC Program (and other funding program) objectives are satisfied, continued use of joint funding and the SSC Unsolicited Proposal Fund should be arranged.

<u>Q13</u> CAN THIS PROGRAM be restructured to achieve its objectives of industry and technology development more cost effectively?

The preceding comments have covered to some extent the question of changes in scope within the context of a discussion on funding. Restructuring of the DSSC program alone is unnecessary and inappropriate without concurrent changes in the overall framework of space sector programs.

Within the DSSC program, however, it is worth considering the possibility of separating earth and space hardware development projects. The two sides of the program differ substantially in many respects:

- the time, cost and complexity of research and development is different in each area,
- they address different markets, developing at different rates, and
- there are many fewer companies able to manufacture space qualified components than there are working with terrestrial technology.

Despite the differences, earth and space projects are closely linked by the fact that they comprise single systems which are planned and developed as systems, using a single or shared technology.

It is also desirable that some flexibility be allowed in determining the relative proportion of funding to support space or terrestrial activities so that current plans can be accounted for and projects can compete freely for support based on their merits and potential benefits. These arguments support the idea of leaving funding of both types of projects within the management and planning framework of a single program.

<u>It is therefore recommended that:</u>

> Proposals for funding of terrestrial and space activities continue to be considered within the same program framework but some appropriate mechanism be established to take into account the different characteristics and requirements of R&D in each area of technology.

This mechanism would incorporate into the selection process a means of recognizing the different environments and requirements of space and terrestrial parts of space systems. The balance between the two sides can be determined annually based on the relative merits and payoffs of acceptable projects, their priority related to other R&D activities, currrent strategic plans, current market data, available funding and other relevant program level information.

<u>Q14</u> IS 100% FUNDING still appropriate in all cases or would a shared cost approach result in a higher success rate by motivating companies toward product promotion and tighter project control?

This question must be considered in conjunction with another issue identified by industry representatives: that of proprietary rights in intellectual property. The two issues are inseparable in that they share a common logical derivation and trade off directly against one another. It is also in relation to these issues that the dual objectives of the DSSC program are most problematic and directly contradictory.

Retention of rights was nearly universally expressed as a major concern by the senior industrial representatives interviewed. In two cases, it was implied that the companies would be most reluctant to undertake R&D which would allow rights to be vested outside the firms performing the work.

The firms concerned have displayed or are developing an aggressive, market-driven posture. The senior executives state flatly that they are <u>not</u> simply or primarily in the R&D business and that these activities will be undertaken only in support of a profitable manufacturing operation.

The firms' reluctance is based in two concerns: first, that they would be unable to take full advantage of proprietary developments without free access to them; and second that their market positions (and therefore, investments) would be compromised by the possibility that the technology would be exposed to competing firms. Even where government funding is sought because the company has insufficient capital to make the necessary R&D investment, retention of rights was identified as a major consideration.

It is obvious that achievement of DSSC's technology development objectives can be compromised severely by the unwillingness of market-oriented industrial firms to participate in DSSC contracts when rights to the resulting technology do not remain with the company. These, after all, are the firms most likely to be successful in commercializing the technology and therefore in achieving DSSC's industrial and economic development goals.

At the same time, it is evident that these firms, having a belief in the marketability of the technology, are willing to assume some of the risk themselves through joint funding arrangements.

These attitudes have some consistency with the normal government practises relating to each part of the DSSC's objectives. The government spends money through DSSC for two reasons:

1. to purchase R&D related to a technology or product, and

2. to help develop the space industry: for example, when a company cannot afford to underwrite development of a promising product or technology.

Both must be satisfied for any project to be acceptable for funding under DSSC, and it is nearly impossible to get agreement on which is the primary objective in any particular case.

In its role as an adjunct to the Contracting Out Policy, DSSC is a vehicle for buying R&D from industry. The Contracting Out Policy is clear in its direction in the area of proprietary rights:

> "The Department of Supply and Services shall ensure that proprietary rights with regard to intellectual and industrial properties, technical information, designs and prototypes arising out of contracts awarded under this policy, become vested in the Crown."

No corresponding direction is provided with regard to funding, but it is reasonable to assume that since the government is buying something, it is willing to pay full price for its purchase, including profits.

On the other hand, DSSC also has an industrial development objective. No other federal industrial development program in Canada permits the government to retain rights to intellectual property developed during the course of contracts let under these programs. It is also extremely rare for other industrial development programs to fund 100% of any given project; in no case is profit also paid. This provides some assurance of the company's interest in the product rather than the research, and provides motivation for effective project control and marketing follow up.

The lack of agreement on which program objective is primary for any project makes it impossible to use this as a way to determine how funding and rights should be handled in each case.

Several other considerations are also relevant to this issue. First and most important is the idea basic to this program that DOC is looking for a commitment by industry, given recognized limitations on the firm's resources and uncertainties about markets, to follow through with commercialization of the product or technology if it proves feasible. This is a strong argument for dropping the payment of profit as a general practice, in exchange for some mechanism which would give the company exclusive use of any intellectual property developed during the contract.

Secondly, the R&D tax writeoff provisions which are generally available can be used for DSSC projects. Since these exceed 100%, the company would in effect be getting more than 100% funding even if 100% of costs (and no profit) were covered by DSSC.

Current proposals for amendment of R&D tax incentives make provision for tranfer of writeoff benefits to investors, a provision which would make it easier for firms to improve their capitalization. In some cases, the firms interviewed did not need to use the DSSC projects as writeoffs because enough other projects were available for this purpose. For these firms, the new provisions would be a very attractive means of encouraging investment. The effects of these policies will become more obvious if and when they are implemented, but it is at least clear that the existing incentives complement the effect of DSSC funding.

Finally, a general observation was made by SSC managers that there is currently room for negotiation with regard to intellectual property clauses, but this is seldom exercised by companies. The standard clause applied to all R&D contracts funded by the government is DSS Supplemental General Conditions - Research & Development (form 1036), vesting rights to any property developed in the Crown. Since deviations to 1036 clauses can only be approved by Treasury Board, the process would inevitably be cumbersome and time consuming, possibly compromising the project to be undertaken. Although the observation is legally correct, therefore, it is somewhat impractical.

These considerations tend to make the existing approach to funding less effective (from DOC's point of view) than it should be.

<u>It is therefore recommended that:</u>

Companies be encouraged in all cases to participate directly in project funding or to arrange other non-government participation,

A maximum of 100% of costs be paid for each project, with no profit, and

Rights in intellectual property be vested in the company in cases where the company makes a significant contribution to the cost of the project.

The determination of what comprises a "significant" contribution might be made on a case-by-case basis considering such factors as the size of the project, the resources of the company, and so on.

The recommendations above are aimed at having the DSSC more effectively use industry's profit motive to provide leverage on program funds. They demand an implicit commitment on the part of the firm to following through with commercialization and provide latitude for DOC to negotiate different levels of company participation depending on the level of risk and marketability of the technology or product.

Two cautionary notes must be recorded in relation to the last of the above recommendations. First, any projects using the Unsolicited Proposal Fund may be subject to the clear direction by SSC that, in those cases, rights will rest with the Crown. This issue should be resolved with SSC. Secondly, in cases where rights remain with the company, the government would require specific assurances that:

1. The technology would be freely available to the government, without cost,

2. The technology will be available to meet the expected requirement in anticipation of which it was developed, and

3. Rights would revert to the government if there is a requirement for the technology which the company will not satisfy.

The specific mechanisms to be used to gain these assurances (conditional rights, exclusive or non-exclusive licensing, protection from distribution of technology to competitive firms, etc.) should be investigated in detail.

Q15 SHOULD LARGE, WELL established companies be excluded from eligibility for DSSC projects in light of extensive funding support available elsewhere within the space program?

The information collected during this study shows that the relative payoffs on successful projects have been higher to small companies with an entrepreneurial style and who specialize, ComDev being an obvious example. The risks of failure also appear to be higher in the case of smaller firms for a variety of reasons from corporate bankruptcy (as occurred during a contract with Digital Devices), to an inability to obtain funding for further development.

The large companies, (SPAR in particular), are generally safer in terms of risk associated with business factors. On the other hand, there is a possibility that the projects will not enjoy such a strong corporate backing and commitment as they might in a smaller firm, and be lost in the large company's overall program. In more than one instance, DOC staff have ventured the opinion that the (large) company involved in a DSSC funded project has used the project as a means of training technical personnel, to the detriment of the achievement of technical objectives.

It also seems that the projects of interest to the larger companies are substantially more costly than those the smaller firms are willing to undertake. This has the disadvantage of tying up a large portion of available DSSC funds and thereby limiting the number of technical lines of enquiry which can be established by the program, and the number of companies whose development can be assisted by these projects.

Despite these limitations, there was no evidence that the size of the company related directly to achievement of the technical objectives of a project. In relation to the program's objective of development of Canadian technology, therefore, funds should be made available industry wide, without prejudice to either large or small firms.

The objective of space industry development, however, causes more difficulty. It has been noted that the tendency of larger firms to undertake large projects results in limited participation by the rest of the industry.

One means of ensuring that these limitations are not overly severe would be to restrict the level of funding which can be applied to a single project and on an annual budget basis, to a single company. A "project" would be defined so that undertakings with several phases are considered as one project with a single product or technology objective (e.g., heat pipes or a battery management system) and not as several separate units, each eligible for funding up to the established limited. The entire life of the project would be considered.

It is also important to point out that SPAR Aerospace, clearly the largest and key member of the Canadian space industry and the designated prime contractor, is the recipient of a high level of financial support through DOC and other departments. Although none of these programs directly overlap DSSC objectives, the industrial development value of DSSC in this context will be of less marginal significance than had the funds been directed elsewhere. SPAR has to date received almost exactly half of available DSSC funds, and over 60% of the funds devoted to space applications.

A further observation on SPAR is relevant. It is very important to the stability and longevity of SPAR as the Canadian prime contractor for the rest of the Canadian space industry to be stable, diversified and competent enough to support SPAR in this capacity. DSSC, as the only program with space industry development objectives which applies across the industry, must assume a special role in this regard.

<u>It is therefore recommended that:</u>

Limits be placed on the total funding available to any given project over its entire life, and to a single company over one fiscal year.

In view of the foregoing considerations, the limits proposed are:

- $500,000 per project (over its entire life), and
- 1/3 of total program budget per company per year ($1,000,000 based on the current size of the program).

Exceptions to these limits could be formally granted at the program management level only.

One phenomenon is occurring which may require re-evaluation of the above recommendations in the future. Companies with a strong space applications capability (like SPAR, ComDev) are currently developing product lines for terrestrial applications. SPAR, for example, is poised to enter the market for small earth terminals, thus introducing a new and substantial element of competition into that market. Depending on the space program and other policies at the time, it may be appropriate to increase or decrease the funds available to SPAR to ensure continuing equitable distribution through the industry. This is the type of issue which must be examined regularly as part of the program planning process discussed later in this chapter.

Q16 SHOULD DSSC CONTINUE to have a finite life or should funding for it become part of the "A" base budget?

Based on the direction by Cabinet to DOC to carry out a program of this type, and given sufficient evidence of its value, the sunset provisions should eventually be removed and funding provided within the "A" base.

The evidence which was collected during this study on program impacts and effects indicates that many of the products or technologies which have been supported have high potential for commercial return and will support Canada's space activities. In many cases, however, the market or technology has not matured to the point where these benefits can be unequivocally demonstrated, and an additional period of time is required before effects can be convincingly measured.

It is therefore recommended that:

> The DSSC program be funded for a further period of five years and an evaluation of program impacts and effects carried out after four years.

This will allow the program to be planned without interuption while the follow-up evaluation is carried out. Also during this period, review of individual projects and company performance records would be part of the program and project management activities discussed below.

Responsibility for approving the lifting of sunset provisions will have to be determined by negotiation between the department, Treasury Board and Ministry of State for Science and Technology. Although Treasury Board was responsible for original approval of the program and for granting extensions to program funding, the Policy and Expenditure Management System (PEMS) has vested policy decision-making in the Economic Envelope sector management committee.

Q17 COULD THE PROGRAM be more effectively delivered by another department or agency? (e.g., ITC/DREE)

Several factors argue against the option of transferring responsibility for management of the DSSC program to another department or agency.

First, the original TB submission (TB740025, December 3, 1975) specifies a signifcant DOC mission-related content in the program. Another department, particularly one that was essentially non-technical in character, would not be in a position to ensure that these considerations were incorporated into the process of program and project planning and management.

The highly technical nature of most of these projects and their links with related research activities impose a requirement for competent technical management. Often the CRC Scientific Authorities participate directly in establishing research directions, solving problems, specifying sources of information and so on, as well as acting to represent the interests of the Crown in a supervisory sense. Only DOC is in the position to regularly supply this type of support, mainly through CRC based staff. The department would be obligated to continue to provide the required expertise even if DSSC were under the direction of another department. In view of staff commitments and mission-related obligations, DOC would be understandably reluctant to provide this service without appropriate increases in the number of technical person-years.

DSSC projects are frequently closely related to CRC research directions. The close contact which DOC and especially CRC working level staff have with their counterparts in industry is a vital element in the successful achievement of individual project objectives. Maintenance of this relationship as far as DSSC is concerned would be at best difficult if the program were the responsibility of another organization outside DOC.

It is therefore recommended that:

DOC retain responsibility for management and operation of the DSSC program.

Q18 CAN THE PROGRAM be delivered more cost effectively through changes or improvements in program management and/or project management methods?

The evidence collected during the project showed, as one might expect, room for improvement of certain program and project management practices. The dilemma in addressing these shortcomings is substantial: how best to instill good planning and control techniques without compromising the freedom and creativity required to pursue the objectives of research and development. A strong case can be made against the harmful effects of overregulation in this regard. The fact remains, though, that minimum standards must be met, and the following comments and recommendations are made with this balance in mind.

Program Management

The best environment for scientific creativity is one in which the limits are familiar, well articulated and not excessively detailed. Program management is aimed at providing this environment through three activities: program planning, program monitoring and program followup. DSSC has not been managed on this basis.

It has been noted that industry has no appreciation for the specific objectives of DSSC and that the Directors' primary concern is with the areas covered by their individual mandates. In the case of the Directors, their directions are not always consistent, and their perspectives on the DSSC projects include consideration of much more than just that program's goals. In these circumstances, it is essential that there exist strong central control over the directions taken by the program; otherwise, there is a real risk of suboptimization of the use of the program funds or, in the extreme, of invalidating the value of individual projects. Further, what may seem to be optimal may not be so from the overall viewpoint of the space program. This implies a need for a more organized and comprehensive program planning process than currently exists.

A formal DSSC program planning process can do several things:

1. Force a review and articulation of strategic issues relating to the program's subject area;

2. Make the link between strategic concerns and more specific operational concerns (e.g. specific lines of scientific enquiry to be pursued);

3. Establish continuity between DSSC and complementary programs which are part of the framework within which DSSC operates;

4. Provide current criteria for priorizing projects within a program context; and

5. Provide a forum for identification of those sectors of the space industry which can most productively be assisted with development funds (based on consultative input from appropriate expertise).

The management level contact which has been relied on as the main line of communication on policy and direction is insufficient to ensure that proposals for funding have adequately taken into account all the strategic issues. Nor does it provide a means of informing industry of DOC's interest. In planning for 1982/83, for example, DOC requested proposals for DSSC funding from a selected list of companies. Several were received, but most were irrelevant because no direction had been given the companies. Similarly, in-house proposals for funding are developed without formal guidance and are based on the interests of the individual CRC directorates. Time is wasted in each case both in preparing and dealing with questionable submissions

A substantial amount of planning activity should precede the actual allocation of funds. This would include assessing the space program's strategic directions, forecasting the future needs of non-DOC users of space communications systems, and collecting information on markets and the industry (with the assistance of appropriate expertise, possibly from within the space industry itself). Based on this information, direction can be prepared and communicated to industry and to DOC technical staffs in time to influence the preparation of proposals. This planning activity would focus the projects proposed on the overall directions of the program.

Two additional benefits can be noted. First, the process of reviewing the strategic framework of the program allows for identification of shortcomings in general policy direction to the program, which can then be raised with departmental management. The program planning process also provides an opportunity to identify areas where Senior management will have followup responsibility. For example, if projects are undertaken in anticipation of a new technology like MSAT (before it arises as a program itself), managers will be aware of the availability of the technology and more inclined to influence purchases from Canadian sources.

It is therefore recommended that:

A formal program planning mechanism be instituted to provide direction for proposals and the annual project selection process.

It must also be noted that planning, particularly at the program level, too often is regarded as casting in concrete the directions of the plan. Hence, the tendency is to develop vague plans or no plans at all. The opposite should be true--that not only does each project reflect the plans for the program, but the plan evolves and changes to incorporate experience with projects, changes in markets, new technologies and a host of other factors. Maintenance of current plans which reflect these influences in a flexible way is very important to a program like DSSC, in order that it be able to recognize and respond to good development opportunities identified by industry as well as government.

Program monitoring involves a similarly high level observation of the overall program during the course of the fiscal year. The process must be ongoing so as to avoid the usual tendency to arbitrary allocation of excess funds as the fiscal year end approaches. Where availability of funds can be forseen, it is more appropriate to dispose of the funds on the same basis as that on which projects are required to compete at the start of the year. This implies a need for the project selection committee to meet more than once per year to update strategic directions, review progress of approved projects, and consider the allocation of spare resources in support of these directions.

<u>It is therefore recommended that:</u>

The DSSC project selection committee meet at least once during the fiscal year to consider changes in direction, progress of approved projects and allocation of available funds.

Once projects are completed, there has been a tendency to let the technology or product stand on its own. The lack of programs available to help industry with the expensive process of product refinement and commercialization has been discussed earlier. Even so, DSSC, by its nature, offers other opportunities for program management to follow through with support to the program.

At the simplest level, occasional evaluation (in the current sense) is necessary to ensure relevance of the program. On an ongoing basis, program management can assume a marketing type role. One example of this type of situation is the decision to purchase an LSAT bus for the proposed MSAT demonstration project, thus denying the opportunity for use of Canadian battery management and/or heat pipe technology. In another case, Telsat contracted to purchase, through a foreign-controlled company, equipment whose development by Canadian industry had been supported by DSSC.

Part of DOC's role is to "Encourage Telsat to buy Canadian". These decisions can influence if and how DSSC supports further development of these technologies, and more important, identifies opportunities to influence decision-making for any production satellites which might follow the demonstration project. This influence could have a substantial effect on the commercialization of the technology, and therefore on the effectiveness of the DSSC program.

<u>It is therefore recommended that:</u>

A mechanism be established for following up DSSC projects to ensure the products or technology developed are being used to best advantage within government.

A point of emphasis can be added at this point. Provision of strategic direction and program level management is the obligation of senior management. Within the limits established, the project selection committee and scientific managers should retain the freedom to choose and manage the set of projects which best fits these constraints. Without this latitude, the creative environment required to ensure effective operation of a program like DSSC may be subdued. The recommendations on program management have been made with these considerations in mind.

Project Management:

Although it is very much an operational concern, project management is relevant to evaluation in that it affects how well funds are being managed and therefore the impact they will have. The observations in this section are therefore specific but have their roots in program level concerns.

Project management is a major concern in the DSSC program. There has never been a project manager formally assigned to a DSSC project: that is, someone who had responsibility not only for controlling technical aspects of the work, but also the cost and timeliness. Historically, the Scientific Authorities were appointed from CRC only to deal with technical matters, while financial concerns and progress reporting to management was done centrally. This situation has been perpetuated even after program management responsibility was transferred to CRC.

Additionally, no standards exist for project planning, record keeping or reporting (except for Level I and II Management Reports). The difficulties this situation imposes for evaluation have been referred to earlier. More importantly it also impedes the ability to control projects, as in one case where a new scientific authority was placed in charge of the last stage of a three phase project. No historical files were available to him covering earlier stages, placing him in a position of not being able to understand fully the historical course of events and compromising his ability to manage the third phase effectively. The project is valued at over $650,000.

It is therefore recommended that:

A set of standards for project management within DSSC be developed and implemented without delay.

The standards should cover documentation and record keeping, reporting, responsibilities for maintenance of information, establishment of milestones, and so on. Normal standards for project management should apply.

It is also recommended that:

A project manager be specifically appointed to manage each DSSC project.

The project manager would have complete responsibility for technical aspects, most management, and ensuring timely completion of the project. In most cases he would be the person who would be assigned the Scientific Authority role.

Recognizing the propensity of scientific staff to be less interested in management than science, and considering earlier comments on the need for technical creativity, it is clear that every available opportunity to remove the administrative burden from the project manager should be exercised. This could include using directorate administrative assistants to maintain project records, including financial information. In the end, however, there must be one person who is clearly accountable for all aspects of each project.

Figure 7 shows how the elements of program and project measurement which have been dealt with above relate to one another. Those elements currently in place have been underlined; the others remain to be addressed.

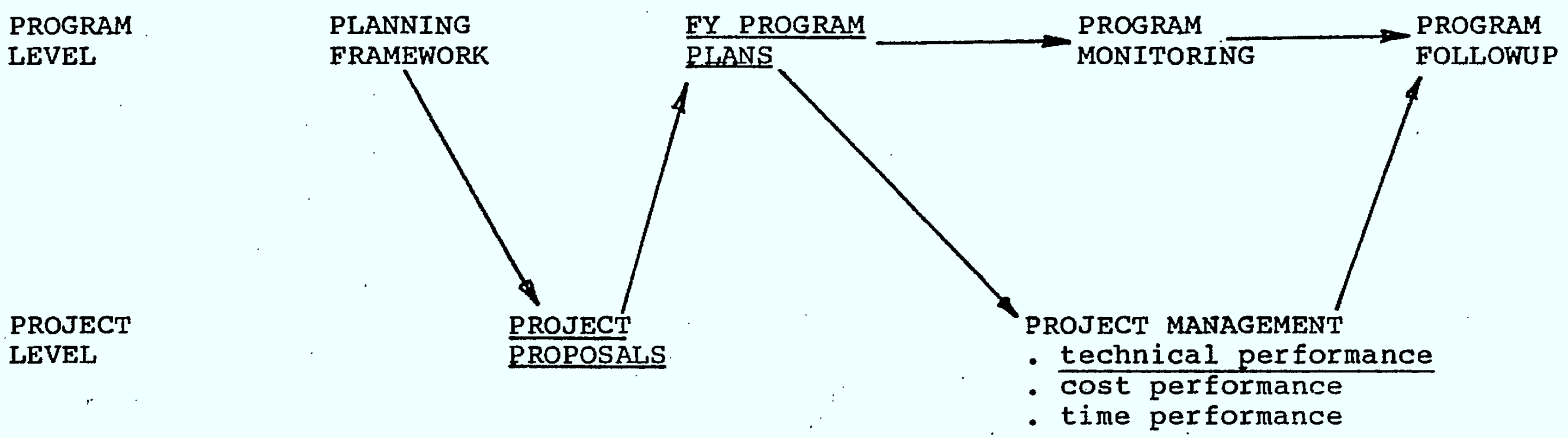


Fig. 7 Program and Project Management Elements

ANNEX A: Project List by Company

Project Title	SCO No.	Req. No.	Company Name	Dir.	Scientific Authority	DSSC Funds (000's)	FY Started
Accelerometer R&D	764	10099	ANCON	DSM	McMath	100.2	81/82
Two Axis Gyro R&D	765	10101	ANCON	DSM	McMath	115.8	81/82
Tuned Rotor Gyro	AAA	20562	ANCON	DSM	McMath	68.2	82/83
Sidelobe Reduction Tech	120	60452	Andrew Ant	DSE	Kong	24.1	76/77
Develop Helix Antenna (MUSAT)	247	74808	Andrew Ant	DSE	Kong	30.0	76/77
MSAT Ant R&D	710	13005	Andrew Ant	DSS	Butterworth	26.9	81/82
JSB Mobile Ant. Dev.	82E	22761	Antech	DSS	Huck	67.4	82/83
Study Analog Voice Privacy	261	74803	BNR	DSS	Wohlberg	12.3	77/78
Battery Management System	249	74792	CAL	DSE	Gore	129.6	77/78
Battery Management System	541	90888	CAL	DSE	Hum	525.1	79/80
Study Analog Voice Privacy	260	74804	CMC	DSS	Wohlberg	15.3	77/78
Heat Pipe System	386	84257	Chromalox	DSM	Wehrle	143.4	78/79
Heat Pipe R&D	845	10407	Chromalox	DSM	Wehrle	122.1	81/82
UHF Diplexer	119	75172	Com Dev	DSS	Daniel	55.9	76/77
14 GHz Combining Network	274	72378	Com Dev	DSE	Douville	101.4	77/78
Variable Pwr Div 14/12 GHz	521	94003	Com Dev	DSE	Lo	60.0	80/81
12 GHz Parametric Amplifier	6.2	60313	Com Dev	DSE	Douville	126.8	76/77
Report RCA/Mux	811	10296	Com Dev	DSA	Fortier	50.0	81/82
UHF Transmitter-TVRO	832	10325	DBC	DSE	Kuley	34.5	81/82
Demand Asst Controller Ptype	131	60524	Digital Dev	DPM	Boudreau	26.1	76/77
Dynamic Mod & Ctl Syst	775	10953	Dynacon	DSM	Reynaud	92.0	81/82
Dynamics & Control	923	20727	Dynacon	DSM	Reynaud	94.0	82/83
Fault Tolerant Proc System	809	10274	Eidetic	DSM	Millar	50.0	81/82
Fault Tolerant Proc System	914	20561	Eidetic	DSM	Millar	150.0	82/83
Indoor Unit LCET	485	90452	Electrohome	DSE	Douville	66.0	79/80
LCET Tuner	590	91458	Electrohome	DSE	Douville	21.7	80/81
ELT 406 MHz	595	00247	Hermes	DSS	Hayes	24.9	80/81
CAE Phase I	810	10273	Intellitech	DSM	Millar	122.1	81/82
Computer Aided Eng'g Tools	913	20560	Intellitech	DSM	Millar	150.0	82/83
ELT 406 MHz	595	00248	Leigh	DSS	Hayes	0.0	80/81
Reflector LCET	512	90711	Lindsay	DSE	Kong	4.1	79/80
SS PA 2W 14GHz	537	90934	MAECL	DSE	Douville	236.7	80/81
SS PA 2W 14GHz (build 7)	777	10192	MAECL	DSE	Douville	75.0	81/82
6-4 GHz Translator	236	74802	Miller	DSS	Nuspl	9.5	77/78
MuSAT SET Channel Unit	241	74005	Miller	DSS	Sewards	270.4	77/78

Study Error Coder/Decoder	251	74806	Miller	DSS	Sewards	23.0	77/78
TDMA SET Study	264	74801	Miller	DSS	Nuspl	23.2	77/78
TDMA	424	84982	Miller	DSS	Hindson	132.5	79/80
TDMA Modem & Codec	718	04004	Miller	DSS	Nuspl	0.0	80/81
TDMA Parameters	867	10477	Miller	DSS	Robertson	20.3	81/82
FEC TDMA	887	24018	Miller	DSS	Robertson	15.8	81/82
TDMA/DAMA	969	22587	Miller	DSS	Robertson	19.8	82/83
DMSK Eng Model	FFF	22872	Miller	DSS	Bryden	190.4	82/83
Optical Com System	82A	22249	Opto Elect.	DSE	Hum	73.9	82/83
Reflector LCET	512	90711	Parker	DSE	Kong	5.9	79/80
I.C. Metallization Study	888	24021	QRL	DSE	Hum	19.0	82/83
Dual Ant/Australia	866		Raytheon	DGSCP	Threinen	302.6	81/82
F-4 Satellite Subsystem	115	60399	SED	DSL	Huck	39.9	76/77
4&12 GHz Circulators	229	73130	SED	DSE	Douville	11.2	77/78
Lo Cost SET 12 GHz	246	74793	SED	DSE	Douville	122.4	77/78
R&D on Voice Coding	248	74809	SED	DSS	Wohlberg	20.2	77/78
Shuttle Component Tests	259	74805	SED	DSM	Ahmed	23.6	77/78
12 GHz FET Ampl.	302	75933	SED	DSE	Minkus	104.2	77/78
Orbit Determ & Prediction	310	80281	SED	DSM	Mamen	79.3	78/79
LSI Codec Ph I	381	84221	SED	DSS	Wohlberg	30.5	78/79
LCET Ph I	383	84358	SED	DSE	Douville	29.7	78/79
Transient Event Counter	388	84793	SED	DSE	Gore	20.0	78/79
SHF Component Development	4.1A	40729	SED	DSE	Douville	114.0	75/76
LCET Ph II (QTY100)	483	84358	SED	DSE	Douville	370.9	79/80
Orbit Determ & Prediction	508	90835	SED	DSM	Grahame	55.5	79/80
LSI Codec Ph II	535	90809	SED	DSS	Wohlberg	157.5	79/80
Tel SET PH I	554	90932	SED	DSE	Gruno	75.0	79/80
Oscillator & Multiplier	571	91381	SED	DSE	Douville	105.2	80/81
LCET Ph III (Evaluation)	589	91455	SED	DSE	Douville	22.4	79/80
Tel SET Ph II	662	00638	SED	DSE	Douville	363.3	80/81
DMSK Study	773	10120	SED	DSS	Bryden	98.9	81/82
Strapdown Technology	121	60455	SPAR	DSM	Altman	93.9	76/77
Attitude Sensing System Ph I	218	74001	SPAR	DSM	Ahmed	78.0	77/78
14 GHz FET Amplifier	243	70665	SPAR	DSE	Douville	67.4	77/78
Solid State TWTA Replacement	245	74794	SPAR	DSE	May	81.9	77/78
Solar Array Deployment Mech	258	74719	SPAR	DSM	Ahmed	51.2	77/78
Transponder DBS	342	82272	SPAR	DSE	Palfreyman	452.7	78/79
IASCS Ph II	385	84258	SPAR	DSM	Millar	56.3	78/79
IASCS Ph III	486	90451	SPAR	DSM	Millar	153.8	79/80

IASCS Ph IV	518	90895	SPAR	DSM	Millar	110.5	79/80
SS PA 2W 14GHz	536	90933	SPAR	DSE	Douville	92.6	80/81
SADAPTA Solar Pwr Transfer	551	94004	SPAR	DSM	Jacques	80.7	79/80
Tel SET Ph I	553	90931	SPAR	DSE	Gruno	74.8	79/80
Heat Pipe Study	585	91459	SPAR	DSM	Wehrle	227.4	80/81
Tests on Solar Array Models	6.8	57788	SPAR	DSM	Ahmed	30.0	76/77
Tel SET Ph II	646	00582	SPAR	DSE	Douville	176.6	80/81
Microprocessor for ACS	669	04002	SPAR	DSM	Millar	340.0	81/82
SS PA 11.5W 4GHz	688	00811	SPAR	DSE	Cuhaci	229.0	81/82
TDMA/DSI Ph I (Teleglobe)	703	00863	SPAR	DSA	Nuspl	100.0	80/81
TEM Line R&D	721	04005	SPAR	DSE	Minkus	10.5	81/82
Tel SET Ph III	755	10059	SPAR	DSE	Douville	236.0	81/82
SADAPTA R&D & Monitoring	766	10100	SPAR	DSM	Ahmed	265.9	81/82
Attitude Beam Ctl R&D	768	10102	SPAR	DSM	Reynaud	266.8	81/82
TDMA/DSI Ph II	780	10217	SPAR	DSA	Buchanan	1530.0	81/82
Modal Analyses	82B	21794	SPAR	DSM	Vigneron	68.0	82/83
High Pwr Solar Array Devt.	82C	21911	SPAR	DSM	Ahmed	250.0	82/83
Space Station Study	82D	24603	SPAR	DSM	Altman	50.0	82/83
"L" Band Transmitter	240	70602	SPAR (STL)	DSS	Werstuik	400.9	77/78
Passive Radiative Cooler	299	75934	SPAR (STL)	DSM	Douville	59.1	78/79
TVRO SET 12GHz (Cable head)	332	81717	SPAR (STL)	DSE	Douville	65.5	78/79
Dichroic Surface Antenna	387	84505	SPAR (STL)	DSE	Lo/Milne	98.0	78/79
UHF Quartz Oscillator	472	85834	Sparton	DSE	Kuley	31.9	78/79
GaAs Solar Cells	965	22402	TPK	DSE	Hum	38.6	82/83
Reflector LCET	512	90711	Victrix	DSE	Kong	6.0	79/80
Reflector LCET	615	00438	Victrix	DSE	Douville	36.6	80/81
Reflector LCET	512	90711	Wind Turb	DSE	Kong	6.1	79/80
Reflector LCET	616	00428	Wind Turbine	DSE	Douville	19.6	80/81

ANNEX B: Project Costs and Sources of Funding

COMPANY	SCO	SOURCE OF FUNDS DSSC	DSS	CO	OTHER	TOTAL DSSC $ COST	AS % OF TOT DSSC $
ANCON	764	100.16	65.00			165.16	0.84
	765	115.83				115.83	0.98
	AAA	68.21				68.21	0.58
TOTAL ANCON		284.20	65.00	0.00	0.00	349.20	2.40
ANDREW	120	24.11				24.11	0.20
	247	29.96				29.96	0.25
	710	26.89				26.89	0.23
TOTAL ANDREW		80.96	0.00	0.00	0.00	80.96	0.68
ANTECH	82E	67.36	0.00	0.00	0.00	67.36	0.57
BNR	261	12.34	0.00	0.00	0.00	12.34	0.10
CAL	249	129.59	19.28			148.87	1.09
	541	525.10		150.00		675.10	4.43
TOTAL CAL		654.69	19.28	150.00	0.00	823.97	5.52
CMC	260	15.31	0.00	0.00	.0.00	15.31	0.13
CHROMAL	386	143.40		60.00		203.40	1.21
	845	122.08				122.08	1.03
TOTAL CHROMALOX		265.48	0.00	60.00	0.00	325.48	2.24
COM DEV	6.2	126.82	148.03			274.85	1.07
	119	55.91				55.91	0.47
	274	101.40	43.68			145.08	0.86
	521	60.00	86.80			146.80	0.51
	811	50.00		67.80	108.90	226.70	0.42
TOTAL COMDEV		394.13	278.51	67.80	108.90	849.34	3.32
DBC	832	34.46	0.00	34.57	0.00	69.03	0.29
DIGITAL DEV	131	26.10	0.00	0.00	0.00	26.10	0.22
DYNACON	775	92.01				92.01	0.78
	923	93.95				93.95	0.79
TOTAL DYNACON		185.96	0.00	0.00	0.00	185.96	1.57
EIDETIC	809	50.00				50.00	0.42
	914	150.00				150.00	1.27
TOTAL EIDETIC		200.00	0.00	0.00	0.00	200.00	1.69
ELECTROHO	485	66.03				66.03	0.56
	590	21.70				21.70	0.18
TOTAL ELECTROHOME		87.73	0.00	0.00	0.00	87.73	0.74
HERMES	595	24.93	0.00	0.00	0.00	24.93	0.21
INTELITEC	810	122.08				122.08	1.03
	913	150.00				150.00	1.27
TOTAL INTELLITECH		272.08	0.00	0.00	0.00	272.08	2.29
LEIGH	595	0.00	0.00	0.00	0.00	0.00	0.00
LINDSAY	512	4.05	0.00	0.00	0.00	4.05	0.03

COMPANY		SCO	SOURCE OF FUNDS DSSC	DSS	CO	OTHER	TOTAL COST	DSSC $ AS % OF TOT DSSC $
ANCON		764	100.16	65.00			165.16	0.84
		765	115.83				115.83	0.98
		AAA	68.21				68.21	0.58
TOTAL	ANCON		284.20	65.00	0.00	0.00	349.20	2.40
ANDREW		120	24.11				24.11	0.20
		247	29.96				29.96	0.25
		710	26.89				26.89	0.23
TOTAL	ANDREW		80.96	0.00	0.00	0.00	80.96	0.68
ANTECH		82E	67.36	0.00	0.00	0.00	67.36	0.57
BNR		261	12.34	0.00	0.00	0.00	12.34	0.10
CAL		249	129.59	19.28			148.87	1.09
		541	525.10		150.00		675.10	4.43
TOTAL	CAL		654.69	19.28	150.00	0.00	823.97	5.52
CMC		260	15.31	0.00	0.00	0.00	15.31	0.13
CHROMAL		386	143.40		60.00		203.40	1.21
		845	122.08				122.08	1.03
TOTAL	CHROMALOX		265.48	0.00	60.00	0.00	325.48	2.24
COM DEV		6.2	126.82	148.03			274.85	1.07
		119	55.91				55.91	0.47
		274	101.40	43.68			145.08	0.86
		521	60.00	86.80			146.80	0.51
		811	50.00		67.80	108.90	226.70	0.42
TOTAL	COMDEV		394.13	278.51	67.80	108.90	849.34	3.32
DBC		832	34.46	0.00	34.57	0.00	69.03	0.29
DIGITAL DEV		131	26.10	0.00	0.00	0.00	26.10	0.22
DYNACON		775	92.01				92.01	0.78
		923	93.95				93.95	0.79
TOTAL	DYNACON		185.96	0.00	0.00	0.00	185.96	1.57
EIDETIC		809	50.00				50.00	0.42
		914	150.00				150.00	1.27
TOTAL	EIDETIC		200.00	0.00	0.00	0.00	200.00	1.69
ELECTROHO		485	66.03				66.03	0.56
		590	21.70				21.70	0.18
TOTAL	ELECTROHOME		87.73	0.00	0.00	0.00	87.73	0.74
HERMES		595	24.93	0.00	0.00	0.00	24.93	0.21
INTELITEC		810	122.08				122.08	1.03
		913	150.00				150.00	1.27
TOTAL	INTELLITECH		272.08	0.00	0.00	0.00	272.08	2.29
LEIGH		595	0.00	0.00	0.00	0.00	0.00	0.00
LINDSAY		512	4.05	0.00	0.00	0.00	4.05	0.03

MAECL	537	236.66				236.66	2.00
MAECL	777	75.00			30.00	105.00	0.63
TOTAL MAECL		311.66	0.00	0.00	30.00	341.66	2.63
MILLER	236	9.55				9.55	0.08
	241	270.37		30.00		300.37	2.28
	251	23.02				23.02	0.19
	264	23.20				23.20	0.20
	424	132.49	353.00	52.00		537.49	1.12
	718	0.00	39.00			39.00	0.00
	867	20.33				20.33	0.17
	887	15.79				15.79	0.13
	969	19.82				19.82	0.17
	FFF	190.38				190.38	1.61
TOTAL MILLER		704.94	392.00	82.00	0.00	1178.94	5.95
OPTO. ELECT.	82A	73.92	178.60	0.00	61.07	313.59	0.62
PARKER	512	5.89	0.00	0.00	0.00	5.89	0.05
QRL	888	19.02	100.00	20.00	0.00	139.02	0.16
RAYTHEON	866	302.60	0.00	0.00	0.00	302.60	2.55
SED	4.1	114.00	256.00			370.00	0.96
	115	39.99				39.99	0.34
	229	11.20	31.70			42.90	0.09
	246	122.42				122.42	1.03
	248	20.20				20.20	0.17
	259	23.57				23.57	0.20
	302	104.20		20.00		124.20	0.88
	310	79.29				79.29	0.67
	381	30.55				30.55	0.26
	383	29.73				29.73	0.25
	388	20.00				20.00	0.17
	483	370.92				370.92	3.13
	508	55.52				55.52	0.47
	535	157.49				157.49	1.33
	554	75.00				75.00	0.63
	571	105.19		22.19		127.37	0.89
	589	22.37				22.37	0.19
	662	363.34		363.34		726.67	3.06
	773	98.91		3.81		102.72	0.83
TOTAL SED		1843.88	287.70	409.33	0.00	2540.91	15.55
SPAR	6.8	30.00	34.00			64.00	0.25
	121	93.89				93.89	0.79
	218	78.00	238.00			316.00	0.66
	240	400.92				400.92	3.38
	243	67.40				67.40	0.57
	245	81.93				81.93	0.69
	258	51.21				51.21	0.43
	299	59.10				59.10	0.50
	332	63.19		147.44		210.63	0.53
	342	452.70				452.70	3.82
	385	56.30				56.30	0.47
	387	97.96				97.96	0.83
	486	153.82				153.82	1.30
	518	110.51				110.51	0.93

SPAR (CONT)	536	92.56				92.56	0.78
	551	80.68	85.00	25.00		190.68	0.68
	553	74.77				74.77	0.63
	585	227.43		20.00	35.00	282.43	1.92
	646	176.60		176.60		353.19	1.49
	669	340.00	225.00			565.00	2.87
	688	229.00				229.00	1.93
	703	100.00				100.00	0.84
	721	10.50	41.79	14.20		66.49	0.09
	755	235.99		235.99		471.98	1.99
	766	265.90		50.00		315.90	2.24
	768	266.79				266.79	2.25
	780	1580.00		1500.00	3080.00	6160.00	13.33
	82B	68.00	116.90			184.90	0.57
	82C	250.00	168.92			418.92	2.11
	82D	50.00	200.00		250.00	500.00	0.42
TOTAL SPAR		5845.16	1109.61	2169.23	3365.00	12488.99	49.30
SPARTON	472	31.88	0.00	23.91	0.00	55.79	0.27
TPK	965	38.64	0.00	0.00	0.00	38.64	0.33
VICTRIX	512	6.00				6.00	0.05
	615	36.57		10.00		46.57	0.31
TOTAL VICTRIX		42.57	0.00	10.00	0.00	52.57	0.36
WIND TURB	512	6.13				6.13	0.05
	616	19.60		10.00		29.60	0.17
TOTAL WIND TURB		25.73	0.00	10.00	0.00	35.73	0.22
GRAND TOTAL		11855.66	2430.70	3036.84	3564.97	20888.17	100.00
% OF TOTAL		56.76	11.64	14.54	17.07	100.00	

TOTAL TO ROW 101		5871.69	1321.09	823.70	199.97	8216.45	49.53
TOTAL TO ROW 151		5983.98	1109.61	2213.14	3365.00	12671.72	50.47

ANNEX C: Project Descriptions/Fact Sheets

PROJECT FACT SHEETS

This Annex contains brief one page summaries of the cost, timing and objectives of each project funded under the DSSC program. The sheets are organized by SCO number, and the comments are in most cases those made by the scientific authority.

There are wide variations in the characteristics of the DSSC projects:

a) Duration ranges from a few months to several years

b) The projects cover all areas of ground and flight systems, including bus and payload

c) The time frame for payoff of the project activity ranges from several months to years

d) The products or technologies developed address markets ranging from one or more custom units to large quantities of production type items, and

e) The projects range in nature from studies and high risk research activities to development and refinement of engineering models of specific products.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Evaluation and prototype development of a tuned rotor gyroscope system for spacecraft use.

SCO: AAA

REQ: 2056236001-2-2872

Contractor: ANCON

2. HISTORY: Start Date: August 23, 1982

Target Date: August 31, 1983

Completion: Projected February 1984

Funding:

Estimated Cost: $68,211.00
Actual Cost: Not finished

Source: ICF $68,211.00
DSS
Company
Other

Objectives: Evaluation of a prototype tuned rotor gyro using a previously developed test system, and to certify the applicability of the test system.

Objectives were: Partly met.

3. GENERAL COMMENTS:

Project not complete. Delay due to late delivery of tuned rotor gyro (a prototype development unit, now expected in June 83). Expect to fully meet objectives.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of Engineering Prototype DMSK Modem - Phase III

SCO: FFF

REQ: 19SV.36001-2-2872

Contractor: Miller

2. HISTORY: Start Date: 1982

Target Date: 29 February 1984

Completion: Ongoing

Funding:

Estimated Cost: $190,384.00
Actual Cost:

Source: ICF $190,384.00
DSS
Company
Other

Objectives: To design and fabricate six half-duplex DMSK modems which use differential detection. The modems are to be engineering models with packaging suitable for follow-on production in volume.

Objectives were: On schedule

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: SHF Component Development

   SCO: 4.1A

   REQ: 14SQ-36100-4-0729

   Contractor: SED

2. HISTORY: Start Date: July 1975

   Target Date:

   Completion: August 1977

   Funding:

   Estimated Cost: $370,000.00
   Actual Cost: 370,000.00

   Source: ICF $114,000.00
   DSS 256,000.00
   Company
   Other

   Objectives: To develop an SHF fabrication facility and expertise for earth terminal applications and more specifically for low noise amplifiers and mixer/preamps at 4/12 GHz.

   Objectives were: Fully met.

3. GENERAL COMMENTS:

   Very little information available.

DSSC
PROJECT FACT SHEET

1. **PROJECT:** Title: Development of a reliable, economic parametric amplifier design for 12GHz receiver applications.

   SCO: 6.2

   REQ: 16ST-36100-6-0313

   Contractor: Com Dev

2. **HISTORY:** Start Date: 19 June 1976

   Target Date: 18 March 1977

   Completion: July 1977

Funding:

Estimated Cost: $126,851.00
Actual Cost: 126,816.00

Source: ICF $126,816.00
DSS
Company
Other

Objectives: Overall development and integration of the parametric amplifier design; construction and testing of a prototype.

Objectives were: Not met.

3. **GENERAL COMMENTS:**

Technical problems much more difficult than anticipated. Com Dev staff too inexperienced.

The contract was predicated on the development of a new solid state device by an American supplier which was unsuccessful.

Low noise microwave FET technology became available, with the result that the need for the paramp began to evaporate.

Phase I was totally funded by DSS starting in 1975 (Phase I value $148,034.00).

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Rigid Panel Solar Array Breadboard Model Testing.

   SCO: 6.8

   REQ: 36001-5-7788

   Contractor: SPAR

2. HISTORY: Start Date: January 7, 1976

   Target Date: 42 Weeks Later

   Completion: March 31, 1977

Funding:

Estimated Cost: $63,300.00
Actual Cost: $64,000.00

Source:	ICF	$30,000.00
	DSS	$34,000.00
	Company	Yes, but amount unknown
	Other	

Objectives: To conduct vibration tests on rigid panel solar array engineering model (hardware refurbishment; pre-test analysis; substrate test and fabrication; deployment; modification, acoustic testing at NRC (uplands); vibration testing at DFL (CRC).

Objectives were: Exceeded.

3. General Comments:

The technical objectives were exceeded. DOC obtained results from two series of tests although the contract called for only one. The first series of tests were conducted on the array model using simulated solar cells. The second series of tests were carried out with actual solar cells in critical areas. Both tests were successful and the technical feasibility of the design was established. The project took longer than estimated because of the additional tests. The cost of the additional tests were funded out of SPAR's own R&D budget. The cost to the Crown was within the budgeted $64,000. The results of the study are reported in SPAR reports R-806, R-823 and R-824.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: F-4 satellite subsystem - 12GHz frequency synthesizer.

SCO: 115

REQ: 12ST.36100-6-0399

Contractor: SED

2. HISTORY: Start Date: October 28, 1976

Target Date: March 31, 1977

Completion: March 31, 1977

Funding:

Estimated Cost: $40,000.00
Actual Cost: $39,900.00

Source: ICF $39,900.00
DSS
Company
Other

Objectives: To develop a frequency synthesizer for use in 12GHz receiver terminals.

Objectives were: Fully Met

DSSC
PROJECT FACT SHEET

1. **PROJECT:** Title: Feasibility study and developement of a UHF diplexer for use in a satellite communications system.

   SCO: 119

   REQ: 36100-6-0451

   Contractor: ComDev Ltd.

2. **HISTORY:** Start Date: November 29, 1976

   Target Date: May 24, 1977

   Completion: Hardware: September 15, 1977
   Report: December 01, 1977

Funding:

Estimated Cost: $55,912.00
Actual Cost: $55,912.00

Source: ICF $55,912.00
DSS
Company
Other

Objectives: To design and manufacture an advanced development model UHF Diplexer for MUSAT feasibility study. Investigate multipactor and passive intermodulation problems.

Objectives were: Fully Met

3. **GENERAL COMMENTS:**

Lengthy manufacturing time and PIM measurement problems were the primary causes of schedule delay.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of sidelobe reduction techniques for 4/6 GHz parabolic earth terminal antennas.

   SCO: 120

   REQ: 60452

   Contractor: Andrew Antenna

2. HISTORY: Start Date: 26 November, 1976

   Target Date: 31 March, 1977

   Completion: 12 May, 1977

Funding:

Estimated Cost: $24,105.00
Actual Cost: $24,105.00

Source: ICF $24,105.00
DSS
Company
Other

Objectives: The objectives are basically the same as that described in the title above.

Objectives were: Fully Met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: A feasibility study for stability augmentation of the SRMS control system using strapdown technology - Phase II.

SCO: 121

REQ: 36100-6-0455

Contractor: SPAR

2. HISTORY: Start Date: 13 September 1976

Target Date: 31 March 1977

Completion: 31 March 1977

Funding:

Estimated Cost: $107,464.00
Actual Cost: $ 93,888.00

Source: ICF $ 93,888.00
DSS
Company
Other

Objectives:
1. Review existing RMS control system.
2. Conduct study to determine feasibility of providing stability augmentation.
3. Identifiy likely condidate configurations.
4. Demonstrate that chosen schemes can provide augmentation.
5. Conduct sensor hardware survey/elevation and prepare a preliminary specification.
6. Prepare a report and submit a proposal for hardware phase to interface with SRMS system tests.

Objectives were: Partly Met

3. General Comments:

The contractor got behind schedule early on in the contract and was unable to make up the effort.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Digital Demand Assignment Controller Prototype

SCO: 131

REQ: 36100-6-0524

Contractor: Digital Devices

2. HISTORY: Start Date: 13 October 1976

Target Date: 30 April 1977

Completion: Terminated 28 October 1977

Funding:

Estimated Cost: $30,172.00
Actual Cost: $26,100.00

Source:	ICF	$26,100.00
	DSS	
	Company	
	Other	

Objectives: To conduct a design study of a demand assignment controller for application in portable and mobile ground stations.

Objectives were: Partly met.

3. GENERAL COMMENTS:

This project was terminated because Digital Devices stopped all operations in June 1977. In October DOC decided that the completion of the contract would be of limited value to the Department and it was unlikely that Digital could complete this contract to the satisfaction of the Department.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Study to develop an Integrated Attitude Sensing and Control System for use with future spacecraft/satellites.

SCO: 218

REQ: 36100-7-4001

Contractor: SPAR

2. HISTORY: Start Date: October 6, 1977

Target Date: October 6, 1978

Completion: December 1978

Funding:

Estimated Cost: $315,978.00
Actual Cost: 315,978.00

Source: ICF $ 78,000.00
DSS $237,978.00
Company
Other

Objectives: Design an integrated attitude sensing system: propose test technique to demonstrate proof of performance; procure hardware; integrate hardware with test equipment; carry out system test; prepare and deliver report and experimental hardware to CRC.

Objectives were: Partly Met

3. General Comments:

U.P.-S-149

The amount of work involved to meet objectives was under-estimated. Cost over-runs were absorbed by the company.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Development of 4 GHz and 12 GHz Ferrite circulators.

SCO: 229

REQ: 13ST-36001-7-3130

Contractor: SED

2. HISTORY: Start Date: November 7, 1977

Target Date: May 19, 1978

Completion: June 13, 1978

Funding:

Estimated Cost: $42,897.00
Actual Cost: 42,897.00

Source: ICF $ 11,200.00
DSS $ 31,697.00
Company
Other

Objectives: To develop advanced design minimum loss circulators for use primarily in satellite earth terminal receiver front ends at 4&12 GHz.

Objectives were: Partly Met

3. General Comments:

Technical objectives were not met because of a technical problem which could not be overcome.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Design, assembly and documentation of 6/4 GHz test translator.

SCO: 236

REQ: 16ST.36001-7-4802

Contractor: Miller

2. HISTORY: Start Date: 16 January 1978

Target Date: 31 March 1978

Completion: April 1979

Funding:

Estimated Cost: $10,000.00
Actual Cost: $ 9,546.49

Source: ICF $ 9,546.49
DSS
Company
Other

Objectives: To design, construct, test, document and deliver a test-loop translator. Full technical specifications were provided to the contractor.

Objectives were: Fully Met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Design, develop, construct and life test a general purpose L-Band Transmitter.

SCO: 240

REQ: 36100-7-0602 (7-5440)

Contractor: SPAR

2. HISTORY: Start Date: 27 February 1978

Target Date: 31 October 1979

Completion: 31 March 1981

Funding:

Estimated Cost: $333,114.00
Actual Cost: $400,916.33

Source: ICF $400,916.33
DSS
Company
Other

Objectives: The contract provided for a design study, the construction of a test model and life test for an L-Band transmitter suitable for satellite telemetry application.

Objectives were: Fully Met

3. General Comments:

The delays in completion date were caused by technical problems which were eventually overcome. These were partly due to the concurrent SARSAT program.

Also contributing to the delay were union labour problems (engineering strike) at SPAR along with other larger contracts competing for resources.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: MUSAT Channel Unit.

SCO: 241

REQ: 74005

Contractor: Miller

2. HISTORY: Start Date: March 1978

Target Date: January 1979

Completion: January 1979

Funding:

Estimated Cost: $189,840.00
Actual Cost: $270,371.00

Source: ICF $270,371.00
DSS
Company
Other

Objectives: To provide a complete channel unit suitable for a mobile terminal in the MUSAT system.

Objectives were: Partly Met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of an 14 GHz radiation cooled FET amplifier for spacecraft applications.

   SCO: 243

   REQ: 16ST-36102-7-0665

   Contractor: SPAR

2. HISTORY: Start Date: 1 December 1977

   Target Date: 15 April 1978

   Completion: 10 August 1978

   Funding:

   Estimated Cost: $67,402.00
   Actual Cost: $67,402.00

   Source: ICF $67,402.00
   DSS
   Company
   Other

   Objectives: To develop a low noise 14 GHz FET amplifier to be cooled to nominally - 100°C for use in satellite transponder front ends and to be used with a passive radiation cooler (to be developed under a related contract.)

   Objectives were: Exceeded

3. GENERAL COMMENTS:

   A cooled amplifier has still not been flown. The scientific authority sees no reason for this.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: A Solid State Replacement for TWTA's at 4 and 12 GHz.

SCO: 245

REQ: 36001-74794

Contractor: SPAR

2. HISTORY: Start Date: 1 February 1978

Target Date: 15 January 1979

Completion: 31 March 1979

Funding:

Estimated Cost: $87,428.00
Actual Cost: $81,932.00

Source: ICF $81,932.00
DSS
Company
Other

Objectives: To produce an amplifier using gallium arsenide FET to replace TWTA at 4 and 12 GHz.

Objectives were: Exceeded

3. GENERAL COMMENTS:

Initial design goals for 4GHz exceeded.

For 12 GHz only achieved 50% of specified power output, due to the limitation of the devices available.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Development of prototype earth terminals for direct-to-home reception of broadcast TV at 12GHz.

SCO: 246

REQ: 16ST-36001-7-4793

Contractor: SED

2. HISTORY: Start Date: 7 March 1978

Target Date: Approximately 35 weeks

Completion: March 80 (est)

Funding:

Estimated Cost: $106,365.00
Actual Cost: $122,423.00

Source: ICF $122,423.00
DSS
Company
Other

Objectives: To develop prototype earth terminals for direct-to-home reception of broadcast TV at 12GHz.

Objectives were: Fully met

3. GENERAL COMMENTS:

The scope was increased which increased cost to $122,423.00. Most delay time was due to failure to produce final report rather than work. SED was working on other contracts.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Develop Helix Antenna (MUSAT) for concept study on Man-Pack Earth Station Antenna for MUSAT.

SCO: 247

REQ: 74808

Contractor: Andrew Antenna

2. HISTORY: Start Date: 25 February 1977

Target Date: 31 January 1978

Completion: 7 February 1978

Funding:

Estimated Cost: $30,000.00
Actual Cost: $29,960.32

Source: ICF $29,960.32
DSS
Company
Other

Objectives: To evaluate possible antenna configurations suitable for use as part of a portable ground station for the proposed multi-purpose UHF satellite (MUSAT).

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Research and Development on Voice Coding

SCO: 248

REQ: 16ST. 36001-7-4809

Contractor: SED

2. HISTORY: Start Date: 2 January 1978

Target Date: 31 March 1978

Completion: 31 March 1978

Funding:

Estimated Cost: $20,172.00
Actual Cost: $20,200.00

Source: ICF $20,200.00
DSS
Company
Other

Objectives: To develop a delta codec with improved signal to noise ration and dynamic range over commercially available codecs.

Objectives were: Fully met.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Study of high reliability advanced battery management system--Phase I (HRBMS).

SCO: 249 (I)

REQ: 3600-7-1339

Contractor: Canadian Astronautics

2. HISTORY: Start Date: 12 July 1977

Target Date: December 15, 1977

Completion: December 15, 1977

Funding:

Estimated Cost: $19,254.00
Actual Cost: $19,254.00

Source: ICF
DSS $19,254.00
Company
Other

Objectives: To assess the feasibility of a high reliability battery management system.

Objectives were: Fully Met

3. GENERAL COMMENTS:

This initial phase was completely funded by DSS and there was, therefore, very little documentation available at CRC.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: High reliability advanced battery management system--Phase II (HRBMS).

SCO: 249 (II)

REQ: 3600-7-4792

Contractor: Canadian Astronautics

2. HISTORY: Start Date: 2 March 1978

Target Date: 31 March, 1978

Completion: 31 March, 1978

Funding:

Estimated Cost: $129,230.93
Actual Cost: $129,588.68

Source:	ICF	$129,588.68
	DSS	
	Company	
	Other	

Objectives: To design, develop and test prototype hardware for a high reliability battery management system.

Objectives were: Fully Met

3. GENERAL COMMENTS:

Not all aspects of the design were breadboarded. This caused delays in Phase III.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Forward Error Correction Codec

SCO: 251

REQ: 7-4806

Contractor: Miller

2. HISTORY: Start Date: 20 January 1978

Target Date: May 1978

Completion: 31 March 1979

Funding:

Estimated Cost: $17,135.00
Actual Cost: $23,024.00

Source: ICF $23,024.00
DSS
Company
Other

Objectives: Develop coder/decoder employing microprocessor, manufacture and supply two prototypes with technical report and documentation.

Objectives were: Fully Met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Large Hybrid Solar Array Design Verification Study

SCO: 258

REQ: 74719

Contractor: SPAR

2. HISTORY: Start Date: 25 January 1978

Target Date: 31 March 1978

Completion: 31 March 1978

Funding:

Estimated Cost: $57,383.00
Actual Cost: $51,211.00

Source: ICF $51,211.00
DSS
Company
Other

Objectives: To design a "design verification unit" for a large hybrid solar array to augment confidence that the critical features of the flight design would perform as expected.

Objectives were: Fully Met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Shuttle Component Tests

SCO: 259

REQ: 74805

Contractor: SED

2. HISTORY: Start Date: January 12, 1978

Target Date: March 31, 1978

Completion: March 31, 1978

Funding:

Estimated Cost: $24,972.00
Actual Cost: $23,568.62

Source:	ICF	$23,568.62
	DSS	
	Company	
	Other	

Objectives: To establish feasibility of using the STS orbiter as a test bed for in-situ testing spacecraft components that would otherwise be difficult to test in an earth environment.

Objectives were: Fully Met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Analogue voice privacy devices study.

SCO: 260

REQ: 16ST.36001-7-4804

Contractor: Canadian Marconi

2. HISTORY: Start Date: 27 January 1978

Target Date: 31 March 1978

Completion: 30 April 1978

Funding:

Estimated Cost: $15,000.00
Actual Cost: $15,309.06

Source: ICF $15,309.06
DSS
Company
Other

Objectives: To examine various techniques for providing voice privacy over telephone and radio channels primarily for police communications.

Objectives were: Exceeded

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Development of conceptual designs of Analogue Voice Privacy Devices.

SCO: 261

REQ: 16ST.36001-7-4803

Contractor: BNR

2. HISTORY: Start Date: 24 February 1978

Target Date: 31 March 1978

Completion: 30 March 1978

Funding:

Estimated Cost: $14,490.15
Actual Cost: $12,342.65

Source: ICF $12,342.65
DSS
Company
Other

Objectives: To research and develop conceptual designs, to the block diagram level of analog voice privacy devices suitable for satellite communications services.

Objectives were: Partly Met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: TDMA SET Study

SCO: 264

REQ: 7-4801

Contractor: Miller Communications

2. HISTORY: Start Date: December 1977

Target Date:

Completion: April 1978

Funding:

Estimated Cost: $23,200.00
Actual Cost: $23,200.00

Source: ICF $23,200.00
DSS
Company
Other

Objectives: To investigate the feasibility and economic viability of a medium capacity TDMA ground station.

Objectives were: Fully Met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Design and Development of an efficient low-loss high-power combining network for satellite earth terminals operating in the 14-14.5GHz frequency band.

SCO: 274

REQ: 36001-72389

Contractor: Com Dev

2. HISTORY: Start Date: 3 October 1977

Target Date: 3 September 1978

Completion: February 1979

Funding:

Estimated Cost: $145,078.00
Actual Cost: $144,854.00

Source:	ICF	$101,400.00
	DSS	43,678.00
	Company	
	Other	

Objectives: To design and develop an efficient low-loss, high-power combining network for satellite, earth terminals operating in the 14-14.5 GHz frequency band.

Objectives were: Fully Met

3. GENERAL COMMENTS:

Contract was handled well and the company has ultimately made sales.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of a Passive Radiative Cooler.

SCO: 299

REQ: 36001-7-5934

Contractor: SPAR

2. HISTORY: Start Date: April 14, 1978

Target Date: August 31, 1978

Completion: April 28, 1979

Funding:

Estimated Cost: $52,704.75
Actual Cost: $59,104.75

Source:	ICF	$59,104.75
	DSS	
	Company	
	Other	

Objectives: To develop Canadian capability to design, fabricate and test a component for the cooling of low noise amplifiers on communications and other spacecraft.

Objectives were: Fully Met.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of a low cost Peltier cooled 12 GHz FET amplifier.

SCO: 302

REQ: 75933

Contractor: SED

2. HISTORY: Start Date: March 21, 1978

Target Date: August 31, 1978

Completion: May 31, 1978

Funding:

Estimated Cost: $ 84,764.00
Actual Cost: $104,198.34

Source: ICF $104,198.34
DSS
Company
Other

Objectives: To design, develop and fabricate a broadboard model of a 12 GHz low cost FET amplifier using Peltier cooling suitable for satellite ground stations.

Objectives were: Partly met

3. General Comments:

The Peltier cooling was never fully realized. Another company approached DOC to do further work on Peltier cooling, however, SED has the rights to this work. SED has not yet performed further work on this.

Originated as a UP.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: To perform studies to modify and extend satellite orbit determination and predictions program.

SCO: 310

REQ: 36001-8-0281

Contractor: SED

2. HISTORY: Start Date: May 1, 1978

Target Date: 31 March 1979

Completion:

Funding:

Estimated Cost: $75,327.00
Actual Cost: $79,289.00

Source: ICF $75,327.00
DSS
Company
Other

Objectives: A. Modify the existing ODAP program to operate on a parametric representation of orbital dynamics instead of the current cartesian coordinates and perform a comparison on the basis of speed, accuracy, size of program, computing requirements.

B. Extend the software for accurate orbit prediction (for the generation of satellite position and velocity tracking data at arbitrary times), to be implemented as Fortran subroutines and in an interactive mode.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of prototype 12GHz earth terminals for CATV.

SCO: 332

REQ: SST.36001-8-1717

Contractor: SPAR

2. HISTORY: Start Date: 16 October 1978

Target Date: 30 April 1979

Completion: 27 March 1980

Funding:

Estimated Cost: $63,817.00
Actual Cost: $63,190.00

Source: ICF $63,190.00
DSS
Company Yes (amount unknown)
Other

Objectives: Development of prototype 12GHz earth terminals for CATV as opposed to DBS reception.

Objectives were: Partly met

3. GENERAL COMMENTS:

Technical objectives were met but they did not achieve a suitable design for production. Final report was slow in coming which caused the late delivery date.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: DBS Transponder

SCO: 342

REQ: 82272

Contractor: SPAR

2. HISTORY: Start Date: February 26, 1979

Target Date: March 31, 1980

Completion: March 31, 1980

Funding:

Estimated Cost: $452,700.00
Actual Cost: $452,700.00

Source: ICF $452,700.00
DSS
Company
Other

Objectives: To develop a brassboard DBS transponder at 14/12 GHz incorporating new technology eg. passively cooled receiver front end, ALC, modular construction, new L.O., etc.; to include additional 19/12 GHz image enhanced mixed front end.

Objectives were: Fully Met.

3. GENERAL COMMENTS:

The work performed on the 14/12 GHz portion was very good - all specs were met. The noise figure on the 19/12 GHz front end was outside spec.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Duplex LSI Delta Codec - Phase I

SCO: 381

REQ: 36001-8-4221

Contractor: SED

2. HISTORY: Start Date: 26 January 1979

Target Date: March 1980

Completion: November 1979

Funding:

Estimated Cost: $30,500.00
Actual Cost: $30,549.00

Source: ICF $30,549.00
DSS
Company
Other

Objectives: Development of a delta codec with improved signal to noise ratio and dynamic range over commercially available codecs.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Production and Evaluation of Direct-to-home TVRO Terminals

   Phase I: Engineering

   SCO: 383

   REQ: 36001-8-4358

   Contractor: SED

2. HISTORY: Start Date: December 1979

   Target Date: January 1979

   Completion: March 1979

Funding:

Estimated Cost: $44,390.00
Actual Cost: $29,734.00

Source: ICF $29,734
DSS
Company
Other

Objectives: The objective of the project was to advance the development of 12 GHz TVRO (TV Receive-Only) terminals for direct broadcast satellite reception to the state where reliable units could be produced in volume. Phase I was to address aspects of the developmental prototype design which would best be changed to accommodate production manufacturing and reliability concerns and to generate the required engineering design changes and reliability histories of such units.

Objectives were: Fully Met

3. GENERAL COMMENTS:

As a result of the contract, SED established supplier relationships with General Instruments and CODAN (Australia).

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Study for the development of an on-board processor for a satellite integrated attitude sensing and control system (IASCS Phase II).

SCO: 385

REQ: 36001-8-4258

Contractor: SPAR

2. HISTORY: Start Date: 18 January 1979

Target Date: 15 April 1979

Completion: April 1979

Funding:

Estimated Cost: $56,325.00
Actual Cost: 56,325.00

Source: ICF $56,325.00
DSS
Company
Other

Objectives: As noted in title.

Objectives were: Fully Met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Design, fabrication and test of 12 variable capacity heatpipes--Phase I.
SCO: 386

REQ: 36001-8-4257

Contractor: Chromalox

2. HISTORY: Start Date: January 23, 1979

Target Date: March 31, 1980

Completion: December 16,1980

Funding:

Estimated Cost:	$134,338.04
Actual Cost:	143,404.00

Source:	ICF	$143,404.00
	DSS	
	Company	60,000.00 (estimated)
	Other	

Objectives: To design, fabricate and test to flight qualification standards a variable conductance heatpipe system for thermal control of communications and other types of spacecraft.

Objectives were: Fully Met

3. GENERAL COMMENTS:

The contractor was slow to get to the heart of the required work, and consequently failed to accomplish all the activities originally planned. The final report was late by nearly 9 months.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Dichroic Surface Antenna.

SCO: 387

REQ: 17ST-036001-8-4505

Contractor: SPAR

2. HISTORY: Start Date: March 22, 1979

Target Date: March 22, 1980

Completion: N/A

Funding:

Estimated Cost: $97,385.12
Actual Cost: 97,963.56

Source: ICF $97,963.56
DSS
Company
Other

Objectives: To demonstrate an antenna design principle which would permit an antenna to operate in more than 2 frequency bands simultaneously.

Objectives were: Partly Met

3. GENERAL COMMENTS:

Did not satisfactorily carry out the final testing.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Transient event counter (SED System Inc. Saskatoon).

SCO: 388

REQ: 8-4793

Contractor: SED

2. HISTORY: Start Date: March 30, 1979

Target Date: April 1, 1980

Completion: February 27, 1980 (termination)

Funding:

Estimated Cost: $52,406.36
Actual Cost: $20,000.00

Source: ICF $20,000.00
DSS
Company
Other

Objectives: To manufacture an engineering model of a spacecraft transient event counter.

Objectives were: Not Met.

3. GENERAL COMMENTS:

Contractor failed to recognize deficiencies in CRC developed specifications and was unable to perform satisfactorily. Project terminated by CRC.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: TDMA SET Development

SCO: 424

REQ: 8-4892

Contractor: Miller Communications

2. HISTORY: Start Date: April 18, 1979

Target Date: October, 1980

Completion: November, 1980

Funding:

Estimated Cost: $395,535.00
Actual Cost: $485,486.00

Source: ICF $132,486.00
DSS $353,000.00
Company $40,000.00
Other

Objectives: Development and delivery of 2 TDMA terminals to DOC.

Objectives were: Fully Met.

3. GENERAL COMMENTS:

Resulted from an unsolicited proposal. Two terminals were built at the same time for CNCP.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Development of a high-stability UHF Oscillator using a quality crystal.

SCO: 472

REQ: 36001-8-5834

Contractor: Sparton

2. HISTORY: Start Date: March 1 1979

Target Date: October 1 1979

Completion: March 15, 1980

Funding:

Estimated Cost: $31,883.52
Actual Cost: $31,883.52

Source: ICF $31,883.52
DSS
Company
Other

Objectives: To develop a high stability UHF quartz oscillator for applications to 406MHz ELT EPIRBS as 401 MHZ DRP's.

Objectives were: Not Met.

3. GENERAL COMMENTS:

The approach used by the Company did not result in an oscillator unit which met the temperature - frequency specifications of the ELT.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Production and Evaluation of Direct-to-home TVRO Terminals, Phase II (Production)

SCO: 483

REQ: 36001-8-4358

Contractor: SED

2. HISTORY: Start Date: March 1979

Target Date: December 1979

Completion: March 1980

Funding:

Estimated Cost: $345,862.00
Actual Cost: $370,922.00

Source: ICF $370,922.00
DSS
Company
Other

Objectives: The objective of the project was to advance the development of 12 GHz TVRO (TV Receive Only) terminals for direct broadcast satellite reception to the state where reliable units could be produced in volume. Phase II was the manufacturing phase and was to establish a representative production capability for this type of product and to resolve any outstanding process problems which had not been identified in Phase I. This phase was also to provide a total of 100 units which would be used in field trials by DOC to further develop an appreciation of design features which might be desirable in later consumer product lines. Of these, 25 units were to be selected at random for particularly close monitoring at all stages.

Objectives were: Fully Met

3. GENERAL COMMENTS:

The experience assisted SED in establishing and improving their design for 4 GHz TVRO's thus realizing major sales to both Canada and the U.S.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Indoor Unit for Low Cost Earth Terminals for use with satellite broadcasting of TV signals.

SCO: 485

REQ: 36001-9-0452

Contractor: Electrohome

2. HISTORY: Start Date: May 1979

Target Date: May 1980

Completion: September 1980

Funding:

Estimated Cost: $66,025.00
Actual Cost: $66,025.00

Source: ICF $66,025.00
DSS
Company
Other

Objectives: This contract was aimed at assisting Electrohome to improve upon a design established at CRC for the indoor unit portions of 12 GHz direct-to-home TV receiver terminals and to establish Electrohome as a supplier of such systems (particularly to SED for the LCET Production and Evaluation Contracts (SCO 483, 383)).

Objectives were: Fully met.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Integrated Attitude Sensing and Control System (IASCS) Phase III.

SCO: 486

REQ: 36001-9-0451

Contractor: SPAR

2. HISTORY: Start Date: 11 June 1979

Target Date: 24 Weeks

Completion:

Funding:

Estimated Cost: $153,824.00
Actual Cost: 153,824.00

Source: ICF $153,824.00
DSS
Company
Other

Objectives: Evaluation and system simulation of alternative methods for obtaining attitude control and estimating attitude data for the development of an automatic reacquisition procedure for a satellite integrated attitude sensing and control system.

Objectives were: Fully Met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Orbit Determination and Prediction.

SCO: 508

REQ: 36100-9-0835

Contractor: SED

2. HISTORY: Start Date: February 1, 1980

Target Date: October 31, 1980

Completion: October 31, 1980

Funding:

Estimated Cost: $55,500.00
Actual Cost: 55,516.00

Source: ICF $55,516.00
DSS
Company
Other

Objectives: Survey of Canadian requirements in Orbit Determination and Prediction; modification and documentation of existing software.

Objectives were: Fully Met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Fabrication Techniques.

SCO: 512

REQ: 36100-9-0711

Contractor: Wind Turbine Co.

2. HISTORY: Start Date: 22 January 1980

Target Date: 31 March 1980

Completion: 31 March 1980

Funding:

Estimated Cost: $6,125.00
Actual Cost: 6,125.00

Source:	ICF	$6,125.00
	DSS	
	Company	
	Other	

Objectives: To develop a practical fabrication technique leading to a low cost production microwave antenna, including reflection, feed and antenna mount.

Objectives were: Fully Met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Antenna Fabrication Techniques.

SCO: 512-1

REQ: 36100-9-0711

Contractor: Lindsay Co.

2. HISTORY: Start Date: 18 January 1980

Target Date: 31 March 1980

Completion: 31 March 1980

Funding:

Estimated Cost: $4,050.00
Actual Cost: 4,050.00

Source:	ICF	$4,050.00
	DSS	
	Company	
	Other	

Objectives: To develop a practical fabrication technique leading to a low cost production microwave antenna, including reflection, feed and antenna mount.

Objectives were: Fully Met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Antenna Fabrication Techniques.

SCO: 512

REQ: 36100-9-0711

Contractor: Parker

2. HISTORY: Start Date: 18 January 1980

Target Date: 31 March 1980

Completion: 18 March 1980

Funding:

Estimated Cost: $5,885.00
Actual Cost: 5,885.00

Source:	ICF	$5,885.00
	DSS	
	Company	
	Other	

Objectives: To develop a practical fabrication technique leading to a low cost production microwave antenna, including reflection, feed and antenna mount.

Objectives were: Fully Met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Antenna Fabrication Techniques.

SCO: 512

REQ: 36100-9-0711

Contractor: Victrix Co.

2. HISTORY: Start Date: 18 January 1980

Target Date: 31 March 1980

Completion: 31 March 1980

Funding:

Estimated Cost: $6,000.00
Actual Cost: 6,000.00

Source: ICF	$6,000.00
DSS	
Company	
Other	

Objectives: To develop a practical fabrication technique leading to a low cost production microwave antenna, including reflection, feed and antenna mount.

Objectives were: Fully Met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Study for the development of an on-board processor for an integrated satellite attitude sensing and control system (Phase IV).

SCO: 518

REQ: 36100-9-0895

Contractor: SPAR

2. HISTORY: Start Date: 1 February 1980

Target Date: 13 Weeks

Completion: April 1980

Funding:

Estimated Cost: $105,342.00
Actual Cost: $110,508.00

Source: ICF $110,508.00
DSS
Company
Other

Objectives: Define and report on the control system's on-board computational requirements; develop a preliminary design for the on-board processor.

Objectives were: Fully Met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Development of Variable Power Dividers and Phase Shifting Networks for Communications Satellites.

SCO: 521

REQ: 15SV-36100-9-4003

Contractor: ComDev Ltd.

2. HISTORY: Start Date: June 17, 1980

Target Date: September, 1981

Completion: October, 1982

Funding:

Estimated Cost: $143,189.00
Actual Cost: $146,800.00

Source: ICF $ 60,000.00
DSS $ 86,800.00
Company
Other

Objectives: To develop variable power dividers at 12/14 GHz for spacecraft applications by investigating two types of technology:
a. Faraday rotor VPD (ferrite version)
b. Mechanical VPD.

Objectives were: Fully met

3. GENERAL COMMENTS:

The development of the phase shift version was stopped after 80% complete because of losses in the ferromagnetic material beyond the control of the contractor. The mechanical configuration also presented problems but these were solved.

RCA funded ComDev with an additional $146,800 to flight qualify the unit at the end of this contract.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Duplex LSI Delta Codec - Phase II.

SCO: 535

REQ: 36001-9-0809

Contractor: SED

2. HISTORY: Start Date: February 1980

Target Date: March 15, 1981

Completion: March 31, 1981

Funding:

Estimated Cost: $122,000.00
Actual Cost: $157,485.00

Source: ICF $157,485.00
DSS
Company
Other

Objectives: Follow-on contract to 36001-8-4221. This contract required the codec design to be implemented in chip form.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: 14GHz Power Amplifier for Low Cost Telephony Terminals.

SCO: 536

REQ: 15SV 36100-9-0840
15SV 36100-9-08332

Contractor: SPAR

2. HISTORY: Start Date: April 1980

Target Date: January 1981

Completion: Not completed - terminated work in December 1980 - contract final date March 1981

Funding:

Estimated Cost: $173,994.00
Actual Cost: 92,558.00

Source: ICF $ 92,558.00
DSS
Company
Other

Objectives: To develop a 14GHz SSPA suitable for use in low-cost telephony terminals.

Objectives were: Not Met.

3. GENERAL COMMENTS:

Company decided not to pursue this market any further and initiated termination of the contract.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Development of and fabrication of 14GHz power amplifiers for single channel telephony terminals.

SCO: 537

REQ: 36100-9-0934

Contractor: MAECL

2. HISTORY: Start Date: May 15, 1980

Target Date: January 10, 1981

Completion: March 1981

Funding:

Estimated Cost: $231,661.00
Actual Cost: $236,661.00

Source: ICF $236,661.00
DSS
Company
Other

Objectives: Develop and fabricate 14 GHz solid state power amplifiers

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: High reliability advanced battery management system development, phase III--Engineering Model

   SCO: 541

   REQ: 3600-9-0888

   Contractor: Canadian Astronautics Ltd.

2. HISTORY: Start Date: 14 February 1980

   Target Date: 26 February 1982

   Completion: 30 July 1980 (estimated)

   Funding:

   Estimated Cost: $381,788.00
   Actual Cost: $525,103.79 (estimated)

   Source: ICF $525,103.79 (estimated)
   DSS
   Company 150,000.00 (estimated)
   Other

   Objectives: To design an engineering model of the high reliability battery management system.

   Objectives were: Partly met

3. GENERAL COMMENTS:

   Phase III was greatly underestimated by the company. Even with amendments to increase the funding level, the objectives as initially agreed upon had to be reduced.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of Solar Array Drive and Power Transfer Assemblies for future Canadian Communications Satellite Missions.

   SCO: 551

   REQ: 36100-9-4004

   Contractor: SPAR

2. HISTORY: Start Date: 4 February 1980

   Target Date: 31 March 1981

   Completion: 3 July 1981

   Funding:

   Estimated Cost: $171,600.00
   Actual Cost: $165,684.11

   Source: ICF $80,684.11
   DSS $85,000.00
   Company
   Other

   Objectives:
   1. Consolidation of data on Canadian and non-Canadian SADAPTA's.
   2. Review and define spacecraft SADAPTA requirements of future Canadian missions.
   3. Outline SADAPTA designs and identify critical technology areas needing development.
   4. Build and test breadboard hardware in support of objectives.

   Objectives were: Fully met

3. GENERAL COMMENTS:

   Unforseeable component delivery problems caused the delay in the delivery date.

DSSC
PROJECT FACT SHEET

1. **PROJECT:** Title: Phase I of the Development of two-way telephony Earth Terminals for 12-14 GHz Service.

SCO: 553

REQ: 36100-9-0931

Contractor: SPAR

2. **HISTORY:** Start Date: 25 February 1980

Target Date: 9 June 1980

Completion: 26 September 1980

Funding:

Estimated Cost: $74,772.52
Actual Cost: $74,772.52

Source: ICF $74,772.52
DSS
Company
Other

Objectives: To develop and establish a production capability for a small 14/12GHz FM single channel per carrier low cost telephony communications terminal using analog technology.

Objectives were: Fully met

3. **GENERAL COMMENTS:**

Phase 1 of a 3 phase endeavor.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Phase I of the Development of two-way telephony Earth Terminals for 12-14 GHz Service.

SCO: 554

REQ: 36100-9-0932

Contractor: SED

2. HISTORY: Start Date: 22 February 1980

Target Date: 9 June 1980

Completion: 9 June 1980

Funding:

Estimated Cost: $75,000.00
Actual Cost: $75,000.00

Source: ICF $75,000.00
DSS
Company
Other

Objectives: To carry out preliminary systems analyses of requirements AND establish nominal design for terminal using digital technology.

Objectives were: Partly met

3. GENERAL COMMENTS:

There were insufficient funds to permit all aspects of this highly complicated system to be comprehensively addressed.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Development and fabrication of a prototype GaAs FET Oscillator frequency multiplier and phase locked oscillator for SHF applications.

SCO: 571

REQ: 36100-9-1381

Contractor: SED

2. HISTORY: Start Date: April 22, 1980

Target Date: June 20, 1981

Completion: 29 October 1982

Funding:

Estimated Cost: $105,185.00
Actual Cost: 105,185.00

Source:	ICF	$105,185.00
	DSS	
	Company	$ 22,167.88
	Other	

Objectives: To develop and demonstrate microwave phase locked oscillator based on a dialectric resonator technique used with a FET multiplier.

Objectives were: Fully Met

3. GENERAL COMMENTS:

Design of this oscillator proved to be key to the realization of sales of up and down converters to AEL microtel.

Delay largely due to the commitment of SED project staff to LCTT contracts.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Design and Development of a Variable Capacity Heat Pipe Radiator--Phase II.

SCO: 585

REQ: 36100-9-1459

Contractor: SPAR

2. HISTORY: Start Date: June 5, 1980

Target Date: July 31, 1981

Completion: July 20, 1982

Funding:

Estimated Cost: $204.282.00
Actual Cost: $227,434.00

Source: ICF $227,434.00
DSS
Company $20,000.00 by Chromalox
$35,000.00 by SPAR
Other

Objectives:
1. To mature Chromalox beyond its current knowledge of heatpipes as isolated thermodynamic entities, to a proficiency in the analysis, design, fabrication and test of integrated heatpipe systems.
2. To continue life testing those individual heatpipes fabricated in Phase I.
3. To exercise the SPAR/Chromalox relationship in a fashion representative of a flight program:
   a. SPAR to develop a thermal design for cooling a bank of TWT amplifiers on a high power direct broadcast satellite.
   b. Chromalox to design, fabricate and deliver to SPAR the associated heatpipe hardware.
   c. SPAR and Chromalox to jointly perform tests (at DFL) on the integrated heatpipe system.

Objectives were: Fully Met

3. GENERAL COMMENTS:

The schedule slippage was attributed to two key personnel changes at Chromalox. See Case Study.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Production and Evaluation of Direct-to-home TVRO Terminals

Phase III: Evaluation

SCO: 589

REQ: 36001-9-1455

Contractor: SED

2. HISTORY: Start Date: May 1980

Target Date: August 1981

Completion: March 1982

Funding:

Estimated Cost: $25,371.00
Actual Cost: $22,371.00

Source: ICF $22,371.00
DSS
Company
Other

Objectives: The objective of the project was to advance the development of 12 GHz TVRO (TV Receive--Only) terminals for direct broadcast satellite reception to the state where reliable units could be produced in volume. Phase II was to provide a total of 100 units which would be used in field trials by DOC to further develop an appreciation of design features which might be desirable in later consumer product lines. Of these, 25 units were to be selected at random for particularly close monitoring at all stages. These units were then to be returned to SED during Phase III for re-evaluation against originally documented performance and to establish a synopsis of degradation mechanisms and reliability histories of such units.

Objectives were: Fully Met

3. GENERAL COMMENTS:

By virtue of major sub-contracts with Andrew and Electrohome, the contract also assisted Andrew and Electrohome to establish themselves in the TVRO business.

DSSC
PROJECT FACT SHEET

1. **PROJECT:** Title: Development of a low-cost UHF tuner for direct broadcast TV terminals.

   SCO: 590

   REQ: 80-00273

   Contractor: Electrohome

2. **HISTORY:** Start Date: March 30, 1981

   Target Date: August 30, 1981

   Completion: March 19, 1982

Funding:

Estimated Cost: $21,700.00
Actual Cost: $21,700.00

Source: ICF $21,700.00
DSS
Company
Other

Objectives: To evaluate an image reject microwave/microstrip tuner to be used in the indoor unit of TVRO terminals.

Objectives were: Fully met.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Conceptual Design Study of Electronics for use in Experimental 406 ELT's and EPIRB's.

   SCO: 595

   REQ: 36100-0-0247

   Contractor: Hermes Electronics Limited

2. HISTORY: Start Date: 6 August 1980

   Target Date: 31 January 1981

   Completion: 31 January 1981

Funding:

Estimated Cost: $25,000.00
Actual Cost: $24,926.72

Source:		
	ICF	$24,926.72
	DSS	
	Company	
	Other	

Objectives: To carry out a study resulting in a proposed baseline electronics design which would meet the performance requirements of the SARSAT 406 emergency beacons.

Objectives were: Exceeded.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Conceptual Design Study of Electronics for use in Experimental 406 MHz ELT's and EPIRB's

SCO: 595-1

REQ: 36100-0-0248

Contractor: Leigh Instruments Limited

2. HISTORY: Start Date: 6 August 1981

Target Date: 12 December 1980 later extended to 31 January 1981

Completion: Contract never completed

Funding:

Estimated Cost: $24,915.00
Actual Cost: $NIL

Source: ICF NIL
DSS
Company
Other

Objectives: To carry out a study resulting in a proposed baseline electronics design which would meet the performance requirements of the SARSAT 406 MHz emergency beacons.

Objectives were: Partly met.

3. GENERAL COMMENTS:

The company defaulted on this contract and it was cancelled at no cost to the government.

DSSC
PROJECT FACT SHEET

1. **PROJECT:** Title: 1.2 Meter Fiberglass Antenna for LCET Terminals.

   SCO: 615

   REQ: 80-00067

   Contractor: Victrix

2. **HISTORY:** Start Date: 28 July 1980

   Target Date: 28 April 1981

   Completion: June 1981

Funding:

Estimated Cost: $36,570.00
Actual Cost: $36,570.00

Source: ICF $36,570.00
DSS
Company
Other

Objectives: Design, develop and deliver 3 fiberglass antennas and 3 micro re-inforced antennas.

To examine fiberglass technology for low cost reflectors.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of low cost fabrication techniques for direct to home TV earth terminal antennas.

SCO: 616

REQ: 0-0428

Contractor: Wind Turbine

2. HISTORY: Start Date: April 1980

Target Date: March 1981

Completion: March 1981

Funding:

Estimated Cost: $19,581.00
Actual Cost: $19,581.00

Source: ICF $19,581.00
DSS
Company
Other

Objectives: Develop and deliver three low cost metal antennas, 1.2 meter diameter.

To examine stamping as a technique for low-cost reflector fabrication.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Phase II of the Development of two-way telephony Earth Terminals for 12-14GHz Service.

SCO: 646

REQ: 36100-0-0582

Contractor: SPAR

2. HISTORY: Start Date: 18 June 1980

Target Date: March 1981

Completion: 2 July 1981

Funding:

Estimated Cost: $176,595.15
Actual Cost: $176,595.15

Source:	ICF	$176,595.15
	DSS	
	Company	$ 88,297.00
	Other	

Objectives: To do prototype design of terminal and development of key subsystems.

Objectives were: Fully met

3. GENERAL COMMENTS:

There were some normal schedule slippages but no major problems.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Phase II of the Industrial Development of 12-14GHz Two-Way Telephony Earth Terminal.

SCO: 662

REQ: 36100-0-0638

Contractor: SED

2. HISTORY: Start Date: 5 December 1980

Target Date: 28 December 1982

Completion: August 1982 (Stop work order)

Funding:

Estimated Cost: $456,000.00
Actual Cost: $363,337.00

Source:	ICF	$363,337.00
	DSS	
	Company	$181,668.00
	Other	

Objectives: To finalize designs for terminal and system and to demonstrate all major subsystems and prepare a proposal for Phase III.

Objectives were: Not met

3. GENERAL COMMENTS:

DOC was not convinced that SED was going to meet the stated goals of the contract and developments elsewhere cast doubt on the value of the work, therefore, DOC issued a stop work order. The contract itself has not yet been officially closed since the parties have not reached agreement on final cost.

DSSC
PROJECT FACT SHEET

1. **PROJECT:** Title: Advanced attitude control electonics for satellites using microprocessor technology.

SCO: 669

REQ: 36100-0-4002

Contractor: SPAR

2. **HISTORY:** Start Date: 1 June 1981

Target Date: 20 months (1 February 1983)

Completion: April 1983

Funding:

Estimated Cost: $564,702.00
Actual Cost:

Source: ICF $340,000.00
DSS $225,000.00
Company
Other

Objectives:

1. Configure, breadboard, and test an integrated compatible set of flight-qualifiable microprocessor hardware (HW) components consisting of CPU and RAM/ROM chips, interval timers, interrupt controllers, bus arbitration logic, serial/parallel I/O ports and floating point hardware etc.

2. Develop the necessary software (SW) and test set, to exercise and test the breadboard microprocessor system HW.

3. Conduct a "failure modes and effects" analysis on the breadboard hardware developed.

4. Specify the type of multi-processor HW architectures that could be implemented with an expanded set of such compatible microprocessor components.

Objectives were: Partly Met

3. General Comments:

UP-S-281

SPAR made up for delays in the early stages as staff became available and the product was delivered early.

SPAR requested another $35K to complete the testing of the breadboard Microcomputer system developed. The request was denied. The testing was only partially completed. Spar intends to finish the testing at its own expense.

SPAR proposes a 5 year follow-on program at $1M/yr. on microprocessors in space.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: 41.5 Watt 4 GHz solid-state power amplifier for Satellites.

SCO: 688

REQ: 36100-0-0811

Contractor: SPAR

2. HISTORY: Start Date: January 1, 1982

Target Date: July 30, 1982

Completion: March 30, 1983

Funding:

Estimated Cost: $240,853.00
Actual Cost: $229,000.00 (approximate - final invoice not received.)

Source: ICF
DSS
Company
Other

Objectives: To design an engineering prototype of a 11.5W 4 GHz solid state power amplifier.

Objectives were: Partly met

3. General Comments:

Electrical design objectives were partly met and thermal vacuum and vibration tests were not carried out because of lack of funding.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: TDMA/DSI Phase I

SCO: 703

REQ: 00863

Contractor: SPAR

2. HISTORY: Start Date: 1982

Target Date: 1982

Completion: 1983

Funding:

Estimated Cost: $100,000.00
Actual Cost: $100,000.00

Source: ICF 100,000.00
DSS
Company
Other

Objectives: To carry out feasibility and design studies on Intelsat TDMA requirements.

Objectives were: Partly met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: A study to develop suitable antennas for the MSAT transportable terminals.

SCO: 710

REQ: 36001-1-3005

Contractor: Andrew Antenna Company Limited

2. HISTORY: Start Date: April 1981

Target Date: September 1981

Completion: March 1982

Funding:

Estimated Cost: $25,000.00
Actual Cost: 26,894.15

Source:	ICF	26,894.15
	DSS	
	Company	
	Other	

Objectives: This contract was a study to examine candidate antennas for MSAT transportable terminals.

Objectives were: Partly met.

3. GENERAL COMMENTS:

"Managing this contract was an experience I would not care to repeat. The work done was, in my opinion, of minimum quality and quantity. The terms of the contract were essentially ignored. The contractor went into default on delivery date several times. I was forced to arrange for contract extensions on the Contractor's behalf. The report finally obtained was of little value."

-Scientific Authority

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of a High Efficiency TDMA Modem and FEC codec.

SCO: 718

REQ: 0-4004

Contractor: Miller Communications Systems

2. HISTORY: Start Date: March 5, 1981

Target Date: November 26, 1981

Completion: May 6, 1981 (terminated)

Funding:

Estimated Cost: $99,916.00
Actual Cost: $39,000.00

Source:	ICF	NIL
	DSS	$39,000.00
	Company	
	Other	

Objectives: Support MCS in development of a modem/codec as part of their bid to TELESAT's LRTES requirement.

Objectives were: Not met

3. GENERAL COMMENTS:

Resulted from an unsolicited proposal. Project was cancelled when Telesat made the decision to purchase their equipment from DTL/DCC.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development of TEM line components for spacecraft applications.

SCO: 721

REQ: 36100-0-4005

Contractor: SPAR

2. HISTORY: Start Date: October 1981

Target Date: March 31, 1982

Completion: March 31, 1982

Funding:

Estimated Cost: $52,285.00
Actual Cost: $52,285.00

Source: ICF $10,500.00
DSS $41,785.00
Company
Other

Objectives: To develop a 2 to 3 power divider in the 4GHz frequency range having lower losses, reduced weight and fabrication lost in comparison with the traditional waveguide network.

Objectives were: Fully met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Phase III of the Development of Two-Way Telephony Earth Terminals for 12/14 GHz Service.

SCO: 755

REQ: 36100-1-0059

Contractor: SPAR

2. HISTORY: Start Date: 5 November 1981

Target Date: 5 October 1982

Completion: Not yet complete

Funding:

Estimated Cost: $235,992.00
Actual Cost:

Source: ICF $235,992.00
DSS
Company$117.996.00
Other

Objectives: To develop and demonstrate a complete terminal to the production prototype stage.

Objectives were:

3. GENERAL COMMENTS:

It is expected that objectives will be fully met and the costs will be as estimated.

Schedule slippage was due to MAECL's inability to meet schedule commitments.

DSSC
PROJECT FACT SHEET

1. **PROJECT:** Title: Accelerometer R&D (Development of an accelerometer test facility)

   SCO: 764

   REQ: 10099

   Contractor: ANCON

2. **HISTORY:** Start Date: October 13, 1981

   Target Date: September 30, 1982

   Completion: Projected November 1983

Funding:

Estimated Cost: $165,157.00
Actual Cost: $165,157.00

Source: ICF $100,157.00
DSS
Company $65,000.00
Other

Objectives: Evaluation of accelerometer technology, development of accelerometer test facility, and development of new accelerometer electronics and instrumentation.

Objectives were: Partly met

3. **GENERAL COMMENTS:**

Project not yet complete. Expect to fully meet technical objectives.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Two Axis Gyro R&D (Development of a two axis gyro system)

SCO: 765

REQ: 10101

Contractor: ANCON

2. HISTORY: Start Date: September 1, 1981

Target Date: July 31, 1982

Completion: September 1982

Funding:

Estimated Cost: $126,027.00
Actual Cost: $115,828.00

Source: ICF $115,828.00
DSS
Company
Other

Objectives: Development of a two axis gyro test system, including a digital rebalance loop, for eventual application to tuned rotor gyros.

Objectives were: Exceeded

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development and manufacture an engineering model of a solar array drive and power transfer assembly (SADAPTA).

SCO: 766

REQ: 36100-1-0100

Contractor: SPAR

2. HISTORY: Start Date: 21 September 1981

Target Date: 20 September 1982

Completion: 4 April 1983

Funding:

Estimated Cost: $265,033.00
Actual Cost: $265,898.00

Source: ICF $265,898.00
DSS
Company $50,000.00 (estimated hardware costs)
Other

Objectives: To design, develop, manufacture and test a SADAPTA for a higher power (3-10 KW) spacecraft. An engineering model SADAPTA to be built which is fully representative of a flight design and subjected to simulated geostationary and low orbit testing.

Objectives were: Fully met

3. GENERAL COMMENTS:

SPAR's subcontractors who delivered all the gears according to SPAR's design were not able to:

a. meet the design specifications, and
b. meet the delivery date.

These problems caused delays in overall project delivery.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Design an attitude and communications beam control system for a third generation spacecraft.

SCO: 768

REQ: 36100-1-0102

Contractor: SPAR

2. HISTORY: Start Date: 7 October 1981

Target Date: 31 May 1982

Completion: 31 March 1983

Funding:

Estimated Cost: $233,000.00
Actual Cost: $266,790.00 (includes change of scope)

Source: ICF $266,790.00
DSS
Company
Other

Objectives: To develop a technology base within the prime contractor for the control of future large, flexible spacecraft. To provide a baseline for operational MSAT.

Objectives were: Partly met

3. GENERAL COMMENTS:

Late completion due to difficulty of project plus major technical problem. Detailed analysis and simulation indicated baseline design was not adequate (unstable). Contract funds were not sufficient to undertake alternate design.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Technical and economic study of Differential Minimum Shift Keyed (DMSK) modem technology, followed by development and testing of two breadboard units.

SCO: 773

REQ: 19ST.36100-1-0120

Contractor: SED

2. HISTORY: Start Date: August 1981

Target Date: March 1982

Completion: Septembr 1982

Funding:

Estimated Cost: $110,000.00
Actual Cost: $ 98,909.00

Source:	ICF	$ 98,909.00
	DSS	
	Company	
	Other	

Objectives: To perform a technical and economic study of differential minimum shift keyed (DMSK) modem technology, followed by development and testing of two breadboard units.

Objectives were: Partly met.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: To develop dynamic models and control system design for third-generation spacecraft.

SCO: 775

REQ: 01-100953

Contractor: Dynacon

2. HISTORY: Start Date: August 17, 1981

Target Date: March 31, 1982

Completion: September 10, 1982

Funding:

Estimated Cost: $92,039.00
Actual Cost: 92,009.00

Source: ICF $92,009.00
DSS
Company
Other

Objectives: To develop a standardized dynamics model for a large flexible spacecraft (MSAT) for use by Dynacon and other contractors

Objectives were: Exceeded

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Development and Fabrication of 14 GHz Power Amplifiers for SCPC Telephone Terminals.

SCO: 777

REQ: 36100-1-0192

Contractor: MAECL

2. HISTORY: Start Date: December 1, 1981

Target Date: October 31, 1982

Completion: To be completed May 31/83

Funding:

Estimated Cost:		$105,293.00
Actual Cost:		$ 75,000.00
Source:	ICF	$ 75,000.00
	DSS	$ 30,000.00
	Company	
	Other	$ 30,000.00 (SCOPO)

Objectives: Develop and fabricate 14GHz, 1 Watt amplifiers deliver 6 amplifiers to CRC.

Objectives were: Not yet completed.

3. GENERAL COMMENTS

Some technical problems have been encountered.

The contractor has also received orders for similar units from another company and resulting conflicts with the CRC contract have caused delays.

DSSC
PROJECT FACT SHEET

1. PROJECT:	Title:	TDMA/DSI Phase II
	SCO:	780
	REQ:	
	Contractor:	SPAR
2. HISTORY:	Start Date:	January 1981
	Target Date:	April 1984
	Completion:	

Funding:

Estimated Cost:		$6,160,000
Actual Cost:		in progress
Source:	ICF	$1,580,000
	DSS	
	Company	$1,500,000
	Other	$3,080,000 (Teleglobe)

Objectives: Design, develop, document common TDMA terminal equipment, power subsystems and special test equipment for the Intelsat standard TDMA/DSI terminal.

Objectives were: In progress

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Spacecraft Fault-Tolerant processing system - Phase I.

SCO: 809

REQ: 3ER-36100-1-0274

Contractor: Eidetic

2. HISTORY: Start Date: September 1981

Target Date:

Completion: March 1982

Funding:

Estimated Cost:		$50,000.00
Actual Cost:		$50,000.00
Source:	ICF	$50,000.00
	DSS	
	Company	
	Other	

Objectives: Survey and study of distributed fault-tolerant microprocessor systems for spacecraft.

Objectives were: Fully met.

3. GENERAL COMMENTS

UP-E-124

DOC was not able to allocate sufficient funds for the UP. They initiated and funded a small 50K study contract instead. This study resulted in SCO 914 contract.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Computer Aided Engineering (CAE) tools - Phase I.

SCO: 810

REQ: 3ER-36100-1-0273

Contractor: Intellitech

2. HISTORY: Start Date: October 1981

Target Date:

Completion: March 1982

Funding:

Estimated Cost:	$120,000.00
Actual Cost:	$122,080.00

Source:	ICF	$122,080.00
	DSS	
	Company	
	Other	

Objectives: Development of a CAE methodology and specification of software packages, for the design, simulation, evaluation and testing of multiprocessor systems.

Objectives were: Fully met.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Report on RCA/MUX

SCO: 811

REQ: 36100-1-0296

Contractor: Com Dev

2. HISTORY: Start Date:

Target Date:

Completion:

Funding:

Estimated Cost:	$50,000.00
Actual Cost:	$50,000.00

Source:	ICF	$50,000.00
	DSS	
	Company	$67,800.00
	Other	$108,900.00 (RCA)

Objectives: Develop methods for, and carry out, simulations and tradeoff studies for RCA GStar multiplexer network.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: A study on the development and construction of low-power TV UHF transmitters for program distribution from TVRO.

SCO: 832

REQ: 12ST-36100-1-0325

Contractor: Delta Benco Cascade

2. HISTORY: Start Date: November 20, 1981

Target Date: March 15, 1983

Completion: April 1982

Funding:

Estimated Cost: $34,464.00
Actual Cost: $34,464.00

Source: ICF $34,464.00
DSS
Company
Other

Objectives: To study the feasibility of fabricating a UHF TV broadcast transmitter with 10W power output.

Objectives were: Exceeded

3. GENERAL COMMENTS:

20 W Brassboard amplifier was COnstructed, and DOC type approval was obtained. Sales of this unit are very successful.

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Development of Heatpipes for Space Applications--Phase III.

SCO: 845

REQ: 36100-1-0407

Contractor: Chromalox

2. HISTORY: Start Date: March 11, 1982

Target Date: March 31, 1983

Completion: March 31, 1983

Funding:

Estimated Cost:	$122,080.00
Actual Cost:	$122,080.00

Source:	ICF	$122,080.00
	DSS	
	Company	
	Other	

Objectives:

1. To advance the technology of machining deep axial grooves in stainless steel heat pipes.
2. To establish by test the relationship between heat transport capability and groove depth in axial groove heat pipes.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Dual Antenna--AustralSat

SCO: 866

REQ:

Contractor: Raytheon

2. HISTORY: Start Date: FY 1981/82

Target Date: FY 1981/82

Completion: FY 1981/82

Funding:

Estimated Cost:		$302,600.00
Actual Cost:		$302,600.00
Source:	ICF	$302,600.00
	DSS	
	Company	
	Other	

Objectives: Support Raytheon's bid on AustralSat.

Objectives were: Fully met

3. GENERAL COMMENTS:

No information available.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: TDMA Parameter Optimization

   SCO: 867

   REQ: 10477

   Contractor: Miller Communications Ltd.

2. HISTORY: Start Date: February 13, 1982

   Target Date: May 12, 1982

   Completion: September 9,1982

Funding:

Estimated Cost:		$20,325.80
Actual Cost:		$20,325.80
Source:	ICF	$20,325.80
	DSS	
	Company	
	Other	

Objectives: Investigate the effect of TDMA preamble parameters on acquisition and retention and thereby select optimum parameters.

Objectives were: Exceeded

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: TDMA Adaptive FEC Study

SCO: 887

REQ: 36100-2-4018

Contractor: Miller Communications Ltd.

2. HISTORY: Start Date: 1 March 1982

Target Date: 28 June 1982

Completion: 24 August 1982

Funding:

Estimated Cost:		$15,785
Actual Cost:		$15,785
Source:	ICF	$15,785
	DSS	
	Company	
	Other	

Objectives: To study adaptive FEC, including coding algorithms, implementation alternatives, and operational implications.

Objectives were: Exceeded

3. GENERAL COMMENTS:

Lack of manpower at CRC delayed monitoring and evaluation.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Study of aluminum metallization on integrated circuits.

SCO: 888

REQ: 36100-2-4021

Contractor: QRL

2. HISTORY: Start Date: April 1, 1982

Target Date: March 31, 1983

Completion: March 31, 1983

Funding:

Estimated Cost: $119,012.34
Actual Cost:

Source:		
	ICF	$ 19,012.34
	DSS	$100,000.00
	Company	
	Other	

Objectives: To determine the cause of the AL metallization problem which was observed on IC's and to assess the reliability implications particularly for devices included for space applications.

Objectives were: Fully met

3. General Comments:

This contract was not completed at the time of the questionnaire. The scientific authority has reviewed a draft of the final report and provided comments.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Computer Aided Engineering (CAE) Tools Phase II.

SCO: 913

REQ: 36001-2-0560

Contractor: Intellitech

2. HISTORY: Start Date: June 1982

Target Date: March 1983

Completion: May 1983

Funding:

Estimated Cost: $150,000.00
Actual Cost: 150,000.00

Source: ICF $150.000.00
DSS
Company
Other

Objectives: Procurement and utilization of low level CAE tool for detailed simulation of spacecraft processing system architectures.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Spacecraft Fault - Tolerant Processing System - Phase II.

SCO: 914

REQ: 1SST-36001-2-0561

Contractor: Eidetic

2. HISTORY: Start Date: July 1982

Target Date: March 1983

Completion: July 1983

Funding:

Estimated Cost: $150,000.00
Actual Cost: 150,000.00

Source: ICF $150,000.00
DSS
Company
Other

Objectives: Conceptual design of a fault tolerant computer system for autonomous spacecraft management.

Objectives were: Fully met

DSSC

PROJECT FACT SHEET

1. PROJECT: Title: Design of laboratory demonstration for dynamics models and control system design for third-generation S/C.

   SCO: 923

   REQ: 36001-2-0727

   Contractor: Dynacon

2. HISTORY: Start Date: July 16, 1982

   Target Date: March 31, 1983

   Completion: March 31, 1983

Funding:

Estimated Cost: $90,000.00
Actual Cost: 93,951.00

Source: ICF $93,951.00
DSS
Company
Other

Objectives: To develop a laboratory system for verifying the dynamic models and control system design for a large flexible spacecraft in a one gravity environment.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Gallium Arsenide Solar Cells for space applications.

   SCO: 965

   REQ: 36100-2-2402

   Contractor: TPK

2. HISTORY: Start Date: June 7, 1982

   Target Date: March 31, 1983

   Completion: May 31, 1983

Funding:

Estimated Cost: $38,640.00
Actual Cost: $38,640.00

Source:	ICF	$38,640.00
	DSS	
	Company	
	Other	

Objectives: To conduct a survey of both the space solar cell technology and the future market of GaAs solar cells, particularly for a Canadian manufacturer. To determine the viability of a Canadian manufacturer in terms of a commercial enterprise.

Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: TDMA Demand Assignment

SCO: 969

REQ: 2-2587

Contractor: Miller Communications

2. HISTORY: Start Date: January 1, 1982

Target Date: March 3, 1983

Completion: February 1, 1983

Funding:

Estimated Cost: $19,822.00
Actual Cost: $19,822.00

Source: ICF $19,822.00
DSS
Company
Other

Objectives: To report on demand assignment techniques related to light route TDMA.
Objectives were: Fully met

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Optical Communications System

SCO: 82A

REQ: 2-2249

Contractor: Opto Electronics

2. HISTORY: Start Date: FY 1982/83

Target Date:

Completion:

Funding:

Estimated Cost: $313,593
Actual Cost:

Source: ICF $ 73,924
DSS $178,600
Company
Other $ 61,070 (Research Branch)

Objectives:

Objectives were:

3. GENERAL COMMENTS:

No information available.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Modal Analysis

SCO: 82B

REQ: 2-1794

Contractor: SPAR

2. HISTORY: Start Date: FY 1982/83

Target Date:

Completion:

Funding:

Estimated Cost: $184,907
Actual Cost:

Source:	ICF	$ 68,000
	DSS	$116,900
	Company	
	Other	

Objectives:

Objectives were:

3. GENERAL COMMENTS:

No information available.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: High Power Solar Array Device

SCO: 82C

REQ: 2-1911

Contractor: SPAR

2. HISTORY: Start Date: FY 1982/83

Target Date:

Completion:

Funding:

Estimated Cost: $418,923
Actual Cost:

Source: ICF $250,000
DSS $168,920
Company
Other

Objectives:

Objectives were:

3. GENERAL COMMENTS:

No information available.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: Space Station Study

SCO: 82D

REQ: 2-4603

Contractor: SPAR

2. HISTORY: Start Date: FY 1982/83

Target Date:

Completion:

Funding:

Estimated Cost: $499,941
Actual Cost:

Source:	ICF	$ 50,000
	DSS	$200,000
	Company	
	Other	$250,000 (NRC)

Objectives:

Objectives were:

3. GENERAL COMMENTS:

No information available.

DSSC
PROJECT FACT SHEET

1. PROJECT: Title: JSB Mobile Antenna Device

SCO: 82E

REQ: 2-2761

Contractor: Antech

2. HISTORY: Start Date: FY 1982/83

Target Date:

Completion:

Funding:

Estimated Cost: $67,361
Actual Cost:

Source: ICF $67,361
DSS
Company
Other

Objectives:

Objectives were:

3. GENERAL COMMENTS:

No information available.

ANNEX D: Case Study Writeups

CASE STUDIES LIST

1.	ComDev Ltd.	119	UHF Diplexer
		274	14 GHz Combining Network
		521	Variable Power Divider
		811	Report on RCA/Multiplexers
2.	Canadian Astronautics Ltd.	249	Battery Management System
		541	Battery Management System
3.	Miller Communications Systems Ltd.	264	TDMA SET Study
		424	TDMA Development
		718	Slim Route TDMA
		867	TDMA Parameters
		887	TDMA FEC
		969	TDMA/DAMA
4.	SPAR Aerospace/Canadian Chromalox Ltd.	386	Heat Pipes (Ccx)
		585	Heat Pipes (SPAR)
		845	Heat Pipes (Ccx)
5.	SPAR Aerospace Ltd.	240	L Band Transmitter
6.	SPAR Aerospace Ltd.	551	SADAPTA Power Transfer
		766	SADAPTA R&D and Monitoring
7.	SPAR Aerospace Ltd.	121	Strapdown Technology
		218	IASCS Phase I
		385	IASCS Phase II
		486	IASCS Phase III
		518	IASCS Phase IV
		669	ACS Microprocessor
		768	Attitude Beam Control
8.	SPAR Aerospace/SED Systems Ltd.	554	LCTT Phase I (SED)
		662	LCTT Phase II (SED)
		553	LCTT Phase I (SPAR)
		646	LCTT Phase II (SPAR)
		755	LCTT Phase III (SPAR)
9.	SED Systems Ltd.	248	R&D on Voice Coding
		381	LSI Codec Phase I
		535	LSI Codec Phase II
10.	SED Systems Ltd./ Electrohome	383	LCET Phase I (SED)
		483	LCET Phase II (SED)
		589	LCET Phase III (SED)
		485	LCET Indoor Unit (Elect.)
		590	LCET Tuner (Elect.)

CASE STUDY 1
COMDEV LTD.

Projects:

119	UHF Diplexer
274	14 GHz Combining Network
521	Variable Power Dividers and phase shifting networks
811	Report on RCA/Multiplexers

Funding:	DSSC	SSC	Company	Other
119	$ 55,912			
274	101,400	$43,678		
521	60,000	86,800		
811	50,000		$67,800	$108,900
Total	267,312	130,478	67,800	108,900
Grand Total:		$574,490		

Project Objectives:

119: To deliver a breadboard model and a development model for a UHF diplexer.

274: To design and develop an efficient, low-loss, high power combining network for satellite earth terminals operating in the 14-14.5 GHz frequency band.

521: To develop and manufacture variable power dividers (or combiners) and phase shifting networks for satellite communications at 14/12 GHz.

811: To carry out simulations and tradeoff studies for a direct broadcast satellite multiplexer network and fabricate breadboard versions of specified components.

Project Objectives Achievement:

The objectives of all projects were fully met from both DOC and the contractor's point of view.

Support to DSSC Objectives:

All projects are considered to have supported DSSC program objectives.

Impacts and Effects:

Although it did not result in a specific product, the first project was extremely significant to ComDev because it laid the technological groundwork for three highly successful product lines subsequently developed by the company:

1. 14 GHz Combining Network
2. Variable Power Dividers
3. Antenna Diplexers.

Development of the first two of these products was also supported by DSSC through projects 274 and 521 respectively. In addition, the company's expertise in passive intermodulation (PIM) measurement techniques was strengthened, giving them the capability to undertake further work on high power components.

The Combining Network developed in project 274 has been sold to Satellite Business Systems (SBS) and other customers. Sales to date total $320,000 and the potential market is estimated by the company to be 100 times that, of which ComDev is aiming for a substantial share.

The Variable Power Divider has been sold for use in RCA's GStar. Revenue for this multiplexer/variable power divider sale is quoted by the company as $3 million, and a potential market 10 times that is forseen. The technology has also been stepped down for use in fixed power dividers for other applications. The firm has also identified great market potential for the technology for use in earth stations as a combiner.

The RCA studies also contributed to the sale of the multiplexer/variable power divider for GStar. ComDev sees a large future payoff from this project for other satellites, and is using the technology and experience to do simulations and tradeoff studies for other missions, including BrazilSat.

The company has been growing at an average annual rate of 40% over the past five years, with current sales over $20 million annually and a work force of over 200. In 1977/78, earth station work accounted for 95% of total revenue, while current revenues from this source are less than 20% of the total for the firm. The change in focus and growth is a direct result of the products developed and the technical abilities and reputation which were established from the DOC/DSSC project work, to the point where ComDev now has 75% of the world market for satellite microwave devices. The success which the company enjoys with its space qualified components also gives credibility in support of sales of earth station devices, and provides some insight to downstream earth station requirements.

Background and History:

119: This project was planned as part of the MUSAT feasibility study. The design authority was developing a brassboard model of a UHF transponder to verify its feasibility in a communications spacecraft application, and the diplexer(s) developed under this contract were to be integrated into the brassboard model in preparation for system level testing during 1977. Problems had been encountered on two UHF satellite programs (FLEETSAT and MARISAT) due to passive intermodulation (PIM) products. Data from these two programs on PIM performance specifications considered practical for satellite hardware were included in the statement of work for this project.

274: This project was undertaken as a result of an unsolicited proposal submitted by ComDev. The potential for use of the technology in earth station applications was recognized and funding agreed to by DOC.

512: At the time of this contract, one of DOC's objectives was to enhance the development of novel and advanced microwave space qualified hardware. DOC awarded this contract as the result of an unsolicited proposal submitted by ComDev. Intelsat and NATO also issued RFP's for VPD's in that same year and there was definite interest during this period in this type of technology.

The ComDev proposal was selected over one submitted at approximately the same time by SPAR because of the operating frequency and ferrite design proposed by ComDev.

On completion of the contract, ComDev was able to obtain funding from RCA to flight qualify the unit and subsequently received the contract to produce the units for RCA's GStar.

811: RCA undertook to simulate a transponder for an advanced direct broadcast satellite and awarded ComDev an R&D contract on a 50% cost sharing basis for the input and output multiplexing networks. DOC agreed to underwrite half of ComDev's share of the cost of this program.

General Comments:

The projects funded by DSSC have obviously had a substantial effect on the growth of the company. ComDev gives a very clear impression, however, of having effectively used the program to support its own market development plans, rather than having taken an opportunistic approach and performed the research for its own sake. It is an good example of the most appropriate type of company to be supported by DSSC: one that has a strong market orientation and entrepreneurial approach to its business. This stance fully supports the objectives of the DSSC program, both for industry development and technology development, since it represents an implicit commitment by the firm to follow through with the technology addressed by each project.

CASE STUDY 2
Canadian Astronautics Ltd. (CAL)
High Reliability Battery Management System

Projects:

249 (Ph.1) Study of high reliability advanced battery system for use on spacecraft. Proof of concept. July 12, 1977 to December 14, 1977

249 (Ph. 2) High reliability advanced battery management systems development. March 2, 1978 to March 31, 1979

541 (Ph. 3) High reliability advanced battery management systems engineering model development. February 14, 1980 to July 30, 1983.

Funding:	DSSC Funds	SSC Funds	Company Funds
249 (Ph I)		$19,254	
249 (Ph II)	$129,589		
541 (Ph III)	$525,104		$150,000 (est)
Totals	$654,693	$19,254	$150,000
Grand Total:	$723,947		

Project Objectives:

Overall: To develop and manufacture a qualifiable engineering model of an advanced autonomous high reliability battery management system (HRBMS) for use on geostationary spacecraft.

249 (I): Proof of concept and assessment of feasibility.

249 (II): Design, develop and test prototype hardware to breadboard stage.

541 (III): Develop and fabricate a qualifiable engineering model based on the design developed in Phase II.

Project Objectives Achievement:

Phase I objectives were fully met. In Phase II, not all aspects of the design were breadboarded, causing delays in Phase III. Other major problems were also encountered in Phase III. In the face of major overruns (funded in part by DOC and in part by CAL) and a delay of two years from the original plan, DOC agreed to descope the technical objectives of Phase III. Overall, the project can be considered to have only partially met its original technical objectives.

Support to DSSC Objectives:

These contracts are considered to have fully supported the objectives of the DSSC program.

Impacts and Effects:

Direct: No direct sales have been realized for the battery management system to date. CAL is, however, in a position to support SPAR and other prime contractors as a subcontractor able to supply batteries and battery subsystems (e.g., cell switching, charge controllers, discharge regulators, etc.). The company has developed credibility in the area of spacecraft energy storage, resulting in contracts from Intelsat and SPAR for the development of nickel-hydrogen battery packs, an allied technology. These contracts total $504,000. CAL is also responding to an RFP from Intelsat for a managed NiH system. The firm feels they have a good chance of success in this proposal, since the RFP appears to be based on CAL's system concept, at least at the block diagram level.

Spinoff: The company is following up several spinoffs identified as a result of this work. The discharge power regulator is an advance in the state of the art and can be marketed as a separate item for DC to DC conversion and regulation. The work in this area has resulted in a breadboard design that is very efficient, and for this reason alone (notwithstanding its inherently higher reliability) may find use in terrestrial applications.

In addition, the battery management system involves designs for microprocessor based data acquisition and control circuits. These have wide application to a number of industrial products such as instrumentation systems that the company is engaged in developing: for example, a microprocessor controlled void fraction monitor for AECL.

CAL was also successful in bidding a $2.1 million program for development of the ultraviolet imager experiment for the Swedish Viking spacecraft. CAL credits this award at least partly to the company's credibility which results from designing and constructing space hardware like the HRBMS.

Background and History:

One of the weakest parts of a communications satellite has long been recognized to be the secondary battery system. The complex process of management of these batteries is critical to their useful life span and hence that of the spacecraft itself. This series of projects was aimed at developing a management system which would optimize energy storage, increase battery voltage, reduce battery mass and extend the useful life of the system. The first project was undertaken in response to an Unsolicited Proposal submitted by CAL. The company has stated that without the availability of this funding, it would not have been in a position to carry out the development work, because the potential for commercial payoff was too uncertain.

The costs of Phase III of this project were grossly underestimated by the contractor. Initially contracted for $381,788, the company has received additional funding of $143,316 and claims to have expended a further $150,000 of its own money. Had the initial cost estimates been more accurate, it may have resulted in a decision not to proceed. The decision to allocate further funding after the initially approved level had been exceeded was based on the sunk costs of the project. DOC decided to supply limited further funding and descope the original objectives.

At the completion of this project, it is intended to undertake at CRC a long term assessment of the managed battery system. This will compare reliability and weight of the manged system with the levels achieved through use of redundant batteries. Further funding by either the contractor or government would be necessary to bring the system to a production level.

General Comments:

The major overruns in time and funding encountered in this project can be partly ascribed to the unknowns normally associated with R&D in a new technological area. Most of the problem, however, is associated with project management, within the company and at CRC. The company grossly underestimated the level of effort required in the first place and did not publicly identify the need for additional help or rescoping until well into the third phase. The scientific authority for Phase III was new to the project and could not therefore benefit from a knowledge of what had happened in the earlier phases either from a technical or project management point of view. The records which he inherited from his predecessor were extremely limited. He was consequently in a position where, in his words, he found it hard to objectively evaluate the real progress being made by the company and identification of problems was delayed as a result.

This experience underscores the need for both project management standards (including project documentation) and specific identification of the role of project manager. The experience of having critical staff diverted to other tasks by the contractor is not unique to this project and is one which must be carefully covered in the original contracting process and monitored throughout the project.

The consequences of these shortcomings in relation to this project have been additional unplanned expenditures and a loss of competitive position by the company, assuming they continue to develop the technology.

CASE STUDY 3
Miller Communications Systems Ltd.
Time Division Multiple Access (TDMA)
Satellite Earth Terminal

Projects:

Miller:

264 Technical feasibility and economic viability study of a medium capacity TDMA ground station
12/77 to 4/78

424 Design, development and manufacture of two TDMA terminals for testing with the Anik B satellite.
18/4/79 to 11/80

718 Development of a high efficiency TDMA modem and FEC Codec.
5/3/81 to 06/05/81 (terminated)

867 Selection and optimization of the variable SLIM TDMA operational parameters.
12/2/82 to 30/9/80

887 Adaptive forward error correcting techniques for SLIM TDMA system.
1/3/82 to 24/8/82

969 TDMA/DAMA report.
11/1/83 to 28/2/83

Funding:	DSSC Funds	SSC Funds	Company Funds
264	$ 23,200		
424	132,490	$353,000	$52,000 (est)
718	nil	39,000	
867	20,325		
887	15,785		
969	19,822		
Total	$211,622	$392,000	$52,000

GRAND TOTAL: $655,622

Project Objectives:

264: Determine feasibility and economic viability.
424: Manufacture and delivery of 2 TDMA terminals.
718: Support MCS in development of a modem/codec.
867: Selection of optimum TDMA parameters.
887: Study on adaptive forward error correction (FEC).
969: Report on demand assignment techniques related to light route TDMA.

Objectives Achievement:

Overall the objectives were either met or exceeded, except for project 718, which was terminated prior to completion (see below).

Support to DSSC Objectives:

The listed contracts are considered to support the DSSC program objectives, with the exception of no. 718. This contract was awarded primarily to support Miller in its bid on Telesat's LRTES requirement and not mainly as a development project.

Overall Impacts and Effects:

Direct: No sales have been achieved to date of the products developed during this series of contracts. Miller has, however, greatly increased its capabilities with respect to satellite monitoring systems, acquisition retention effects in TDMA, forward error correction (FEC), benefits tradeoffs in TDMA and demand assignment aspects of light route TDMA. As a result, the company has successfully bid R&D studies to Intelsat on FEC and demand assignment methods and to the European Space Agency (ESA) on Synchronous Methods for Satellite Switched TDMA, the latter valued in excess of $50,000.

Background and History:

It had been felt within DOC that TDMA technology had a high potential for application in Canadian and international communication systems. A TDMA experiment was proposed by CRC for the ANIK B. The ADM at that time required proof of commercial viability before proceeding. Miller was awarded a contract to determine the feasibility and commercial viability of the TDMA technology. Competition included Digital Telecommunications Ltd. of Mississauga, a subsidiary of a U.S. firm, and historically the (almost) sole supplier of digital channelizing equipment to Telesat since 1974.

An unsolicited proposal from Miller for design and building of two TDMA units was subsequently accepted. CN-CP Telecommunications agreed at the same time to purchase two units, at manufacturing cost, for their own testing purposes. The DOC units were integrated with earth stations at CRC comprising antenna, shelter and RF subsystems, and technical field trials were undertaken during the summer of 1981.

DOC and CN-CP later purchased an additional 4 terminals under a joint program not funded by DSSC.

Because of their experience in TDMA, Miller was asked to bid on a Telsat requirement for these units. In keeping with the objective of encouraging Canadian content in satellite system procurements, DOC agreed to support this bid with some further development of the basic TDMA units under DSSC. When Telsat decided to purchase their hardware elsewhere, the DSSC contract with Miller was terminated.

Additional development has since been undertaken to accomodate better defined user requirements and to investigate specific aspects in the design of the TDMA units.

If CN-CP is successful in marketing their system against TCTS, Miller's international credibility in the field will be greatly enhanced, and some Canadian sales will be assured.

Miller is not currently marketing the TDMA. They have made proposals to American Satellite in the fall of 1979 and to Telesat in January 1980, both of which contracts were won by the U.S. parent of Digital Telecommunications Ltd. The company has also undertaken an extensive mail out campaign to publicize the product, and discussed the possibility of collaborative efforts with SPAR.

General Comments:

The effect of these contracts has been to support a primarily R&D oriented company to step piecemeal into development of a marketable product which, if successful, will place the firm in a manufacturing mode. Prior to starting on TDMA, the company's product was (by its own admission), almost entirely R&D. This kind of industrial intervention, while motivated by the objective of developing a totally Canadian source of TDMA technology, has inherent risks which argue for participation in the planning process by persons with the appropriate industrial expertise. There is also considerable difficulty in determining at what point the process becomes one of product improvement rather than advanced development, and therefore outside the bounds of the DSSC program.

The purchase by Telesat of Digital Telecommunications' products over those which Miller developed under these contracts brings up another question: how DOC can follow up the DSSC development projects to ensure that the technology is in fact used, where feasible, by government or government influenced agencies. It is recognized that a great many factors, technical and political, are involved in these decisions, but there is no evidence that any support has been given at the corporate level to encourage Telesat, in this case, to purchase a Canadian-made and developed product.

CASE STUDY 4
SPAR/Chromalox--Heat Pipes

Projects:

Chromalox:

386 Design, fabrication and test of variable capacity heatpipe system
23/1/79 to 16/12/80

845 Development of heatpipes for space applications
11/3/82 to 31/5/83

SPAR:

585 Design and development of a variable heatpipe radiator
5/6/80 to 20/7/82

Funding:		DSSC Funds		Company Funds
386		$143,404		$60,000 estimated
585		227,434	Cx	20,000 estimated
	SPAR	35,000 estimated		
845		122,080		
TOTAL		$592,918		$115,000
GRAND TOTAL:		$707,918 estimated		

Source of Funds:

ICF: $592,918
Companies: $115,000

Project Objectives:

1) To develop a Canadian supplier of heatpipe thermal control systems for future communications and other spacecraft.

2) To enhance both SPAR's and the selected contractor's expertise and capabilities in this area.

3) To advance CRC's knowledge in this field.

Project Objectives Achievement:

The DOC Scientific Authority stated that the project objectives were fully met.

From the contractors' points of view, both companies realized their objectives: SPAR in integrating and testing a variable capacity heatpipe system and upgrading their thermal modelling capability, and Chromalox in designing and manufacturing heatpipes from space level materials. However, more work is required before SPAR will consider Chromalox to be fully competent to deliver space qualified systems.

Support to DSSC Objectives:

These contracts are clearly aimed at giving Chromalox the potential to become a new member of the Canadian space industry as a supplier of space qualified heatpipe systems. The project objectives are fully consistent with those of the program.

Overall Impacts and Effects:

Direct: SPAR improved its mathematical modelling expertise and knowledge of the field of heatpipes as well as increasing its capability to design, fabricate and test complete thermal control subsystems. SPAR has carried out further studies at their own expense in the area of life testing.

Chromalox developed a higher level of expertise in the general theory and operation of heatpipes and the potential to supply space qualified hardware in support of future Canadian space missions.

Spinoffs: Chromalox is currently developing and testing industrial energy recovery units which directly use the technology to which the company was exposed in the course of carrying out this project. Their units are expected to be highly competitive in price and have several features not currently found in commercial systems.

The testing which was carried out as part of this project and the availability of hardware for further testing at CRC have substantially advanced the ability of CRC staff to evaluate the adequacy and efficiency of specific heatpipe designs for future missions.

Background and History:

Difficulties had been encountered on CTS/Hermes with the heatpipe system, which had been supplied by a U.S. contractor and not performed adequately. The opportunity was seen to gain an understanding of alternative heatpipe technologies while at the same time developing a potential Canadian supplier of these components.

Chromalox was selected since it was the only known Canadian company which was developing heatpipes for commercial exploitation in terrestrial applications. It had also expressed a strong interest in becoming involved in space applications.

This project was originally planned in three phases. In the first phase, Chromalox would explore space heatpipe technology and manufacture and test some prototype versions using a CRC specified wicking system. In phase two, Chromalox would supply SPAR with heatpipes made from flight quality materials for integration with a thermal panel. A joint testing program would be carried out. In the final phase, further life testing was planned.

Several problems were encountered during the course of the project. These were primarily the result of two factors:

1. Chromalox had a great deal of difficulty with manufacturing techniques and resolution of these problems caused substantial delays in delivering heatpipes, first to CRC and subsequently to SPAR.

2. Chromalox's inexperience with manufacturing of space hardware resulted in inadequate quality control and testing methods being applied to the units.

These problems were compounded by the loss near the end of Phase II by Chromalox of the Director of R&D, who had been a major force behind the firm's undertaking this research. The force of these factors was such that by the end of Phase II, relations between the two companies had deteriorated somewhat and Chromalox was expressing some reluctance about continuing with the work.

The decision was made by CRC, however, to continue with funding of the third phase in order to ensure at least that CRC's research would not be compromised. This phase has since been successfully completed.

At this point, the R&D staff at Chromalox have informally indicated that they would probably agree to produce flight quality units, given sufficient funding to refine the manufacturing techniques and cover manufacturing costs. The company is also using the technology in terrestial applications, and will therefore retain the necessary technological expertise at least in the short term.

It should be noted that although there are other suppliers of heatpipes for space applications, the particular technology and designs developed during this project are apparently unique and show potential at least for use in Canadian applications like MSAT.

General Comments:

The planned, phased approach adopted in this technology area is one which should be applied to others as well. It is most effective when:

1. Program management is aware of the stepwise approach,

2. Each phase in the development program can stand alone within the rules of the DSSC program, and

3. Each new phase is considered afresh in relation to other proposals during the project selection process. (Past development activities would be taken into account in considering the possibility of success.)

In this case, program management were aware of the phased approach but appear not to have been familiar with the difficulties encountered between the companies (other than technical problems) and in particular with the lack of interest expressed by Chromalox at some points. This clearly had the potential to affect how well the project would satisfy program level objectives and may have affected funds allocation.

The real planning interaction between CRC and the company took place between the scientific authority and the Director of R&D at Chromalox, who enthusiastically supported the company's involvement in the project. It appears that the corporate point of view, however, was to accept the support so long as there was a minimal commitment and risk on the part of the company. Even at this point, the R&D Division is not receiving corporate support for the marketing of the terrestrial spinoffs which were developed out of the project. This experience underscores the need to investigate and document the corporate commitment to following through with the technology.

Considering Chromalox's expressed hesitancy about continuing after Phase II, it may have been more appropriate to fund further work outside the DSSC program as pure research. This emphasizes the need to review the overall development plan in a program context after each phase is completed.

At the present time, the status of development of the technology and the company's attitude mean a substantial additional premium would have to be paid to develop a real capability to produce heatpipes in Canada. On the other hand, there remains the potential for spinoff applications to become a successful product line for the company, and some benefits have been realized by CRC and SPAR.

CASE STUDY 5
SPAR--L-Band Transmitter

Project:

240 Design, development, construction and life testing of a general purpose L-band transmitter.

Funding:	DSSC Funds
240	$400,916

Project Objectives:

To design, develop, construct and life test a general purpose L-band transmitter.

Project Objectives Achievement:

The life testing obligation was carried out under the DND sponsored SARSAT program in accordance with an agreement with DOC. The (modified) objectives were fully met from DOC's point of view.

Support to DSSC Objectives:

This contract is considered to fully support the objectives of the DSSC program.

Impacts and Effects:

Direct: SPAR manufactured 6 flight quality transmitters which are part of the SARSAT repeaters purchased under DND contract. The design was modified to operate at 4GHz and 4 units were incorporated in the ANIK-D satellites purchased from SPAR by Telesat. An additional 4 units identical to those used in ANIK will be incorporated in BrazilSat.

SPAR is also in the process of quoting on three more SARSAT systems, representing 6 units in total, and an addition 4 units will be quoted for a C Band application in the near future. The units are priced at approximately $200,000 to $250,000, depending on the quantity and other specific requirements. Sales to date are over $2.8 million, with an additional $2 million anticipated.

Spinoff: The original L Band/SARSAT program is credited with giving SPAR a technology base in ceramic substrates and microminiaturized components which the company did not previously have.

Background and History:

This contract was precipitated by two factors: experience with failures in the CTS/Hermes telemetry system, and a recognition by SPAR in preparation of the specification for the SARSAT system that there was a possibility of telemetry problems there as well.

The original contract value was $333,114; however, DOC agreed to additional funding to cover the cost of dealing with technical problems encountered during the project. The final results were proven through the life test program to be more than satisfactory.

The contract resulted in a design specifically adopted in the ANIK D satellite. An engineering model was built and tested in February 1980 and a life test model was completed in March 1981.

CASE STUDY 6
SPAR--Solar Array Drive and Power Transfer Assembly (SADAPTA)

Projects:

SPAR:

551 SADAPTA Solar Power Transfer
5/6/80 to 31/7/81

766 SADAPTA R&D and Manufacture
21/9/81 to 20/9/82

Funding:	DSSC Funds	SSC Funds	Company Funds
551	$80,684	$85,000	
766	$265,898		$50,000 (est)
TOTAL	$346,582	$85,000	$50,000
GRAND TOTAL:	$481,582		

Project Objectives:

551: To consolidate data on Canadian and non-Canadian SADAPTA's, review and define spacecraft SADAPTA requirements of future Canadian missions, outline SADAPTA designs and identify critical technology areas needing development, build and test breadboard hardware.

766: To design, develop, manufacture and test an engineering model (EM) SADAPTA for a higher power (3-10 KW) spacecraft.

Project Objectives Achievement:

From DOC's point of view, both projects met their stated contractual objectives.

From SPAR's point of view all technical objectives were fully realized.

Support to DSSC Objectives:

The contracts maintain SPAR's currency, credibility, and competitiveness in a specialized subsystem, support future Canadian procurements and the products have offshore sales potential. They are therefore consistent with the objectives of the overall program.

Impacts and Effects:

Direct: SPAR has been awarded the contract for the LSAT Solar Array Subsystem, of which a SADAPTA will be part. The company's success can be partly attributed to the expertise it developed during the course of these projects. SPAR has also been awarded an Intelsat R&D study valued at $300,000 (US) to develop a SADAPTA for Intelsat 7. The company's general credibility in this area has been enhanced to the point that the firm expects to supply Intelsat 7, MSAT and possibly Italsat SADAPTA's, and are predicting sales of $5 million in Canada and $10 million offshore in the 1985-88 time frame.

In general, the DSSC contracts have raised SPAR's international competitive position in SADAPTA work to among the top 3 of 13 manufacturers worldwide (by SPAR's own assessment), and thereby improved SPAR's ability to bid other international requirements as well.

Spinoff: As a result of a particular technological problem encountered during this project, SPAR undertook special investigations of gear lubrication techniques and fluids in spacecraft gears. This has given SPAR a technological lead in this area. The company is also currently considering the SADAPTA for possible use as one axis of a two-axis antenna positioner.

Background and History:

SPAR had gained considerable experience in design and construction of the CTS/Hermes SADAPTA. Both CRC and SPAR management felt it appropriate to extend this technology to cope with larger higher power array designs which could be used on future communications spacecraft, including MUSAT and DBS.

The first contract was aimed at exploring experience to date, identifying SADAPTA requirements for future Canadian communications satellite missions, and carrying out tests on breadboard hardware. The second contract involved manufacture and testing of an engineering model SADAPTA.

The SADAPTA still requires life tests. SPAR has a commitment to carry these out and may go ahead with or without government financial support.

General Comments:

The full potential for the products developed will not be realized for a few years but there is substantial evidence that these contracts have made a major contribution to the successful development of a new product line at SPAR which will greatly enhance the company's ability to be competitive internationally and to satisfy future domestic spacecraft needs.

CASE STUDY 7
SPAR--Integrated Attitude Sensing and Control System (IASCS)

Projects:

121 SRMS Strapdown technology--Phase II
September 2, 1976 to March 31, 1977.

218 IASCS Phase I--Study, Functional Design and Simulation
October 6, 1977 to December 1978.

385 IASCS Phase II--On Board Processor Study
January 9, 1979 to April 1979.

486 IASCS Phase III--Study of Alternatives for Data Acquisition
June 11, 1979 to December 1979.

518 IASCS Phase IV--On Board Processor Study
February 1, 1980 to April 1980.

669 IASCS Microprocessor Development
June 1981 to April 1983.

768 Attitude Beam Control System
October 7, 1981 to March 31 1983.

Funding:	DSSC Funds	SSC Funds
121	$ 93,888	
218	78,000	$237,978
385	56,325	
486	153,824	
518	110,508	
669	340,000	225,000
768	266,790	
Total	$1,099,335	$462,978

Grand Total: $1,562,313

Project Objectives:

General: This series of projects is aimed at developing an integrated attitude sensing and control system for future Canadian communications satellite needs.

121: To investigate the feasibility for stability augmentation of the SRMS control system using strapdown technology. Phase II--Sensors and control logic.

218: To carry out a study, functional design and proof of performance simulation for an integrated attitude sensing and control system.

385: To determine on board computational requirements and develop a conceptual design for the on board processor.

486: To evaluate and simulate alternative methods for determining spacecraft attitude.

518: To define on board computational requirements and survey spacecraft microprocessor systems.

669: To design, breadboard and test a flight qualifiable modular microprocessor for spacecraft applications.

768: To design and simulate an attitude and communications beam control system for third generation spacecraft; identify critical hardware developments required and identify system development tests.

Objectives Achievement:

121: Partly met: technical problems and delays in establishing a hybrid computing facility resulted in a failure to demonstrate the feasibility of the technology to the level expected.

218: Partly met: the work was underestimated, and cost overruns were absorbed by SPAR.

385: Fully met.

486: Fully met.

518: Fully met.

669: Partly met: required testing was not fully completed. SPAR will finish this at the company's expense.

768: Partly met: major technical problems were encountered, and the baseline design turned out to be unstable. Insufficient funds were available to pursue and alternate design.

Support to DSSC Objectives:

The projects individually support the objectives of the DSSC program; however, see the General Comments section below for a discussion of large programs.

Impacts and Effects:

This series of projects is ongoing and no final overall product has as yet resulted from it which could be developed and marketed by SPAR. There are, however, several identifiable impacts which have already been felt by the firm.

The extensive development activities which have already taken place have clearly brought about major improvements in SPAR's understanding of the state of the art in attitude control systems, especially as they relate to third generation spacecraft structures. SPAR's role in bringing together various elements into the Canadian Attitude Sensing system program (discussed below) will further enhance its capability.

The IASCS microprocessor development has also given SPAR a technology lead in the field of on board microprocessor system architecture and hardware design. The company adopted an approach to the IASCS application which would allow it to develop with minimal additional effort a generalized spacecraft microprocessor which could be used in a central control capacity or in other subsystems such as battery management or telemetry. SPAR has recently submitted a proposal for a five year "Microprocessors in Space" program, at a funding level of $1 million per year to further these developments.

Background and History:

This series of projects originated with an unsolicited proposal from SPAR in 1975 to investigate the feasibility of using strapdown technology in the Shuttle Remote Manipulator System (SRMS). Phase I was funded through SSC using the Unsolicited Proposals Fund, and DSSC funding was awarded for Phase II, starting in 1976. Although the control approach was tentatively shown to be be feasible, NRC and SPAR decided to proceed with an alternate control concept using sequential joint control. The Phase I report had identified a major follow on activity as being development of an attitude control system for geosynchronous satellites.

Subsequently SPAR submitted an unsolicited proposal (SCO 218) for a study to develop an integrated attitude sensing and control system from the CTS/Hermes baseline. The UP was submitted in the context of a request for support to bid on an Intelsat RFP. The following phases of the IASCS program resulted in the specification, design and construction of a flight qualifiable engineering model microprocessor. The last project in the series to date, SCO 768, was aimed at further investigating attitude sensing and control systems and their application to large flexible spacecraft such as the operational MSAT.

SPAR has undertaken additional research and development work in complementary areas such as thrusters, environmental disturbance torque programs and solar arrays. The company has also funded related space microprocessor studies (total value claimed is over $250,000) and activities to bring the microprocessor up to display standards.

CRC has also undertaken complementary projects during this period, including several sensor-related studies (on tuned rotor gyros and accelerometers).

These separate activities are now being brought together within the structure of a thrust to develop a Canadian Attitude Sensing (CAS) system and, specifically, a CAS Experimental Package (CASEP) which will be flown to test the system. Negotiations are currently taking place with SPAR to act as a focal point for these activities, starting with definition of the overall package and the test mission requirements.

General Comments:

Some early difficulties were encountered during project 121 and the IASCS series of projects which were at least in part the result of company resources being diverted to other projects. Comments similar to those made in relation to other case studies were recorded at the time by the Director of Space Mechanics. The observations continue to be relevant:

> "It is recommended that an effective management control be established between Government and contractor, over the work assignment of technical personnel. The present measures available to the Scientific Monitor are not considered appropriate or sufficient."
>
> -DSM, August, 1977

> "As the result of the discussion with R.Allen (SPAR IASCS Microprocessor Project Manager), it is clear that the monthly progress reports and progress meetings do not provide substantive technical data to enable insight into the work progress."
>
> -DSM, October 1981

There is also a question of how major development projects of this type should be undertaken and whether the DSSC program is an appropriate vehicle. The final product, a Canadian Attitude Sensing system flight version, has consumed substanial resources to date and will require a great deal more support to be realized. As long as the DSSC projects are discrete and can individually support the objectives of the program, there is perceived to be no problem. When they obviously run into one another the magnitude of the undertaking becomes large enough to consider funding as a separate research program or, in this case, under one of the other DOC programs which is aimed at exclusive support to SPAR in its prime contractor role. The latter option is particularly appropriate in the case of the IASCS since there is a heavy emphasis throughout the series of projects on development of capability in the prime contractor.

CASE STUDY 8
SPAR/SED
Low Cost Telephony Terminal (LCTT)

Projects:

SED:

554 Development of 12/14 GHz Telephony Earth Terminals
Phase I (Engineering Definition)
March 1980 - June 1980

662 Development of 12/14 GHz Telephony Earth Terminals
Phase II (Engineering Model Development)
December 1980 to August 1982 (cancelled)

SPAR:

553 Development of 12/14 GHz Telephony Earth Terminals
Phase I (Engineering Definition)
March 1980 to June 1980

646 Development of 12/14 GHz Telephony Earth Terminals
Phase II (Engineering Model Development)
June 1980 to September 1980.

755 Development of 12/14 GHz Telephony Earth Terminals
Phase III (Preproduction Prototype Development)
November 1981 - not yet completed.

Funding:	DSSC Funds	Company Funds
554	$ 75,000	$ 50,000
662	363,337	478,200
553	74,772	
646	176,595	176,595
755	235,992	240,000
Total	$925,696	$872,699

Project Objectives:

General: To establish a Canadian capability for production of small 12-14 GHz single channel per carrier low-cost telephony communications terminals.

553 and 554: Investigate performance requirements, perform tradeoff studies, prepare block diagrams and functional specifications for an LCTT.

646 and 662: Develop an engineering model (EM) prototype of an LCTT.

755: Develop and demonstrate a complete terminal to the production prototype stage.

Project Objectives Achievement:

The digital terminal contract being carried out by SED was terminated by DOC because SED was not going to be able to meet the contract goals. SPAR has been successful with the development of the analogue terminal, and is establishing the SPARCom product line based on this work. The project overall has therefore been successful in establishing a Canadian supplier for this technology despite the failure of one of the two contractors.

Support to DSSC Objectives:

These contracts are considered to have supported the objectives of the DSSC program.

Impacts and Effects:

SED: SED has not realized any substantial benefits from these projects to date. They did establish within the company a capability to work with digital telephony communications systems, and have performed some related development work. The modem synthesizer was carried to a high quality prototype stage through the partnership with Codan and could be used if the telephony terminal is developed further. The company also made an additional investment and was partially supported by Microtel Pacific Ltd. to further develop the 14-12 local oscillator and up/down converters which were part of the system. SED is now supplying these items to Microtel and forecast sales of $750,000 per year over the next three to five years.

SED is presently picking up the technology again in an orderly and planned fashion, and intends to pursue primarily the market for small data terminals. The company is developing a marketing plan to guide any further development.

SPAR: Although it is only now in the process of completing its development work, SPAR has made a major commitment to the technology developed under this series of contracts. In addition to the single channel K band terminal developed under these contracts, the firm has also developed C band, multiband and data terminals based on the same technology for sale under the SPARCom product line. SPAR is actively marketing this line in Canada and the US and examining markets elsewhere. In addition, the company has developed a digital version of its terminal under the DIPP program. The Communications Systems Division of SPAR regards this product line and the TDMA/DSI (also funded under DSSC) as the cornerstones of its future activities.

Background and History:

A large market was identified in Australia and expected to be generated elsewhere, including Canada, for low cost earth terminals for two way telephony using 12/14 GHz satellites. No Canadian companies had suitable products to meet this projected market demand, so DOC undertook this series of projects to bring two companies to the point where they could bid competitively at the international level.

The projects were planned in three phases: Phase I to study the requirements and develop functional specifications (with full funding); Phase II to develop an engineering model prototype unit (costs to be shared equally between DOC and the contractor); and, Phase III to build a preproduction prototype (costs again to be shared equally).

Complementary activities were taking place at the same time within DOC, some funded by DSSC, to develop a 1 Watt 14 GHz solid state power amplifier and Demand Assignment Multiple Access (DAMA) systems.

SED satisfactorily completed Phase I of their study and identified digital technology to be the preferred approach. Prior to Phase II, the company proposed development participation by Codan Ltd., an Australian firm with whom SED had established a relationship intended to get SED into the Australian market. They also negotiated a license for any resulting technology.

SED had encountered problems with the development project by early 1982. In January, a design review was held at which it was apparent to DOC and SED that there would be major difficulties in meeting the March 31 target date. A major problem was apparently that resources within the company were constantly being pulled off the project for other work. There was also a major corporate restructuring taking place at this time which had the effect of reducing direction and control on the project from the company's point of view.

By March, SED had reevaluated the project and decided they could achieve certain scaled down results. A proposal was presented to, and seemed to be well received by, CRC. The company started working toward the revised deliverables and rewrote the contracts. These were submitted in August and rejected in September, when DOC issued a stop work order. The final resolution of funding levels has not yet been achieved.

No major difficulties were encountered during the SPAR contracts.

General Comments:

Two general observations can be made on the projects overall. First, there is the question of how far along the product research and development life cycle DSSC is intended to provide support. In this case, the support extended to preproduction prototypes, a point which normally would be considered beyond the scope of the program. The series of projects was also justified in documentation as being undertaken primarily in support of the anticipated Australian requirement for the LCTT technology, and only secondarily to meet domestic and other international requirements. It would have been more appropriate to provide indications of the expected Canadian use of the resulting products in accordance with the focus of the program.

The experience with SED again emphasizes the need for strong project level control and prompt action in the event of difficulties. In this case, the company continued to spend resources on the project even after it was clear it could not meet the full terms of the contract, because there was no direction from DOC. The need for strict control over the continuity of resources the company puts on the project is also evident.

Finally, it is worth noting the observation by SPAR's project manager that the Canadian market is too small to support a large number of suppliers for these items. This raises the issue of how strategic planning of the program takes place--in the case of the LCTT's, a market survey by qualified experts may have pointed towards supporting the development of just one supplier of this technology.

CASE STUDY 9
SED Systems Limited
LSI Codec

Projects:

248	Development and Fabrication Study for Narrow Band Digital Voice Coding February 1, 1978 - March 30, 1978
381	Full Duplex CMOS LSI DELTA CODEC - Phase I December 1978 - April 1979
535	Full Duplex CMOS LSI DELTA CODEC - Phase II March 1979 - October 1981

Funding:	DSSC Funds
248	$ 20,200
381	30,549
535	157,485
Total	$208,234

PROJECT OBJECTIVES:

248: To study and develop techniques for narrowband digital voice coding equipment for space applications.

381: To design, breadboard and test a full duplex codec; to prepare a microcircuit system design.

535: To develop, test and evaluate a full duplex delta codec in LSI form.

PROJECT OBJECTIVES ACHIEVEMENT:

The technical objectives of the projects were fully met.

SUPPORT OF DSSC PROGRAM OBJECTIVES:

These contracts are considered to have supported the objectives of the DSSC program.

IMPACTS AND EFFECTS:

SED has realized little direct benefit as a result of its work under these contracts. The company does have an advantage in understanding of the technology, and has an option to purchase several hundred units immediately at a good price. The SED project manager stated that SED's interest was mainly in the systems applications area and that the company was not necessarily interested in marketing only the component.

Siltronics, on the other hand, has sold a number of units to Northern Telecom and AEL Microtel, and are in the process of refining the product and negotiating with potential users. Since the units represent a new approach to coding/decoding satellite transmissions, they are only useable in entirely new systems where they would become the standard for those systems, for both transmission and reception. Siltronics has contacted General Instruments (through its Jerrold subsidiary) to explore the possibilities of using the units in audio scrambling for Pay TV. The potential volume of this market is very high.

Background and History:

Work had been funded at SED in 1974-75 for early development of delta codec (coder/decoder) technology in relation to an RCMP mobile radio system. BNR had developed the necessary tooling for production of this version.

It was recognized that a low cost narrowband digital voice codec would be an essential element of the MUSAT system and probably for military satellite communications systems, and project 248 was undertaken to study the feasibility of the concept.

DOC decided to proceed with redesign of the half-duplex codec into a full-duplex model with optional voice activation meeting toll quality standards for satellite communications. The DOC project proposal was based on using the existing tooling at BNR, and was approved with funding of $20,000 for SED for redesign and engineering support and $50,000 for MITEL for LSI fabrication.

BNR, however, refused to release the tooling, the position being that although the Crown owned the tooling, it also embodied designs proprietary to BNR. High level meetings failed to resolve this problem. Although it was recognized that under these circumstances it would cost more to develop the codec, the decision was taken to proceed. SCO 381 was revised to cover only the redesign work that SED was to do, now a larger task than previously planned.

The final contract (SCO 535) was then negotiated for actual LSI production and testing. Siltronics Ltd. was accepted as the LSI subcontractor based on a competitive fixed price bid. One change in scope was approved to permit incorporation of a differential pulse code modulation (DPCM) format.

SED was licensed for the technology, but returned their rights to CPDL when it became clear that they would have limited use of the codecs themselves, but would have to pay royalties on all units produced by Siltronics. Siltronics was subsequently awarded the rights to the units and have been manufacturing them for sale in small volumes to AEL Microtel (a competitor of SED's in small voice terminals) and Northern Telecom.

Siltronics has since done further (internally funded) development work on a bipolar version of the chip and incorporated a higher bit sampling rate. The product in its current version is evaluated by Siltronics as operating on a unique algorithm and having no comparable competition. The company expects to penetrate the new systems market (e.g., audio scrambling for Pay TV) and sees large potential.

General Comments:

This case study is an interesting example of success in a project despite the failure of the main contractor. SED has realized little benefit to date, but despite this the technology has been made available to Canadian purchasers and gives promise of being highly marketable for the subcontractor, Siltronics.

Two main points can be made in this regard. First, the interest of the main contractor in following up and marketing the potential products must be well established. Secondly, the unwillingness of SED to pursue marketing of the components emphasizes the need to ensure that, in the event that the main contractor fails to make a useable technology available to willing purchasers, rights can be transferred to a firm which is willing and able to do so.

CASE STUDY 10
SED Systems Limited/Electrohome
Low Cost TVRO Earth Terminals (LCET)

Projects:

SED

383 Production and evaluation of Direct-to-home TVRO terminals. Phase I-Engineering.
December 1978 to December 1979.

483 Production and evaluation of Direct-to-home TVRO terminals. Phase II-Production.
March 1979 to March 1980.

589 Production and evaluation of Direct-to-home TVRO terminals. Phase III-Evaluation.
May 1980 to March 1983.

ELECTROHOME:

485 Indoor Unit for LCET
May 1979 to September 1980.

590 UHF tuner for LCET
March 1981 to March 1982

Funding:	DSSC Funds
383	$ 29,734
483	370,922
589	22,371
485	66,025
590	21,700
Total	$510,752

Project Objectives:

The overall objective of this series of projects was to advance the development of 12 GHz TVRO (TV Receive-Only) terminals for direct broadcast satellite reception to a state where reliable units could be produced in volume.

383: To prepare specifications, production plans and drawings for LCET.

483: To supply 100 LCET units to DOC.

589: To retest and evaluate the performance of 10 selected LCET's following 12 months of operational service.

485: To develop and deliver an improved indoor unit for use in satellite direct to home TV receivers.

590: To develop, test and deliver an improved low-cost mass producible UHF tuner for use in direct to home TV receivers.

Project Objectives Achievement:

The objectives of the projects were fully met.

Support of DSSC Program Objectives:

The contracts undertaken in this series are considered to have marginally supported the objectives of the DSSC program. There is considerable argument about whether the work is advanced development or simply product improvement.

Impacts and Effects:

As outlined in the following section, Electrohome credits the work performed under these contracts with positioning the company to enter the 4 GHz earth terminal market through a highly successful joint venture company, Gensat Communications Corp.

SED has achieved some sales (about $600,000) of the original units to private interests following delivery of the first 100 to DOC. They subsequently redesigned the original receiver and sold an additional $450,000 to two educational networks in Canada. The company is now producing a third generation unit for sale.

SED has also worked extensively with General Instruments on DBS technology at 4 GHz as well as 14/12 GHz. GI has paid the company in excess of $2 million for rights to the technology and for engineering services, and will also pay further royalties on all equipment produced, although it appears at this point that GI will arrange production through Japanese suppliers.

As a result of the stimulus provided through subcontracts for antennas for these units, Andrew Antenna has also established itself as a major supplier with a new 12 GHz product line.

Background and History:

At the time these contracts started, there was no capability in Canada for manufacture of low cost TV receive only earth terminals which it was expected would be widely used in relation to the direct broadcast satellite technology. SED had previously undertaken work under the DSSC program which would familiarize the company with microstrip product work, especially in the 12 GHz band, and had developed a low noise block converter under SCO 246.

DOC decided to support development of an appropriate product and purchase a number of units for evaluation and demonstration using ANIK B. Because of its previous (satisfactory) work in the area, SED was chosen to design the units and integrate its own components with certain parts to be manufactured elsewhere.

Electrohome, who had performed some work for DOC previously in the area of earth terminals, submitted an unsolicited proposal for development of a low cost indoor unit. The proposal was accepted with the intention of having Electrohome eventually supply these units as a subcontractor to SED. A later contract was directed to Electrohome for development of a reliable tuner to be used in the indoor units. SED found the indoor units to be somewhat lacking and were obligated to refine them prior to integration into the LCET units.

Following completion of the contracts, SED purchased an additional 100 tuners from Electrohome and manufactured 100 LCET's for private sale. A further 100 units were manufactured and sold using SED's own receiver design. The company at this time arranged to sell the rights to the technology to General Instruments, but retained the right to 60% of Canadian low noise converter (LNC) production.

Also at this time, the Therrien hearings on service to underserved areas of the country were in progress, with two competing technologies in the running: the North Star group, offering a DBS approach in 12 GHz using ANIK C, which would provide a substantial Canadian lead in the technology, and CANCOM, proposing to extend 4GHz service on ANIK's A, B and D using available technology. SED was working closely with the former group on 12 GHz applications, and when the commission ruled in favour of CANCOM, the technology suffered a major setback, although SED did continue to work with General Instruments. At this point, the US has agreed to lease the ANIK C for direct broadcast in the US, using Canadian technology which, it appears, will be manufactured inexpensively in Japan.

Electrohome decided to shift its corporate strategies and enter the 4 GHz market by forming a joint venture company with Microdesign Inc., a Toronto development engineering company, to design, manufacture and market 4 GHz receivers. Electrohome has spent approximately $2 million in company funds and through Gensat Communications Corp., the joint venture company. Gensat has been successful, and in June introduced a new family of Low Noise Block Converters to compliment the receiver family.

Gensat has current orders of $4.5 million, of which most are to US markets, and claims the potential of achieving $30 million in annual sales by the end of 1985. Although the business that has developed is not directly related to the original CRC funding, Electrohome states unequivocally that without this funding they would not have been positioned to enter the market.

General Comments:

The main issue illustrated by this case study is the need to control the technology which is developed under contract from the DSSC program. Although SED will realize substantial benefits from royalty payments by General Instruments, keeping the rights in Canada would in this case have positioned Canadian industry very strongly in the US direct broadcast market.

The impact of the decision to pursue 4 GHz technology also illustrates the need for high level support within DOC for R&D activities. Direct intervention in favour of the technology developed through these projects would no doubt have been impractical, but there is a clear role for senior managers as promoters and marketers of the products of R&D at least within government.

ANNEX E: Sample Questionnaires

DSSC/ICF PROJECT EVALUATION - COMPANY INFORMATION

PROJECT TITLE: ....

CONTRACT NO: .... YEAR AWARDED: ....

General

1. Who was (were) the company's designated project manager(s) for the project?

Funding

1. Did the funds provided by the ICF cover the total cost of the project?

2. If not, how much additional funding was required? Where did these funds come from (company, other federal or provincial programs, etc.)

Expectations

1. What potential market was being addressed by the product or technology which was to be developed under this project? How was this evaluated? If a market survey was taken, what were the findings?

Outcomes

1. Was the completed project considered by the company to have:
   . exceeded the original technical objectives?
   . fully met the original technical objectives?
   . partly met the original technical objectives?
   . not met the original technical objectives?

2. Did the company continue development of the product or technology at its own expense or with the support of another government program? Was the firm able to develop a new product line based on the product or technology developed as a result of this contract?

3. It is recognized that in research and advanced development work, unexpected technical results are sometimes realized in addition to, or instead of, original plans. Was this the case in this instance?. If so, what unexpected achievements resulted?

4. Were there spinoff products which the firm was able to develop and market as a result of the work carried out under this contract?

Sales

NOTE: The following questions relate to sales achieved and forecast for products and/or technology developed as a result of this project. In all cases, please distinguish between Canadian and offshore sales, and provide sales figures by year, where possible. A preformatted sheet has been enclosed to help organize this information.

1. What sales have been realized for products or technology directly resulting from this project?

2. What future sales are expected of products or technology directly resulting from this project?

3. What sales have been realized for spinoff products or technology which have resulted from this project?

4. What future sales are expected of spinoff products or technology which have resulted from this project?

Effects

1. What employment opportunities have been or are expected to be generated as a result of this contract (excluding any associated with performance of the contract itself)? What is the nature of these opportunities (professional, production, etc.)?

2. To what extent has the firm's technical expertise been improved as a result of this contract? Has there been any change in the company's competitive position in Canada or internationally?

Further Information

1. Please identify the most appropriate current contact in your organization for further information on this project.

PROJECT SALES INFORMATION

PROJECT TITLE:..

CONTRACT NO.:.....................YEAR AWARDED:................

Sales Year	CANADIAN		OFFSHORE	
	Direct Sales	Spinoff Sales	Direct Sales	Spinoff Sales

QUESTIONNAIRE

ICF PROJECTS (Case Studies)
(SCIENTIFIC AUTHORITY)

1. PROJECT: Title ______________________________
____
____

SCO ______________ REQ ______________

2. HISTORY: Start Date ______________________________

Target Date ______________________________

Completion ______________________________

Funding:

Estimated Cost ______________ Source: ICF ______________
Actual Cost ______________ DSS ______________
Company ______________
Other ______________
Specify ______________

Objectives: ______________________________
____
____
____

The project was initiated by UP

DOC

Amendments

DATE	COST Increase(Decrease)	SCOPE	TIMING
1.			
2.			
3.			
4.			
5.			
6.			

Problems: ______________________________
____
____
____

3. SELECTION:

Expected Impacts and Effects: ______________________________
____
____
____

This project supports:

☐ Mission - Specify ______________________________

☐ Industrial - Specify ______________________________

Risk of Failure:

☐ High ☐ Average ☐ Low ☐ None

Planning Input:

Was this part of a planned endeavor? ______________________________

4. RESULTS:

Objectives were:

☐ Not Met ☐ Partly Met ☐ Fully Met ☐ Exceeded

Spinoffs: 1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

5) ______________________________

Effects on Firm: ______________________________
____
____
____
____
____
____
____

5. DELIVERY SYSTEM:

How was project planned? ____________________

____

____

____

Who controlled/Monitored:

1) Costs ____________________

2) Milestones ____________________

3) Results (quality) ____________________

4) Documentation ____________________

How was project evaluated? ____________________

____

____

____

QUESTIONNAIRE

ICF PROJECTS (not in Case Studies)
(SCIENTIFIC AUTHORITY)

1. PROJECT: Title ______________________________
____
____

SCO ______________ REQ ______________

2. HISTORY: Start Date ______________________________

Target Date ______________________________

Completion ______________________________

Funding:

Estimated Cost ______________ Source: ICF ______________
Actual Cost ______________ DSS ______________
Company ______________
Other ______________
Specify ______________

Objectives: ______________________________
____
____
____

Objectives were:

☐ Not Met ☐ Partly Met ☐ Fully Met ☐ Exceeded

ANNEX F: List of Interviewees

List of Organizations Interviewed

Department of Communications:

- A/ADM Space Program
- DG Space Programs and Industrial Development
  - Marketing Support
  - Space Industry Development
- DG Space Communications Planning
  - Program Planning and Resource Management
- MSAT Program
- DG Space Technology and Applications
  - Space Communications
  - Space Electronics
  - Space Mechanics
  - Space Systems
- Program Evaluation

Other Government Departments:

- Energy, Mines and Resources
  - RADARSAT Program
- Industry, Trade and Commerce/Regional Economic Expansion
  - Program Evaluation
  - Portfolio Management
- Ministry of State for Economic and Regional Development
  - Operations Branch
- Ministry of State for Science and Technology
  - Universities Branch
  - Interdepartmental Committee on Space
- National Research Council
  - Program Evaluation
  - Space Science
  - RMS Project Office (National Aeronautical Establishment)
  - Industry Development Office
- Office of the Auditor General
- Statistics Canada
- Supply and Services Canada
  - Science and Engineering Procurement
  - Unsolicited Proposal Program
  - Source Development Program
- Treasury Board
  - Programs Branch
  - Office of the Comptroller General

Private Companies and Organizations:

- Air Industries Association of Canada
- Canadian Astronautics Limited
- Canadian Chromalox Ltd.
- ComDev Ltd.
- Delta Benco Cascade Ltd.
- Eidetic Systems Corporation
- MA Electronics Canada Limited
- Miller Communications Systems Ltd.
- SED Systems Inc.
- Siltronics Ltd.
- SPAR Aerospace Limited
  - Remote Manipulator Systems Division
  - Satellite and Aerospace Systems Division
  - Communications Systems Division
- Telesat Canada
  - Satellite Engineering
  - Earth Station Engineering

PROGRAM FOR THE DEVELOPMENT OF SPACE SUBSYSTEMS AND COMPONENTS : AN EVALUATION