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THE CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING

RESORS

1982 REPORT

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Canada

RESORS

Dr. K. Whitham
Chairman
Interagency Committee on Remote Sensing
Department of Energy, Mines and Resources
Ottawa, Ontario
K1A 0E4

Dear Dr. Whitham:

The theme of this year's CACRS meeting was New Initiatives in the National Remote Sensing Program. The studies and planning for RADARSAT, LANDSAT-4, LANDSAT-D Image Analysis System, MOSAICS and SPOT were presented to the meeting for discussion and comment. There was general agreement with the program direction and implementation.

The keynote speaker at the banquet was Fred Henderson III from the Geosat Committee who gave a very interesting review of the activities of the Geosat Committee and also the views of that committee on the United States Space Program.

An Industrial Panel gave an opportunity for industrial leaders to offer comments on the remote sensing program in Canada and how the involvement of industry could be increased. There was no suggestion that Canada should follow the American example, but rather that we should take a more cautious approach to the issue of commercialisation that would assure the continued health and viability of the program.

The Chairman of this year's meeting was Howard Edel from the Department of Fisheries and Oceans. Mr. Edel took over from Dr. Jim Gower, also from DFO, who was unable to attend the meeting but who did the preliminary planning.

There were 64 recommendations made at the meeting, of which 55 can be dealt with by CCRS and 9 which will be referred to the Interagency Committee on Remote Sensing.

Yours sincerely,

E.A. Godby
Chairman, Canadian Advisory
Committee on Remote Sensing

December 1, 1983

EXECUTIVE SUMMARY

1982 ANNUAL REPORT

CANADA CENTRE FOR REMOTE SENSING

CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING

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1.0 EXECUTIVE SUMMARY

The following is a summary of the discussions that occurred at the annual meeting of the Canadian Advisory Committee on Remote Sensing, which took place at Arnprior, Ontario, from May 9-12, 1983. The attendees at the meeting included the provincial representatives, chairmen of the various CACRS working groups, representatives of specialty groups, and invited speakers from Canadian industry.

Objectives of the Meeting

The general topic of the meeting was New Initiatives in the National Remote Sensing Program. Presentations were made in plenary session describing the various new initiatives:

(a) LANDSAT-4 data reception and production, including Thematic Mapper (TM) data;
(b) the development of a new analysis system (LDIAS) to handle LANDSAT-4 data;
(c) plans for data reception in future years from ERS-1 (the European Space Agency's remote sensing satellite due for launch in 1988) and from SPOT (the French satellite due for launch in 1985);
(d) progress made in the Canadian radar satellite program (RADARSAT);
(e) the development of MOSAICS, a processing tool to enable the combination of data from many different sources;
(f) the Technology Enhancement Program (TEP); and
(g) increased industrial participation in the National Remote Sensing Program.

The plenary group was then broken down into regional workshop groups, which were asked to address the following topics:

(a) Are the new initiatives meeting the perceived needs of the Canadian Remote Sensing Program? What are your recommendations on the future direction of the program?

(b) Is the balance between government and industry correct? What are your comments, concerns, or recommendations with regard to increased industrial involvement in the satellite reception and data distribution system?

(c) Is the CACRS/IACRS organization adequately meeting the needs of the remote sensing community in view of these new initiatives?

The conclusions are summarized below under Results.

Industrial Panel

An industrial panel under the chairmanship of Mr. Leon Bronstein, Canada Centre for Remote Sensing, was made up of senior representatives from 10 Canadian companies with interests in remote sensing. The panel members made individual presentations and then engaged in discussion, addressing the following questions:

(a) Is the sale of remote sensing satellite data a commercially viable activity in Canada, assuming the continued availability of LANDSAT-type data products?

(b) How could industry operate such a commercial activity, taking into account the research and development nature of the present Canadian government program?

(c) Are the new initiatives leading towards more industrial involvement in the Canadian remote sensing program?

In the discussion following the panel presentation, the following conclusions were reached.

The continued availability of multi-spectral LANDSAT-type data is the highest program priority, in order to maintain existing systems using the data and in order to continue the process of weaning resource managers away from conventional sources of information. The benefit/cost ratio in remote sensing has not yet been clearly enough assessed, particularly on a world-wide basis. Increased industrial involvement is both necessary and desirable for the health of the overall Canadian program, but the timing of its implementation needs careful thought; it seems probable that no one agency or company could undertake the total system in an ideal manner and therefore the program should be broken into components which can be more easily handled. The need for continued training at all levels dictates cooperation between universities, governments, and private industry in order to reap greater benefits. The greatest gap in communications, is still that between the technologist and the applications user, and needs to be bridged before the added value that technology gives to data can benefit the user.

Results

The **Western Provinces** workshop group, led by Mr. Frank Hegyi, (see recommendations 3.1.1 to 3.1.9), were concerned about the uncertainties in the LANDSAT program and recommended that contingency plans be prepared to incorporate advice from provincial groups should selective acquisition of data become necessary. They

approved and recommended the continuance of the LDIAS and MOSAICS programs as well as the Technology Enhancement Program. They emphasized the need for training, and recommended that software associated with the new initiatives be identified as a marketable product and that all remote sensing software developed by public funds be made available to all participants in the Canadian Remote Sensing Program at very low cost.

The **Ontario** workshop group, led by Mr. Victor Zsilinszky, (see recommendations 3.2.1 to 3.2.5), emphasized the need for continuity of digital visual data and therefore recommended continued participation in the LANDSAT program and support for the SPOT program. They also recommended the inclusion of an optical sensor as the secondary option on RADARSAT. They were concerned about the amount of funding for applications research in the Canadian radar program. In view of the continued need for research in data processing and analysis, they recommended that CCRS remain fully involved in algorithm and software research and development, and that activities towards privatization proceed with caution.

The **Québec** workshop group, led by M. Ferdinand Bonn, (see recommendations 3.3.1 to 3.3.3), congratulated CCRS on its initiatives taken in the programs for LANDSAT-4, SPOT, RADARSAT, and MOSAICS. They felt that the province of Québec is under-represented on the Canadian Advisory Committee on Remote Sensing, and recommended that a small group be formed, representing le Centre québécois de coordination de la télédétection (CQCT), l'Association québécoise de télédétection, and CCRS, to form a plan of action to improve this situation. They also recommended that an applications user group be formed to advise on the LDIAS project.

Recognizing the importance of the Technology Enhancement Program, they recommended that funds and support for this program be greatly increased to ensure that full benefits are achieved.

The **Atlantic Provinces** workshop group, led by Mr. Ed MacAulay, took the approach of priorizing and commenting on all the recommendations submitted by the provinces and working groups in their individual reports. They placed highest priority on extension to and increased support for the Technology Enhancement Program in the Maritime Region. In view of the closure of the Shoe Cove Satellite Station, they also recommended that every effort be made to provide Eastern Canada with timely access to both LANDSAT and NOAA data at a uniform Canadian price and with full archival of eastern data. They felt that special attention should be given to eastern Canada in the planning process for all future microwave satellites, because of the importance of ice and iceberg monitoring and because of the cloud cover problems associated with land-based applications.

CACRS Organization

The terms of reference for the Canadian Advisory Committee on Remote Sensing have now been approved by the Inter-Agency Committee on Remote Sensing, and were reapproved as read at the CACRS meeting.

2.0 THE CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING (CACRS)

Introduction

The Canadian Advisory committee on Remote Sensing (CACRS) was established in January 1972 to effect the development of a national program of remote sensing. Membership in the committee comprises representatives of provincial and federal organizations, industry and universities. Most members represent a government agency or national working group and thus ensure a broad representation of users, scientists and technologists. Annual meetings are held each calendar year to review programs and make recommendations.

Terms of Reference of CACRS

The Canadian Advisory Committee on Remote Sensing has the following purposes:

1. Advising and assisting the government of Canada, through the Minister of Energy, Mines and Resources, in meeting the objectives of the national program of remote sensing, by assessing national needs and capabilities and making recommendations regarding existing and proposed programs funded by EMR.

2. Advising and assisting all participants in the national program of remote sensing in the application of remote sensing techniques to the nation's resource management systems by:

   - studying the need for technology transfer to the end-user and industry;

   - promoting the active participation of interested parties in the execution of such transfer, and facilitating the coordination of their efforts;

   - evaluating the results.

3. Promoting the development and diffusion of remote sensing methods and applications by:

   - promoting research and development activity

   - exchanging scientific and technical information

   - organizing conferences, seminars, and training courses.

Structure of CACRS

The Canadian Advisory Committee on Remote Sensing has the following structure:

Chairman:	Director General, CCRS
Executive:	An executive committee was established in 1981 with terms of reference and structure described immediately below.
IPTASC:	The Interprovincial/Territorial Advisory Subcommittee of CACRS is a body of representatives appointed to CACRS on the recommendation of the provinces and territories.
Working Groups:	CACRS establishes such working groups as it deems necessary to carry out its work. Some of the groups may operate on an on-going basis, while others may be ad-hoc groups appointed to carry out a specific task and then disbanded upon completion of the task.
Secretariat:	Provided by CCRS.

Terms of Reference of the CACRS Executive

The Canadian Advisory Committee on Remote Sensing has an Executive with the following functions:

1. To analyze and rank, in order of priority, the recommendations of CACRS.

2. To decide on realistic methods of implementing these recommendations.

3. To review and approve the work plans of the working groups and to provide guidance to improve effectiveness.

4. To approve the establishment and terms of reference of limited-life working groups to meet specific needs.

5. To oversee special studies.

6. To prepare plans for and to oversee the reorganization or evolution of CACRS.

7. To plan and co-ordinate the organization of the annual CACRS meeting.

8. To approve a summary of the results and recommendations of the annual CACRS meeting for transmittal to higher authority (i.e. IACRS in the case of the federal government).

9. To review the above-listed Terms of Reference at the CACRS meeting annually.

Structure of the CACRS Executive

The representation on the CACRS Executive is as follows:

Chairman: Director General, Canada Centre for Remote Sensing.

Provinces: Chairman, Vice-Chairman, and Past Chairman, IPTASC, (Interprovincial/Territorial Advisory Subcommittee of CACRS).

Working Groups: Two representatives elected by the working group chairmen, to be appointed for a two-year term.

Industry: A representative of Canadian industry may be invited on an as-required basis to address a particular agenda item at an Executive meeting.

Universities: The Chairman, Education Working Group.

3.0 RECOMMENDATIONS OF CACRS

These recommendations have been extracted from the reports of working groups, provinces, and provincial associations (which may be found in full in the minutes of the 1983 CACRS meeting) and from the reports of the workshop groups which met during the annual meeting of CACRS. They have been considered by the CACRS Executive, and the comments of the Executive have in some cases been expanded upon by CCRS.

3.1 Continuity of Data - LANDSAT Program

3.1.1 CACRS is concerned about the uncertainty of getting a continuous supply of LANDSAT-4 MSS and TM data. Therefore, we recommend that CCRS prepare a contingency plan which should consider the availability of a limited supply of LANDSAT-4 data, airborne MSS and LANDSAT-3 MSS data.

- Western Provinces Workshop

This contingency plan is being prepared by CCRS and the provincial representatives are being kept informed.

3.1.2 Since we may be faced with a reduction of LANDSAT-4 MSS and TM data supply, we recommend that LANDSAT-4 MSS and TM data acquisition priorities in Provinces be coordinated by IPTASC members through a committee consisting of representatives from provincial and federal governments, industry and universities, within the context of CCRS guidelines.

- Western Provinces Workshop

CCRS is in full agreement with this recommendation and will carry it out.

3.1.3 The highest priority for the CCRS hardware program for the Ontario region is continuity of digital visual data. Therefore, we recommend that CCRS maintain a strong involvement with the LANDSAT program and continue support of the future SPOT program.

- Ontario Workshop

CCRS is in full agreement with this recommendation.

3.1.4 CCRS should publicize the availability of good LANDSAT imagery on a regular basis through 1983 due to the frequent interruption of operations of the LANDSAT systems and low level of probability of acquiring LANDSAT-4 imagery in 1983.

- Agriculture Working Group

This action is part of the CCRS contingency plan.

3.1.5 Whereas there has been a real demonstration of the usefulness of satellite images over the past decade, and whereas many areas still suffer from the lack of acceptable images at acceptable dates, new initiatives must be made to assure Canadian resource managers of a continuity of satellite data in order for managers to accept the data as a useful tool.

- Forestry Working Group

CCRS welcomes this input from the Forestry Working Group and solicits the help of the working group in carrying it out.

3.2 Continuity of Data - Results of Closure of the Shoe Cove Satellite Station

3.2.1 Given the closure of the Shoe Cove Receiving Station, it is recommended that Eastern Canada be assured that every effort will be made to provide data from both LANDSAT & NOAA: a) in a time frame required on a project-by-project basis; b) at a uniform Canadian price; c) with full Canadian archival allowing back ordering on request.

- Atlantic Provinces Workshop

3.2.2 Under any revised LANDSAT acquisition or pricing plan, CCRS must ensure that the Nova Scotia user community is supplied with complete MSS and TM Canadian coverage at a uniform Canadian price and in a delivery time frame similar to that for central Canadian coverage.

- Nova Scotia

3.2.3 In light of the closure of the Shoe Cove Receiving Station, thereby reducing the Canadian coverage of New Brunswick, it is strongly recommended that CCRS provide a firm assurance that N.B. users of any form of satellite data will be provided with identical service in terms of cost, quality and speed, as other users who enjoy full Canadian coverage.

- New Brunswick

3.2.4 Given that the closure of the Shoe Cove Receiving Station will reduce or eliminate Canadian coverage over some Eastern Canadian land and water areas, it is recommended that:

a) approved users be given fast access to data from foreign sources.

b) the cost of such data be subsidized to be in line with Canadian prices at the time of purchase.

- Water Resources W.G.

3.2.5 The Agriculture Working Group expresses serious concern over the closing of the Shoe Cove Receiving Station and its depressing effect on the Atlantic data bases.

- Agriculture Working Group

CCRS recognizes the validity of the concerns expressed through all these recommendations, and will make every effort to ensure that the needs of users are fully met.

3.3 **Cost of Data**

3.3.1 That a single band of LANDSAT-4 TM (Band 3) be produced routinely in place of RBV. That the proposed $100 charge for colour masters be eliminated, as it would be prejudicial to the monitoring of large areas.

- Ontario

This recommendation is being referred to the Data Acquisition Division, CCRS, for consideration.

3.3.2 The Agriculture Working Group is greatly concerned over the projected cost increases of LANDSAT imagery tapes and recommends that CACRS strongly support submissions to inter-governmental agencies (e.g. Canadian Space Program) to minimize the increases for all purchasers and to improve availability of LANDSAT imagery for all users.

- Agriculture Working Group

The Executive feels that this recommendation should be referred to the Inter-Agency Committee on Remote Sensing.

3.4 **Technology Enhancement Program**

3.4.1 The Technology Enhancement Program is identified as a key element in the development of information products derived from remote sensing. CACRS strongly supports the initiatives taken and recommends that this be continued.

- Western Provinces Workshop

CCRS supports this recommendation and will forward it on to IACRS.

3.4.2 The workshop recognizes the importance of the technology transfer program and recommends that the resources available to this program be greatly increased so that all regions can benefit from it.

- Québec Workshop

This recommendation will be sent to the Inter-Agency Committee on Remote Sensing.

3.4.3 That CCRS reserve some technology transfer resources to facilitate efforts to transfer technology to private enterprise.

- Québec

CCRS recently participated in the signing of a major agreement in this area between the Quebec private sector and the National Research Council under the latter's PILP program.

3.4.4 That CCRS ensure that sufficient funds are budgeted to support the Technology Enhancement Program in the Maritime region for a sufficient time beyond March 31, 1984 to give a reasonable opportunity for success. This includes the provision of access to image analysis facilities at a location convenient to the user community.

- Nova Scotia

CCRS intends, through appropriate submissions, to request approval to continue the Technology Enhancement Program beyond March 31, 1984. If approval is obtained, the Centre will consult with the Maritimes Remote Sensing Committee regarding the appropriate extension of the current program.

The issue of image analysis facilities is indeed currently being examined in the framework of a joint Maritimes/CCRS effort.

3.4.5 Whereas there is a continuing need for technology transfer in a real-world, active application sense, and whereas it appears that most users of advanced remote sensing are federal employees, new initiatives must be made at selling the tool of remote sensing. It is suggested that government scientists should be involved with work exchanges with industry for extended periods of time (i.e. one year) in order for the remote sensing specialist to more critically understand the needs and problems of industry. Such exchanges would help to demonstrate that new tools like remote sensing with input of a specialist can be used to economic advantage in providing answers and in changing for the better, traditional resource management techniques and attitudes at the working level.

- Forestry Working Group

The "Interchange Canada" program exists to facilitate this proposal.

3.4.6 We recommend that CCRS offer the opportunity for visiting scientists and resource managers to work on the new initiatives.

- Western Provinces Workshop

CCRS is in agreement with this recommendation; in particular, visiting scientists sponsored by their own agencies are welcome to participate in the RADARSAT Program.

3.5 Applications Development

3.5.1 That CCRS be commended for the added emphasis which has been observed in the applications section in 1982. It is recommended that an increased emphasis be further applied in 1983 and that applications section personnel will continue to make themselves more available to the user community.

- Nova Scotia

CCRS appreciates this compliment from the Province of Nova Scotia and will continue its best efforts.

3.5.2 That more research be directed toward cost-effective, operational applications.

- Ontario

CCRS is in agreement with this recommendation and is carrying it out as far as funds allow.

3.5.3 Bird and Hale Ltd. recommends that 5 to 8 test sites be established in different physiographic regions across Canada, where ground truth data would be compiled and made available. These sites would be used both for the testing of sensors under development and for operational sensors, and would allow the accurate comparison of sensor performance by type of terrain feature.

- Ontario

Certain test sites already exist and should be referred to before new sites are established.

3.5.4 Simulated imageries should continue to be available for applications investigation and feasibility studies of high resolution space imageries.

- Engineering Working Group

Such imagery will continue to be available.

3.5.5 Continuing support (both "moral" and financial) be given for both laboratory and field studies of the physical properties of sea ice. The most important properties are those which may be related to the interaction of electromagnetic radiation with ice.

- Ice Working Group

3.5.6 Any research related to iceberg detection by radar encompass as complete an "in-situ" data set as possible and be carried out under different environmental, regional and oceanographic conditions. Specifically by area; Baffin Bay (large sizes, high population), Labrador Sea (smaller sizes, lower population) to Hibernia (including growlers, low population), by temperature; melting and freezing condition, by background; pack ice, landfast ice and ocean under different wind and wave conditions.

- Ice Working Group

3.5.7 Experiments be designed such that the remotely sensed information can be used to help guide the collection of surface truth data for specific regions or anomalies in the remotely sensed data (in addition to more conventional techniques of surface truthing).

- Ice Working Group

CCRS is in general agreement with these three related recommendations and feels that the members of the Working Group on Ice are in the best position to ensure that they are carried out.

3.6 Data Acquisition and Image Processing

3.6.1 CACRS supports the initiatives taken by CCRS in the development of the MOSAICS for the production of geocoded products and recommends the inclusion of AVHRR and airborne products.

- Western Provinces Workshop

3.6.2 The oceans user applications community recognizes the great benefit of geocoded digital imagery available from DICS. It is recommended that AVHRR data be provided in geocoded format from DICS for an applications demonstration with the product being provided operationally from MOSAICS.

- Chairmen of Workshop Groups

3.6.3 The image processing facilities with common software systems must be encouraged to cooperatively develop Canadian oceans applications software in coordination with universities and AES.

- Oceanography Working Group

CCRS is in agreement with these three recommendations and will consult with the Atmospheric Environment Service to discuss their implementation.

3.6.4 That CCRS make all possible efforts to obtain from NASA the processing of larger quantities of Canadian LANDSAT-4 TM coverage.

- Ontario

CCRS will do this, although it will naturally depend upon the availability of TM data from the satellite.

3.6.5 That CCRS discontinue the policy of making duplicate CCT's from the original recorded data; rather, that one CCT be produced from the original data and all other copies made from this master. The original data would thus be protected from the data loss which appears to increase with the number of times a copy is made. As copies can be made from a master CCT without data loss, users would not then have the experience of ordering a CCT on the basis of high quality hard-copy image and finding that the CCT contained too many gaps and errors to be used. The problem has been particularly noticeable on bands 4 and 5 of excellent-quality, cloud-free images which are much in demand.

- Ontario

The funds necessary to implement this suggestion (about $300K) were planned for but not approved in the 1983-84 budget. CCRS will continue to study the problem and will keep users informed of progress.

3.6.6 That CCRS keep users better informed of developments in image processing. Two rather significant examples of a failure to do so were experienced in 1982:

a) CCRS did not inform users that Canada would not have its own facility to process LANDSAT-4 TM data for some two years after the launch of the satellite;

b) CCRS failed to inform users of the change in CCT format from Universal to Standard, or to provide additional information on the new format such as the altered sequence of the bands.

- Ontario

CCRS has taken note of these problems, and will make every effort to keep users better informed in the future.

3.6.7 We recommend that CCRS continue supporting the LDIAS system.

- Western Provinces Workshop

CCRS has taken note of this recommendation and will forward it on to IACRS.

3.6.8 We recommend that software associated with the new initiatives be identified as a marketable product, and that all remote sensing related software developed by public funds be made available to all participants in the Canadian remote sensing program for very low cost (if any).

- Western Provinces Workshop

3.6.9 IPTASC recommends that CCRS closely monitor the production of DICS tapes to ensure that a reasonable delivery time is maintained. This is particularly important with respect to deliveries scheduled prior to the financial year end of the ordering agency. This has severe budget implications if delivery takes place after April 1st. CCRS should ensure (by laying on an extra shift if necessary) that all orders place by the 1st of February are delivered before March 31st.

- IPTASC

3.6.10 That CCRS take steps to accelerate production of DICS images (some orders have taken seven months to complete).

3.6.11 It is recorded that an ad hoc CACRS Working Group be established to define specifications and to prepare by 31 December 1983, a realistic plan for the generation of DTMs for the Canadian land mass by 1990.

- Renewable Resources Working Group

This recommendation has been forwarded to the Surveys and Mapping Branch, EMR, with a letter of support from CCRS.

3.6.12 With the proliferation of microcomputers, there is a need to fully investigate their application to various remote sensing activities. CCRS, as the national agency, should provide direction, coordination and assistance.

- Engineering Working Group

3.6.13 The development of video disc technology continues to be followed and its application and potential for data archival must be evaluated at the earliest opportunity.

- Oceanography Working Group

3.6.14 The development of image analysis capabilities with the Apple PIPS micro-processor system is acknowledged as beneficial for the extension of remote sensing derived information to the manager. We recommend that this technology continue to be supported and that it be extended to other micro-processor systems and integrated with the video disk technology as a high capacity information system for managers.

These three recommendations on the use of microprocessors and of video disc technology will be studied by CCRS.

3.7 RADARSAT

3.7.1 It is recommended that special attention be given to the East Coast for all future microwave satellites, Canadian and foreign. The East Coast must be assured of data coverage in required real time for all future passes. Considering the importance of ice and iceberg monitoring with respect to oil and gas exploration and production and East Coast shipping, and given the general cloud cover problems associated with land-based applications, planning should begin now for acquisition procedures and dissemination of East Coast data for the next generation of microwave satellites.

- Atlantic Provinces Workshop

This recommendation will be forwarded to the RADARSAT Project Office and to IACRS.

3.7.2 It is recommended that CCRS strongly support the inclusion of a VIR sensor on the RADARSAT system. In further support of the VIR system, the group encourages continued research on the MEIS type sensor (as potential replacement for some conventional approaches and a possible airborne backup for spaceborne systems).

- Ontario Workshop

3.7.3 That the second RADARSAT sensor be an optical sensor.

- Québec

These two recommendations will be forwarded to the RADARSAT Project Office and to IACRS.

3.7.4 In view of the high benefits expected from agriculture and forestry

applications of RADARSAT data, it is recommended that Agriculture Canada and the Canadian Forestry Service be represented in the RADARSAT decision making structure.

- Renewable Resources Working Group

This recommendation will be forwarded to the RADARSAT Review Board, to whom specific proposals should also be made by the two organizations concerned.

3.8 **SPOT**

3.8.1 We recommend that CCRS continue with negotiations to acquire SPOT data and inform CACRS members of the financial details; then, CACRS members will provide CCRS estimates of SPOT data requirements.

- Western Provinces Workshop

CCRS is in full agreement with this recommendation.

3.8.2 That coverage of the entire province be provided in TM and SPOT (HRV) images.

- Québec

CCRS has taken all possible steps to acquire the TM data available in Canada, particularly that covering Québec. The Centre is currently discussing the reception of SPOT data with the French agencies in question.

3.9 **Research and Development**

3.9.1 Research is needed to develop applications software and algorithms to take advantage of the next generation of remote sensing systems. This group strongly supports the role of CCRS in algorithm and software research and development programs such as LDIAS.

- Ontario Workshop

CCRS will forward this recommendation to IACRS.

3.9.2 CACRS recommends that continued microwave research be carried on, but would also like to be assured that there is sufficient funding for microwave applications research.

- Ontario Workshop

CCRS is doing as much as possible with the funds available.

3.9.3 The Agriculture Working Group expresses concern over the very low level of resources provided in agricultural research by the government for remote sensing, and recommends that CACRS encourage interdepartmental agencies (e.g. Interdepartmental Committee on Space) to support research and development in the application areas.

- Agriculture Working Group

CCRS believes that the right agency to consider this recommendation is IACRS, and will forward it to them.

3.10 **Industrial Involvement**

3.10.1 We recommend that CCRS pursue with caution, the moves to privatize the data production stages of the CCRS operation. CCRS activities toward privatization should be delayed.

- Ontario Workshop

CCRS has taken note of this recommendation and will forward it to IACRS.

3.10.2 That a brochure or movie be prepared to inform potential international buyers, particularly developing countries, of the remote sensing services available from Canadian private companies, universities, CCRS and provincial remote sensing centres.

- Ontario

CCRS would welcome proposals from industry on such a project.

3.11 **Organization and Communications**

3.11.1 IPTASC wishes to confirm that Dr. Ken Whitham's recent visit to the provincial remote sensing operations was most welcome. His interest in and understanding of provincial remote sensing activities are acknowledged and very much appreciated. The representatives of those provinces Dr. Whitham has not yet been able to visit, look forward to the occasion.

- IPTASC

This statement has been forwarded to Dr. Whitham.

3.11.2 The Association Québécoise de Télédétection (AQT) recommends that Québec representation at CACRS be increased to reflect the proportion of Canada's Francophone population more closely. For this purpose, the AQT asks to be consulted during nominations to CACRS and the working groups, so that it can suggest names.

- The Association Québécoise de Télédétection

CCRS is in complete agreement with the AQT's wish and will act accordingly.

3.11.3 That the CQCT, the AQT and CCRS meet to establish an action plan for better Québec representation within CACRS.

- Québec Workshop

CCRS agrees with the spirit of this recommendation. A first meeting will be held in September 1983.

3.11.4 Given that the activities of the remote sensing associations in Canada provide an important source of contact with the remote sensing community, particularly for those who are only marginally involved in remote sensing or are isolated from others with remote sensing interests, it is recommended that the Chairman of CACRS invite and encourage remote sensing associations to submit annual reports of activities to CACRS, thereby ensuring that the Annual Report provides a complete record of remote sensing activities in Canada.

- Ontario Association for Remote Sensing

CCRS is in agreement with this recommendation and will carry it out.

3.11.5 We recommend that the Image Analysis Sub-Working Group be reactivated.

- Western Provinces Workshop

This is being done, under the larger aegis of the Data Handling Working Group.

3.11.6 That a consultative group for LDIAS be formed to represent the interests of users in the area of applications.

- Québec Workshop

CCRS agrees with this recommendation and will act accordingly.

3.11.7 IPTASC recommends that CCRS airborne mission plots (index maps) be disseminated on a regular basis to applicable provincial remote sensing centres.

- IPTASC

This recommendation has been forwarded to the Data Acquisition Division, CCRS, for implementation.

3.12 Training and Education

3.12.1 That remote sensing imagery collections be set up, similar to the map collections available at depository map libraries across Canada. Updated regularly, these collections would increase the access of the general public to remote sensing data, and would assist the teaching of remote sensing at universities.

- Ontario

CCRS will discuss this recommendation with NAPL ato see what would be involved in its implementation.

3.12.2 That the national remote sensing program give funding for remote sensing education and to support institutions which do not have the resources to advance in remote sensing. Concrete support in terms of funding for hardware, software and staff would be more productive than continued funding for research and token technology transfer efforts.

- Ontario

NSERC funds are available for such purposes and many universities already take advantage of them.

3.12.3 That low-cost lab materials be prepared for instruction at technical schools.

- Ontario

3.12.4 That a series of adequately-documented teaching sets be developed for radar, multispectral and thermal imagery.

- Ontario

Both these recommendations would make good projects for private industry to pick up. Provincial or regional remote sensing centres might also wish to be involved.

3.12.5 That the Working Group on Engineering Applications prepare lab-exercise material based on actual studies for civil engineering students at various levels.

- Ontario

CCRS agrees that this would be an excellent task for the Working Group to undertake.

3.13 **Resource Information Systems**

3.13.1 Whereas there is a need on the part of the resource manager for not only overview data, largely because overview (satellite) images don't provide all the answers, but also for site-specific data, it is recommended that new initiatives be taken to define and explain the potentialities and limitations of remote sensing for resource management. Such re-definition would include the role of multistage remote sensing and aerial photography.

- Forestry Working Group

CCRS suggests that this task be included in the terms of reference of the Forestry Working Group.

3.13.2 Whereas there is currently a perceived bottle neck in the delivery of timely remote sensing data, it is recommended that new initiatives be taken in establishing a nation-wide data delivery system that will handle the data-loads of the new generation of resource satellites. A data base management system must be established which will permit automated change detection, inventory update, and other resource management needs as defined by resource managers.

- Forestry Working Group

CCRS is in agreement with this general recommendation and is constantly working towards improved delivery times. It notes, however, that some of the automated processes mentioned here already exist, and would refer interested people particularly to Dr. Peter Kourtz's work in change detection and inventory update.

Historical Highlights

1971

APRIL 1: Canada Centre for Remote Sensing officially established, with Dr. L. W. Morley as Director-General.

MAY: Agreement signed between EMR and NASA.

1972

FEB. 22-24: First CACRS (third "Montebello") meeting at Montebello, Québec.

JULY 23: LANDSAT-1 launched.

1973

FEBRUARY 7-9: First Canadian Symposium on Remote Sensing (Ottawa, Ontario).

FEBRUARY 19-22: Second CACRS Meeting, Montebello, Québec.

APRIL: Manitoba Remote Sensing Centre established in Winnipeg.

SEPTEMBER: Ontario Remote Sensing Centre established in Toronto.

1974

FEBRUARY 18-21: Third CACRS Meeting, Montebello, Québec.

APRIL 28-May 1: Second Canadian Symposium on Remote Sensing (Guelph, Ontario).

JUNE: Alberta Remote Sensing Center established in Edmonton.

1975

JANUARY 23: Launch of LANDSAT-2.

MARCH 31-APRIL 3: Fourth CACRS Meeting, Montebello, Québec.

SEPTEMBER 22-24: Third Canadian Symposium on Remote Sensing (Edmonton, Alberta).

1976

MARCH 29-APRIL 1: Fifth CACRS Meeting, Arnprior, Ontario.

1977

APRIL 4-7: Sixth CACRS Meeting, Arnprior, Ontario.

MAY 16-18: Fourth Canadian Symposium on Remote Sensing (Québec, Québec).

JULY: Opening of the Shoe Cove Satellite Station in Newfoundland and subsequent reception of LANDSAT data.

1978

JANUARY 7: Closedown of LANDSAT-1 after 5½ successful years.

MARCH 5: Launch of LANDSAT-3.

APRIL: Launch of HCMM.

APRIL 10-13: Seventh CACRS Meeting, Arnprior, Ontario.

JUNE 27: Launch of SEASAT.

AUGUST 28-31: Fifth Canadian Symposium on Remote Sensing (Victoria, B.C.).

OCTOBER 10: Failure of SEASAT.

DECEMBER: Signing of the Cooperative Agreement between the European Space Agency and Canada, to take effect January 1, 1979.

1979

APRIL 9-12: Eighth CACRS Meeting, Arnprior, Ontario.

1980

APRIL 8-11: Ninth CACRS Meeting, Arnprior, Ontario.

MAY 21-23: Sixth Canadian Symposium on Remote Sensing (Halifax, N.S.).

1981

APRIL 13-16: Tenth CACRS Meeting, Arnprior, Ontario.

SEPTEMBER 7-10: Seventh Canadian Symposium on Remote Sensing (Winnipeg, Manitoba).

1982

MARCH 29-APRIL 1: Eleventh CACRS meeting, Arnprior, Ontario.

JULY 16: Launch of LANDSAT-4.

THE CANADA CENTRE FOR REMOTE SENSING

The Canada Centre for Remote Sensing (CCRS) was established in February 1971 as a branch of the federal department of Energy, Mines and Resources.

CCRS develops and demonstrates systems, methods and instruments to acquire, analyze and disseminate natural resources management data obtained from specially-equipped aircraft and satellites. The broad viewpoint of the satellites and their regular coverage of the region with specialized sensors offer new technical and economic possibilities for resource management, while aircraft serve to provide a detailed view where needed, as well as a research and development platform for development of new applications.

Demonstrated techniques are transferred to industry and the user community, as a contribution to the development of effective information and management systems for Canada's land and ocean resources and environment.

Examples of applications in which remote sensing technology can be used include the management of economically accessible forests, forest fire protection, mineral exploration, improvement of agricultural land use practices, crop monitoring and reporting systems, as well as ice reconnaissance in support of oil and gas operations in the Arctic.

TECHNOLOGY ENHANCEMENT PROGRAM

The objective of the Technology Enhancement Program is to assist provincial governments in enhancing their remote sensing capabilities for natural resource management purposes. The objective will be accomplished by CCRS entering into agreements with provincial governments whereby projects, using proven remote sensing technologies, will be undertaken jointly by personnel from provincial resource agencies and the Technology Enhancement Program.

Following approval of the plans by the Inter-Provincial and Territorial Advisory Subcommittee of CACRS (IPTASC), CCRS entered into a planning phase with the coordinators designated by the Province of Manitoba and the Council of Maritime Premiers on behalf the three Maritime provinces. The planning phase has been successfully completed.

Projects included under the Manitoba program include:

(1) Crop Data Monitoring
(2) Wildfire and Forest Fuel Mapping
(3) Mapping Wood Salvage in the Porcupine Mountains
(4) Moose Habitat Monitoring
(5) Valley River Watershed Present Land Use
(6) Park Site Land Use/Land Cover Mapping
(7) Flood Mapping
(8) Weed Growth Monitoring on Cross Lake

The projects envisaged for the Maritime program are:

(1) Forest Clearcuts and Logging Road Monitoring - Periodic Estimation of Timber Extraction - Nova Scotia.
(2) Forest Clearcut Monitoring - Periodic Estimation of Timber Extraction - New Brunswick.
(3) Forest Depletion Monitoring - Periodic Estimation of Timber Extraction - Prince Edward Island.
(4) Soil Erosion and Field Crop Monitoring - New Brunswick.
(5) Field Crop Monitoring Soil Erosion Assessment - Prince Edward Island.
(6) Near Real-Time Snow Cover Monitoring - Mapping, Saint John River Basin - New Brunswick.
(7) Inventory and Monitoring of Peatlands - Nova Scotia.
(8) Geological Mapping of Granitic Complexes in Guysborough, Cumberland and Colchester Counties - Nova Scotia.

APPLICATIONS DEVELOPMENT PROGRAM

During the past year, work in the Applications Technology Division moved closer to operational status in several activity areas.

Agriculture and Rangeland

The operational phase of the rangeland work continued in 1982. The main user agencies are the Public Lands Division of the Alberta Ministry of Energy and Natural Resources and the Prairie Farm Rehabilitation Association in Saskatchewan. The rangeland enhancement production system was implemented using CCRS equipment at the Sheffield Road facility in Ottawa. Production capability will be extended to Prince Albert, Saskatchewan, in 1983. The Alberta Remote Sensing Center (ARCS) has carried out a very

successful marketing and sales distribution effort for these enhancements. A workshop on rangeland enhancement interpretation was held in Lethbridge in February, 1982.

Research activities on crop monitoring were carried out in 1982 in coordination with the Canadian Wheat Board, Statistics Canada and Agriculture Canada. Based on this work it is now possible to produce high quality corrected NOAA imagery on a short turnaround basis. The imagery can be corrected for effects arising from the wide angle of view, the ascending orbit, and the effects of atmospheric radiance. Discussions are now under way with Agriculture Canada to reduce the cost of NOAA data acquisition through the use of GOES for cloud cover assessment and image selection. Efforts are also under way to develop production assessment models for cereal crops using LANDSAT and NOAA data. The operational phase of the project begins in May, 1983.

In 1982, an accurate and timely estimate of potato acreage was produced for New Brunswick by Statistics Canada staff. The original CIAS methodology has now been translated to be compatible with the ARIES II system. With support from the Applications Technology Division's Technology Enhancement Program, the area estimate for 1983 will be produced in St. John, New Brunswick. An estimate for Prince Edward Island will be produced with assistance from Applications Development scientists.

The canola-rapeseed methodology developed in 1981 was applied to three crop districts in Alberta this year. In 1983 the methodology will be transferred to the ARIES II system with CCRS assistance, so that the estimate for Alberta areas can be produced at ARSC.

In 1982, CCRS initiated a research effort to assess the potential of satellite data in discriminating corn from other typical crops in Eastern Canada. More than 500 airborne field spectroscopy observations were obtained between July 5 and October 24, 1982. The implications of current results on corn detectability are very encouraging, particularly for TM. A follow-on project to apply these results in Quebec is to be undertaken in collaboration with the Ministère de l'agriculture, des pêches et de l'alimentation and the Ministère de l'énergie et des ressources.

Forestry

In recognition of the importance of Canada's forests, CCRS efforts in this sector were expanded substantially in 1982.

A cooperative project with the Nova Scotia Department of Lands and Forests (NSDLF) to detect forest clearcuts from LANDSAT data was completed. The data analysis, utilizing LANDSAT MSS band 5/band 5 multitemporal approach, proved the ability of LANDSAT to detect cutovers with less than 10 per cent difference between area estimates using LANDSAT and conventional methods. Presently NSDLF and the CCRS Technology Enhancement team are implementing the procedures in a province-wide survey of Nova Scotia. A three-day workshop in Lawrencetown, N.S. was conducted to transfer methods developed in the forest clearcut project to users from all three Maritime provinces.

In cooperation with the British Columbia Ministry of Forestry (Inventory Branch), CCRS investigated the feasibility of detecting mountain pine beetle infested forests using satellite imagery. The analyses included single and multi-date LANDSAT MSS as well as simulated Thematic Mapper data for four locations in central B.C. Results obtained to date suggest relatively high accuracies with TM data but insufficient accuracy levels with LANDSAT MSS data.

Geology

In cooperation with the Geological Survey of Canada (GSC) and the Canadian Forestry Service (CFS), CCRS initiated a project to produce maps illustrating terrain sensitivity to acid rain. Single theme maps illustrating geochemical characteristics (trace elements and calcium carbonate) and land cover maps with cover types ranked according to sensitivity to acid rain have been completed. Work is in progress to integrate this information into an overall rating scheme for acid rain sensitivity.

Methodology development for exploration geology is being carried out under National Research Council funding in a cooperative project with Acadia University and Saarberg Interplan. A two-day exploration geology workshop was held in Lawrencetown, N.S. based on this work.

SATELLITE PROGRAM

LANDSAT-4

The Satellite Program was restructured in 1982 to accommodate the data from the new LANDSAT-4 spacecraft, launched July 18, 1982, and the considerably higher ($600,000/station) user fees charged by the spacecraft operator.

On October 1, the Shoe Cove Satellite Station ceased LANDSAT tracking but continued with NOAA tracking and processing from the archives until February 1. The station was then disassembled and moved off-site with the antenna, radio frequency and other front end components going to the Prince Albert Satellite Station (PASS) and all of the archives data going to the Ottawa facility with the data processing system. During 1982, the Shoe Cove station recorded data from 366 LANDSAT orbits and 612 NOAA spacecraft orbits. Over the 5½ years of station operation some 66,000 scenes from 4,400 LANDSAT orbits and 10,800 NOAA orbits were recorded on 2,200 High Density Digital Tapes. Additionally, during the short life of SEASAT, some 380 HDDT'S of the SAR sensor were archived.

The Prince Albert Satellite Station has been upgraded to receive X-band data and process LANDSAT-4 MSS data. During 1982, PASS recorded data from 266 LANDSAT-2 orbits, 1,295 LANDSAT-3 orbits and 423 LANDSAT-4 orbits which included 17,497 MSS scenes and 2,700 TM scenes. Support of the GOES-DCP system was maintained 24 hours per day all year.

Thematic Mapper data as well as MSS data are being recorded at PASS while a low volume TM transcription system is operating in Ottawa. The high volume TM bulk processing system is under manufacture at MDA, Vancouver for delivery in 1984. This equipment will provide imagery and CCTs as well as serving as the base for the MOSAICS facility MOSAICS (Multi-Observation Satellite Imagery Correction System) is also under development at MDA and will provide, starting in 1986, platform- and sensor-independent digital and film geocoded products.

Data Processing Support

The Ottawa facility has continued to provide both specialized and generalized system support to CCRS and the remote sensing community during 1982. The Time-Sharing System supports the new TRIAD image analysis station and a high resolution monochrome film recorder.

Specialized systems to transcribe the many CCRS airborne sensors to computer-usable media (the AIR system) and to transform data from analysis systems such as CIAS or the Digital Image Correction System (DICS) to precision color film products are operated on a user-demand basis.

The Synthetic Aperture Radar Processor (C-SHARP) was phased into production at the end of 1982. It can process data from SEASAT and the CV-580 SAR sensors.

Methodology Section

A major initiative was begun in 1982 to develop a state of the art image analysis facility to handle LANDSAT-4 Thematic Mapper data. A VAX 11/780 has been chosen as the host computer but it is supplemented by high speed processing equipment which is required to handle the higher volume of data. A map I/O system has also been incorporated into LDIAS so that relevant map information can be used in the analysis of the remotely sensed data and be used for the output of classified results.

A major agricultural experiment is to start in 1983 to assess to what extent multitemporal, multifrequency SAR and visible and infrared data can be used to determine crop type and condition.

In 1982 a demonstration project was carried out with Lands Directorate, Environment Canada, to transfer thematic data generated from LANDSAT MSS on the CIAS at CCRS to the Canadian Land Inventory, Canadian Geographic Information System (CGIS) data bank. This involved the conversion of the raster data generated on the CIAS to polygon data to be input to CGIS. This work has helped plan the direction of research and development on the integration of geographic information with remotely sensed data.

CANADA'S RADAR SATELLITE PROGRAM

ERS-1

This satellite, planned for launch in 1988 by the European Space Agency, will carry an active microwave instrument (AMI), radar altimeter and along-track scanning radiometer (ATSR). Canadian industry has participated in the Phase B studies of two space radar telemetry and radio frequency subsystems and of the ground segment, including processing. Canadian government representatives are members of the international design and data requirements teams.

Plans have been made to participate in the later phases of this program by building parts of the space radar, building the ground system for Europe and a similar system at Churchill, Manitoba, installing an ice information system at Ottawa, and operating these facilities as a pilot program prior to the RADARSAT program.

RADARSAT

This Canadian satellite, planned for launch in 1990, will carry a multi-beam radar and two other sensors. Agreements have been signed with the United States and the United Kingdom to join in this program. The United States would supply a shuttle launch and a sensor; the United Kingdom would develop a suitable satellite platform and possibly contribute an auxiliary sensor.

The radar will provide images of ice, ocean and land at 25 m resolution. By switching between its beams, daily coverage of the Arctic and coverage every three days in southern Canada can be obtained. The different incidence angles of these beams allow a broader range of applications to be served and also can be used to provide stereo images.

Plans have been developed to start Phase B, program definition, in 1984, and to start Phase C/D, program implementation, in 1986.

Radar Technology

Based on application requirements, processing difficulty and space risk assessment, the C-band frequency was chosen for the RADARSAT multi-beam radar. Preliminary system design, calibration, and subsystem studies have been completed for the spaceborne radar. Studies and development of the antenna and its deployment mechanism and of the high power amplifier system are continuing. A C-band scatterometer will be delivered in September, 1983 and a new C-band aircraft radar will be completed in September 1984. The design of a prototype SAR processor will start in May, 1983 with delivery expected in 1985.

AIRBORNE PROGRAM

Microwave Sensors

The performance of the SAR system on board the CV-580 has improved markedly over the past year. A new extended swath mode on the optical recorders has been added to the SAR, expanding its operational envelope, and the new antenna feed structure and azimuth drive have improved the signal to noise ratio.

Digitally recorded SAR data may be transcribed and correlated at CCRS on the C-SHARP system. The optical correlator developed by the Defence Research Establishment Ottawa and used to process the optically recorded SAR data at X- and C-Band will be moved to CCRS where it will be operational by late spring 1983.

The K-Band profiling radiometer, on loan from NASA, and the Ku-Band scatterometer are available on the CV-580 as research systems to support the SAR and microwave applications work.

Research continued on the use of side looking airborne radars for ice reconnaissance, with data collection missions flown to the Labrador Shelf in the spring of 1982, and to the Beaufort Sea in the spring and summer of 1982. Over the next year the emphasis will change gradually from the classification of sea ice to the detection of icebergs in open oceans.

Visible and IR Sensors

MEIS II, a pushbroom imager delivered in the spring of 1982, has been test flown and will be offered as a production sensor on the Falcon aircraft beginning in the spring of 1983. The user product from this sensor is a CCT in Standard Format which can be read and displayed on most image analysis facilities.

The lidar bathymeter was flown in Nova Scotia and over Lake Huron as part of a series of evaluations by the Canadian Hydrographic Service. In 1983, a sophisticated algorithm which corrects the depths for laser pulse propagation effects in the water column will be incorporated into the software package. The Canadian Hydrographic Service is now converting the bathymeter to a scanner which will be used operationally. Initial results from a study on the application of the lidar data to forestry problems appear promising.

The dual channel analogue line scanner has been withdrawn from service; instead, the MSS installed in the Falcon is now used in tasks which require the collection of IR imagery. A newly developed real-time multi-channel digitizer and display, named ALICE, has upgraded the single channel analogue scanner so that data in up to four spectral channels may be acquired. The system will be available on the DC-3 and, because of its real-time display and sophisticated processing, should be useful for a wide variety of user requirements. The user data product is a JSC image CCT similar to that currently available from the MSS.

Aircraft Systems

Bell & Howell high density tape recorders (used for SAR, MSS, MEIS II and scatterometer data) are now operational in all aircraft.

This change of recorders with their increased reliability does not affect the user community. A new low speed data acquisition system, MAID, has been installed in the Convair 580 and in the Falcon, to be used primarily for the acquisition of navigational and other housekeeping data.

A simplified software package is now available for aircraft track recovery using data from the inertial navigation system, photogrammetrically derived position updates and the barometric altimeter. During the summer of 1983 the package will be improved to accept input data from the lidar altimeter and a microwave range positioning system.

Airborne Operations

The table on this page summarizes the utilization of CCRS aircraft during the last year in each of the four categories under which tasks were flown, the applications discipline for which the tasks were flown, and the province in which they were flown.

In September, 1982 one of the DC-3 aircraft was taken out of service in an effort to contain the rising costs of the program. The forecast user demand over the next few years can be met by a fleet of three aircraft: the CV-580 for microwave work; the Falcon for the optical imagers; and the DC-3 for hydrography and other sensor development tasks.

The dramatic reduction in the number of aircraft hours flown is in part due to the ability of Canadian remote sensing companies (principally MARS and Intertech) to service commercial clients using privately owned sensors and aircraft. The growing acceptance of operational airborne remote sensing, as evidenced by the reduced dependence on Crown owned facilities, is considered to be an indicator of the success of the Airborne Program and the transfer of the relevant technology to the private sector.

INTERNATIONAL ACTIVITIES

Support of CIDA development projects continues at a modest level. CCRS is currently contributing remote sensing expertise to project planning activities in Peru and Thailand. A visiting researcher program for Thai geologists was completed this year under CIDA sponsorship. Pilot investigations were initiated with CCRS support in Sierra Leone and Guyana in the field of land and coastal resources inventory. Work is continuing in industry with CCRS coordination through support from IDRC and CIDA.

As part of its continuing commitment to Canadian industry, CCRS participated in the May 1982 High Technology Mission to Mexico and the September TEC-CAN 1982 Seminars in Brazil. These activites were financed by ITC and CIDA and have led to enhanced opportunities for Canadian industrial involvement in remote sensing development. These opportunities for closer bilateral and trade relations are being actively pursued this year, notably in Ecuador and the ASEAN region.

CCRS Aircraft Utilization
Fiscal Year 1982-83
(Fiscal Year 1981-82)

CATEGORY	NUMBER OF TASKS FLOWN	AIRCRAFT HOURS FLOWN
Internal	20 (17)	258 (257)
External	17 (22)	102 (119)
Lease	1 (7)	39 (276)
Co-op	13 (20)	102 (130)
TOTAL	51 (66)	501 (782)

DISCIPLINE	NUMBER OF TASKS FLOWN	AIRCRAFT HOURS FLOWN
Agriculture	6	35
Forestry	6	30
Geography	3	5
Geology	6	75
Glaciology	2	126
Hydrology	2	6
Limnology	2	12
Oceanography	3	19
Transport	1	6
Sensor Tests	18	157
Aircraft Tests	1	7
Crew Training	1	23
TOTAL	51	501

PROVINCE	NUMBER OF TASKS FLOWN	AIRCRAFT HOURS FLOWN
British Columbia	2	14
Alberta	5	40
Ontario	20	157
Québec	12	61
Nova Scotia	3	43
North West Territories	3	47
Yukon	2	91
Other	2	41
Various Provinces	2	7
TOTAL	51	501