ISSN 0705-5749

CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING

1986 REPORT

Canada

SUMMARY

1986 ANNUAL REPORT

CANADA CENTRE FOR REMOTE SENSING

CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING

TABLE OF CONTENTS

1.0 SUMMARY MINUTES

This annual meeting of the Canadian Advisory Committee on Remote Sensing (CACRS) took place at Cornwall, Ontario, April 21-24, 1987. The attendees included the provincial representatives, chairpersons of the CACRS Working Groups, a wide representation of the remote sensing community in Canada, and invited speakers from industry.

General Topic of the Meeting

The theme of the meeting was "A Strategy to Develop Canadian Remote Sensing Capabilities for the Future" however, through consensus among CACRS members, discussion focussed on the specific issue of how the emergence of Geographic Information System technologies would affect the future development of remote sensing. Emphasis was also placed on the impact of a revised CACRS structure, the Canadian Advisory Council on Remote Sensing, on future developments in the national remote sensing program.

April 22 - General Business

Under the guidance of the general chairperson of the meeting, Lyn Arsenault, the day was given over to presentations by CCRS, the provincial representatives, and the Working Groups on significant events in 1986 and recommendations for the future.

Dr. Art Collin, Special Advisor to the Privy Council Office, led off with an overview of the Space Plan and the role expected of the Canadian Space Agency in its implementation. It is likely that the ground segment of remote sensing programs would remain within the current departments but that space programs such as RADARSAT, would be included in the new agency.

Mr. Les Whitney presented a proposal for the restructuring of CACRS. Essentially the difference would be an emphasis on the participation of industry in the proposed Canadian Advisory Council on Remote Sensing, an emphasis supported by the recently approved National Science and Technology Policy. The Council, reporting to the Minister of State for Forestry and Mines, would be composed of about a dozen members chaired from industry. Three studying committees would report to this Council; the Inter-Provincial/Territorial Advisory Committee (now IPTASC), an Application/Methodology Committee and an Industrial Relations Committee. The Councils annual schedule of meetings would coincide with the federal governments planning cycle to ensure the greatest impact of the new CACRS' advice on remote sensing plans and policies. The new Council structure would eliminate the current annual meeting. There was considerable reaction to the proposal, focussing on: the uncertain future of the current Working Groups, potential changes to the memberhsip of IPTASC as a committee reporting to a federal Minister, a perceived reduction in representation from users, and a concern that the information exchange and joint project coordination benefits of the old CACRS could be impeded by the more formal structure of the new Council. These concerns were further addressed in the recommendations coming from the April 23 Workshops.

CCRS staff gave presentations on current issues with emphasis on the new satellite data archive policy, efforts to increase industrial participation in both airborne and satellite operations, and the recently funded Radar Data Development Program (RDDP) designed to prepare researchers and operational users for the exploitation of data from the microwave remote sensing satellites of the 1990's.

Provincial reports and recommendations were highlighted by Mr. Bill Best, who emphasized concerns about reductions in the number of products now available and about delays in the SPOT program.

The Working Groups reports, summarized by Dr. Richard Protz, Dr. Barry Goodison and Dr. David Goodenough, also expressed concern about delays in research with SPOT data but on the whole were optimistic about the vigour current and planned remote sensing programs.

The guest banquet speaker was Mr. Pierre Bescond, President of SPOT Image Corporation, who gave an overview of SPOT Image's experience in the commercialization of remote sensing and also presented his views on future developments.

April 23-24 - Panel and Workshops

The plenary session was addressed by members of a panel from industry, chaired by Mr. Lee Godby, who gave their views on the development of remote sensing and Geographic Information System (GIS) technologies.

Mr. Bob Barker, Director of Commercial Applications, SPOT Image Corporation, gave an overview off the history of commercial applications in remote sensing, concentrating on the forest industry in the United States. In his view the acceptance by managers of Management Information System methods in the late 1960's was the key development that promoted the growth of remote sensing and GIS

technologies. Delays in exploiting LANDSAT data were due in part to the first satellite being launched several years before GIS technology caught up and could assist in managing the plethora of data generated. An effective GIS must include image, descriptive and "line map" data and integrate these to be effective in giving the manager reliable information. He suggested that the remote sensing industry concentrate on developing digital image data as distinct data-base, which combined with descriptive and "line map" data will give modellers the tool they need to reduce the number of assumptions that go into long range resource management planning models, especially given the ability to update these data on a yearly basis at low cost. If the manager is confident in his database he will invest in remote sensing.

Alex Miller, President of ESRI Canada, talked on Geographic Information Systems under four topics heading:

- State-of-the-Art

The integration of GIS with "operational" management information systems is the key to success in the municipal and resource management sectors. GIS software vendors have become more independant. While Tectronics Graphics is still the de facto standard for displays, P.C.-based systems are now starting to use bit-map graphics. The biggest problem is the lack of data structure standards leading to the proliferation of data exchange formats among GIS.

- Coming on line (6 months)

There will be significant technical advances in 1987 with more sophisticated user interfaces and fourth generation languages at the macro level to help users customize these interfaces, with cheaper higher resolution (e.g. 1024 x 768) graphics and with more powerful mini computer. He also expected that international data exchange standards would be well advanced.

- Future

Distributed data exchange technologies will facilitate the integration of GIS databases and within five years, high speed wide-area networks using fibre optics or satellite links will allow their distributed databases to reach their potential as a tool for decision-making.

- Remote Sensing Integration with GIS

There is no clear answer to optimal integration of remote sensing and GIS, although new display technologies that will overlay vector and image data simultaneously are an encouraging development.

Dr. Leo Sayn-Wittgenstein, President of Dendron Resource Surveys Ltd. spoke on the integration of remote sensing information with GIS, citing many practical examples of integrated information systems. Remote sensing is just one, albeit important, set of data for the rapidly expanding GIS technology and will not effect the pace of GIS proliferation. GIS puts data closer to the decision-making process therefore higher standards for data quality are critical because of the consequences to the manager of making a poor decision. The remote sensing community must therefore concentrate on delivering high quality data. Since government agencies are leaders in resource information technologies in Canada they must be persuaded. Some groups, often those concerned with the "accuracy" of data who have resisted the use of remote sensing in the past are those who control GIS. The high resolution data from SPOT has recently evolved great interest from cartographers and should make remote sensing data a more attractive data source.

Dr. David Goodenough summarized the issues raised and talked on the basic technical problems to be overcome in integrating remote sensing into GIS. Problems included "labelling" of classifications from different data sources, movement between data structures of IAS and GIS, and interface between symbolic reasoning and numerical processing. Expert systems should assist in addressing these problem within five years.

The plenary group was broken into six working groups to make recommendations on the role and organizational substructure of the new Canadian Advisory Council on Remote Sensing in developing and implementing strategies for new technologies.

WORKSHOPS RECOMMENDATIONS

The first group, chaired by Dr. David Goodenough, recommended that the Working Group structure of CACRS be retained and that the chairpersons of Working Groups form one of two committees reporting to the Council, the other being IPTASC. This group also recommended that there should be an annual meeting similar in size and composition to that of the current CACRS and in conjunction with the Canadian Remote Sensing Symposium if possible.

The second group's recommendations, presented by Dr. Peter Murtha, were to make fundamental changes to the Council structure, eliminating

suppliers and with equal representation from government, the user industries and universities. The Council would consider policy matters only; technical advice to CCRS would flow directly to CCRS from Working Groups. This group also recommended that CCRS put much greater emphasis on supporting training and research in the universities. CCRS should adopt a contracting-out policy in support of university research in remote sensing.

The third group, chaired by Mr. Jean-Claude Henein, concentrated on means to increase the proficiency of Canadian agencies in the use of GIS. They recommended that an ad-hoc study group be established, reporting to the Applications/Methodology Committee of CACRS. This study group would be chaired by a user and include users at the policy and operational level, modellers, database managers, vendors and educators. Communication with the other two Committees of CACRS would be encouraged in order to involve a wide range of users and suppliers.

The fourth group, chaired by Mr. John Wightman, recommended that the terms of reference of each Council member should be defined in consultation with the constituents to which they report or represent. They also recommended that the chairperson of the Canadian Remote Sensing Training Institute be an ad-hoc member of the Council. On the issue of integrating remote sensing data into GIS they proposed that an ad-hoc Working Group be formed, involving federal and provincial agencies, to work towards networking from the user point of view. The development of a Canadian GIS database catalogue was seen as a first task of the ad-hoc Group. This group agreed with the second group that policy and technical advice must be separated under the new Council to ensure an effective feedback mechanism to CCRS.

The fifth group, chaired by Dr. Bob O'Neil, addressed the development of airborne sensors and processing facilities. They recommended an ad-hoc Working Group, chaired from industry, with participation from sensor development and data acquisition companies, the research and user communities, and the universities. The Working Group would promote the exchange of non-proprietary information within the sensor industry and university and government laboratories, and would advise federal agencies on instrument development and assessment requirements.

The sixth group, represented by Dr. Susan Till, recommended that Working Group chairpersons should normally be committee members, except for IPTASC. Membership should represent, where possible, in industry, government departments, universities and provincial/territorial agencies. The terms of reference of the new Council should be further reviewed by CACRS members and the Working Group chairpersons should be asked to advise the Minister on the structure and membership of the new Council. Existing Working Groups should be reviewed to see if renewal would be useful. A new Working Group should be set up to recommend sensor development policy. Communication among the Working Groups must be facilitated, one approach being to hold several Groups meetings at the same time, such as at the Canadian Remote Sensing Symposium.

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 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 is structured as follows:

Chairperson:	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 on CACRS is a body of representatives appointed to CACRS on the recommendation of the provinces and territories.
Working Groups:	CACRS established such working groups as it deems necessary to carry out its work. Some of the groups may operate on an ongoing 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 CACRS.

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 coordinate 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 a higher authority (i.e. Interagency Committee on Remote Sensing (IACRS) in the case of the federal government);

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

Structure of the CACRS Executive

The representation on the CACRS Executive is as follows:

Chairperson:	Director General, CCRS.
Provinces:	Chairperson, Vice-Chairperson, and Past Chairperson, IPTASC (Interprovincial/Territorial Advisory Committee of CACRS).
Working Groups:	Two representatives elected by the working group chairperson, 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 Chairperson, Education Working Group.

3.0 RECOMMENDATIONS OF CACRS

These recommendations are drawn from the reports of the provinces, the working groups, the specialty groups and the universities to CACRS. They were reviewed by the CACRS Executive on April 24, 1987, and their responses, expanded on in some cases by the CACRS secretariat, is given below.

3.1 Recommendation of IPTASC

That the past Chairperson of IPTASC be added to the new Canadian Advisory Council on Remote Sensing to ensure regional representation and a national perspective.

- IPTASC

CCRS will propose that provincial participation in the new Council structure be increased.

3.2 Data Access and Dissemination

3.2.1 The Forestry Working Group has one major recommendation for CACRS: "That CCRS work towards maximizing the dissemination of satellite data through development of on-line access to satellite data for all users."

- Forestry

It would be too costly to implement this recommendation within the next five years at least for high resolution data. CCRS will monitor and develop technology towards this as a long term goal. However, CCRS plans to introduce optical archive media by 1990, which should prove suitable for on-line access in the future.

3.2.2 SPOT orders have remained unfilled, and failure to provide products or communicate problems has discouraged customers.

- Alberta

Early problems in SPOT production are acknowledged by CCRS and are now being resolved.

3.2.3 That access to SPOT data of New Brunswick be improved.

- New Brunswick

SPOT production is now fully operational at Prince Albert and should provide acceptable data access.

3.2.4 That CCRS improve the quality of the reference imagery (presently fiche) to assist the user in the ordering of imagery. As part of the CCRS marketing strategy, an alternate product to fiche is suggested that would improve the determination of image quality, the scene limits and in the case of TM products, the quadrant boundaries.

- Nova Scotia

CCRS is currently investigating media and methodologies to improve access to data. An example of this is the evaluation of optical disks as an alternative to fiche.

3.2.5 Dr. S. Pala of the Ontario Centre for Remote Sensing and D. Jobin of A.J. Robinson and Associates Inc. urge that every effort be used to improve the delivery time of TM data. Dr. Pala further recommends that the scheduled price increases for LANDSAT products be withdrawn, because they act as a deterrent to the use of the data.

- Ontario

CCRS will make every effort to improve delivery times. CCRS cannot change the current price schedules until the commercialization issue is resolved, hopefully by January, 1988.

3.2.6 We would like to recommend that the Canada Centre for Remote Sensing take the necessary steps to postpone until the summer of 1987, at the same price, those passes ordered in 1986 that could not be made because of poor weather conditions. The remote sensing laboratory of the University of Quebec in Chicoutimi (UQAC) has a major project underway in urban climatology and forest thermography, to be completed in 1987-88, that depends on an order for passes that has remained unfilled.

- Québec

The airborne electro-optical sensor package will be loaned to the private sector by June, 1987 who will offer data acquisition services commer-

cially. UQAC and other interested agencies will be notified of these commercial services, as soon as an agreement is concluded between CCRS and the company.

3.2.7 Once again, the Centre québécois de coordination de la télédétection (CQCT) must state its dissatisfaction with the waiting periods imposed on clients for satellite data. Furthermore, the CQCT is asking the Canada Centre for Remote Sensing to keep available the full range of satellite products offered prior to April 1, 1987 for as long as the privatization agreement has not been fulfilled.

- Québec

Budget constraints prevent CCRS from providing the full range of products available in 1986, however, these products can be provided as "value-added" imagery at incremental cost.

3.3 **RADARSAT**

3.3.1 The members of the Working Group on Ice strongly support the RADARSAT program. The satellite's SAR will provide the best ice information, in a time series with full regional coverage, which is unavailable by any other means.

- Ice

CCRS appreciates this statement of support for the RADARSAT program.

3.3.2 One of the main obstacles to more widespread use of satellite remote sensing is the rarity of good images for specific areas and dates. It would be desirable to reconsider installing a multispectral sensor on RADARSAT, as it would contribute to making this future Canadian satellite cost-effective.

- Québec

The RADARSAT Project Office has been advised of this recommendation. It is unlikely that a multispectral scanner would be included because of the current cost constraints, unless the sensor could be donated by one of the RADARSAT international partners.

3.4 **Radar Data Development Program (RDDP)**

3.4.1 CCRS collect multi-temporal C-SAR data sets in both Western and Eastern Canada to support the methodology development of agricultural experiments, in view of the importance of the lead up research program in response to the ERS-1 launch.

- Agriculture/Radar

CCRS will apply its best effort to the collection of C-SAR datasets, within the limitation of budgets available.

3.4.2 With the developent of airborne SAR to operational status for ice reconnaissance, various members identified the need for other sensors to be considered by CCRS because a multisensor approach is required in many ice applications. For example, research and development is required for the sensor package for all-weather, tactical support for icebreaker operations, i.e., ice thickness sounder, radar, radiometer, acoustics, LLL TV, and so on.

- Ice

CCRS will inform the RADARSAT Project Office of this recommendation so that the use of other sensors for ice reconnaissance research is proposed through the Radar Data Development Program.

3.4.3 That CCRS use the Radar Data Development Program to maximize the opportunity for development of remote sensing expertise in government line departments, universities and the private sector in advance of ERS-1. This recommendation is consistent with those made last year and with the major effort of the working group to coordinate the ERS-1 National Data Requirements and the Response to the ERS-1 Announcement of Opportunity.

- Oceans

This recommendation is being pursued through the development of individual projects within the Radar Data Development Program.

3.4.4 The Working Group reiterates its former recommendation that an Ocean Satellite Information Centre be set up

in the Marine Environmental Data Centre and, if possible, funds from the Radar Data Development Program be used to seed this initiative.

- Oceans

This is now underway under the Radar Data Development Program.

3.4.5 That a task group be established to investigate the use of SAR for snow cover determination and to assist in the planning and execution of an airborne mission (SAR-580) in support of potential ERS-1 activity. CCRS cooperation, through the hydrological co-ordinator, and support of the airborne mission is requested.

- Water Resources

CCRS will implement this through the Radar Data Development Program.

3.5 **R&D Funding**

3.5.1 CCRS approach NSERC to stress the importance of microwave research.

- Agriculture/Radar

NSERC is restructuring its programs in accordance with the National S&T Policy. CCRS believe that a budget for remote sensing initiatives will be assigned. NSERC will be approached by CCRS for participation in the RDDP when the RDDP projects are approved internally.

3.5.2 Our major concern rests with the uncertain funding picture that has currently emerged at the federal level, and the emphasis on research proposals by industrial participants. We would like to express our regret at the demise of the CCRS airborne program since it was a necessary component of several research programs and these studies had to be terminated. Research grants for "applications" projects are so small that they cannot afford the current private industry fees for collection of airborne data. We foresee increasing emphasis on "space-station" style remote sensing. Every effort should be made by CCRS to support, and encourage cooperative remote sensing research with universities.

- University of British Columbia

CCRS will continue to support and encourage cooperative research with universities, particularly through the Radar Data Development Program.

3.6 **Applications Development**

3.6.1 The Rangeland Sub-committee identifies the following areas for initiation or continuation of research and development:

- TM and SPOT research for parkland, northern fescue and improved boreal pastures, and B.C. rangelands
- NOAA-AVHRR for rangeland monitoring and drought asessment.

- Agriculture/Rangeland

CCRS is now completing of guidelines on the use of TM for range management. SPOT HRV, because of the lack of a SWIR band, is not viewed at present as the sensor of choice for rangeland. NOAA AVHRR will indeed be studied for rangeland monitoring and drought assessment.

3.6.2 That the Agriculture Working Group, CCRS and Agriculture Canada support the preparation of an inventory (using LANDSAT TM and MSS data) of the extent of rangelands in general, and heavily utilized rangelands in particular, throughout western Canada, as an important element in increasing the awareness of range administrators of range problems, and in the transfer of remote sensing technology to the range user.

- Agriculture/Rangeland

CCRS is willing to cooperate with groups and organizations with a mandate to produce and maintain rangeland inventory maps. It is suggested that the Agriculture Working Group may wish to identify such groups and notify CCRS. Satellite imagery could be used to provide a rangeland/non-rangeland background, as well as a historic (LANDSAT) utilization trend since 1972.

3.6.3 Since the major challenge for new mapping in Canada lies north of 80°, attention should be directed to the development of remote sensing systems that would assist the production of 1:50 000 maps in this region. There is a particular need for a non-

photogrammetric solution to the determination of elevations and contours over arctic icefields. The new airborne SAR system should be considered for these cartographic applications.

- Cartography and Photogrammetry

The SPOT satellite can only cover up to 81° (nadir) and 84° (off nadir); therefore, stereo SPOT images cannot be acquired higher than 81°. Canadian SPOT coverage from PASS is limited to 78° (the highest point on the coverage circle). Consequently, SPOT on-board recording would not extend the coverage by much in Canada. In addition, it is operationally difficult to acquire airborne data in the high Arctic with the Convair or Falcon aircraft. Therefore, the main problem deterring the proper determination of elevations and contours over Arctic icefields is the availability of the necessary data rather than the methodology for relief elevation extraction. While the necessary remote sensing technology is available, there is little hope that stereo digital imagery will be available in the near future for the regions above 80° latitude.

3.7 **Publications**

3.7.1 That CCRS should reprint the following out-of-print publication, as it is reviewed as an important contribution to the literature on remote sensing of rangelands in Canada:

Brown, R.J. et al., 1983. Alberta Rangeland Assessment Using Remotely Sensed Data, CCRS Research Report 83-1, 128 pp.

- Agriculture/Rangeland

This report will be re-issued in colour micro-fiche form, as current budget restrictions do not allow a reprint.

3.7.2 The Rangeland Sub-committee has defined as one of its tasks the publication of a comprehensive and practical document in 1988-89 covering the demonstrated uses of remote sensing for rangeland management in Canada, for use by decision-making managers and field users both within and outside Canada. The Sub-committee looks to the financial and technical support of CCRS Applications Division and other funding agencies for the publication of this Canadian Rangeland Remote Sensing Applications document, based on a proposal to be developed by the Sub-committee in early 1987.

- Agriculture/Rangeland

CCRS is willing to provide technical advice and a modest amount (up to $5,000) towards the publication of the document in 1988-89.

3.7.3 Professor A. Brunger of the Department of Geography, Trent University, suggests that the national remote sensing program get the media involved in publicizing satellite imagery; for example, satellite images could be used to demonstrate locations of news items within Canada.

- Province of Ontario

CCRS will pursue this through Communication Branch, EMR.

3.8 **Image Analysis Systems and Artificial Intelligence**

3.8.1 That CCRS pursue high-risk R&D as a core activity. In particular, artificial intelligence applied to remote sensing and geographic information systems should be the highest priority.

- Image Analysis Systems and Artificial Intelligence

CCRS is pursuing means of increasing the level of resources for this area of research.

3.8.2 CCRS is commended for its work and should continue its existing R&D on artificial intelligence and expert systems, geographic information systems, and optical disk technology.

- Image Analysis Systems and Artificial Intelligence

CCRS appreciates the Working Group's expression of support and will continue R&D in these areas.

3.8.3 That crown-owned CCRS data and CCRS software be licensed at no cost to Canadian universities, government agencies, and industry and that sublicensing outside Canada be prohibited

without permission from CCRS. At the very least, CCRS should examine and clarify its position on the availability of its crown-owned data and software.

- Image Analysis Systems and Artificial Intelligence

LDIAS software is now available to Canadian users at no cost.

3.8.4 That CCRS make available a list of all non-propriety software at CCRS. Requests for a copy of the list should be filled even if a full inventory has not been completed.

- Image Analysis Systems and Artificial Intelligence

A list of LDIAS software is now available and will be updated.

3.8.5 That CCRS establish a simple and clear mechanism for transferring software, for which CCRS owns the rights, to any interested party, exploitation on a non-exclusive basis. The software and related documentation would be provided at minimal cost and on an as-is basis.

- Image Analysis Systems and Artificial Intelligence

Software transfer can be arranged either through Canadian Patents and Development Limited or directly through CCRS.

3.8.6 The Working Group encourages the taking over of operational image production by companies.

- Image Analysis Systems and Artificial Intelligence

CCRS is in full agreement with this recommendation and will continue its best efforts in this direction.

3.8.7 That CCRS continue the work on monitoring micro-computer based image analysis systems such as image processing LSI boards, micro-computer based expert systems, optical storage technology, and networking of micro-computers.

- Image Analysis Systems and Artificial Intelligence

CCRS will continue its monitoring of these systems and looks to the Working Group for advise on R&D opportunities and priorities in this area.

3.8.8 That CCRS assess technology for micro-computer based image analysis such as image/graphic boards and optical technology for micro-computers.

- Image Analysis Systems and Artificial Intelligence

CCRS suggests that the IASAI recommend priorities for technology assessments and advise on the level of effort needed.

3.8.9 That CCRS monitor the development of GIS capabilities for micro-computer based systems and their integration to image analysis systems.

- Image Analysis Systems and Artificial Intelligence

CCRS agrees with this recommendation and will continue to monitor developments in this area.

3.8.10 That CCRS be an active number of the international committees/groups on data format standardization such as GIS data and optical recording format.

- Image Analysis Systems and Artificial Intelligence

CCRS agrees that active participation in international bodies is desirable and has asked the Digital Methods Division to recommend groups.

3.8.11 That CCRS make the existing sample CD-ROMs available to selected groups in remote sensing. For groups with little image processing expertise, CCRS should also provide software and documentation to display the data on CD-ROMs on popular personal computers.

- Image Analysis Systems and Artificial Intelligence

CCRS will seek a means to make copies of a sample CD-ROM available (with software and documentation). There will probably be a nominal charge. CCRS is also investigating the creation of CD-ROMs for wider distribution of information plan in Canada.

3.9 **Data Formatting**

3.9.1 That CCRS advocate and adopt a standard for interchange of GIS information as it applies to image analysis system requirements. This standard must include attribute data.

- Image Analysis Data Base Formats/IASAI

CCRS will explore this issue through participation in international committees.

3.9.2 The Working Group endorses the cartographic definitions of objects for digital cartography as depicted by the U.S. National Committee for Digital Cartographic Data Standards. CCRS should adopt these standards.

- Image Analysis Data Base Formats/IASAI

This is not within CCRS mandate to implement, however, CCRS will consider the use of these standards in consultation with the Surveys and Mapping Branch of EMR.

3.9.3 That CCRS make test datasets available and support pilot experiments on the exchange of information between agencies.

- Image Analysis Data Base Formats/IASAI

A SAR-MSS remote sensing data set is available and has been distributed to many organizations. CCRS is examining the provision of other data sets. CCRS is also supporting the Geomatics Committee's pilot experiment on geographic information exchange.

3.9.4 That CCRS investigate the use of communications networks for data interchange and communications amongst IASAI members.

- Image Analysis Data Base Formats/IASAI

The Digital Methods Division has contracted for a study of network and will make the results known to the IASAI.

3.9.5 That CCRS ensure that all of its future specifications for both hardware and software related to the Canadian user community (RS & GIS), contain the provision for the conversion to and from existing systems and new systems developed by/for CCRS.

- Province of Nova Scotia

CCRS cannot adopt such a comprehensive policy because of the diversity of R&D activities. CCRS will use standard formats (e.g., LGSOWG) for data exchange wherever practicable.

3.10 **Reorganization of CACRS**

3.10.1 That a Geoscience advisory group continue to exist under any new CACRS organization. The Working Group should be reorganized to permit more effective communication with CACRS and other bodies representing the geoscience and remote sensing communities. CACRS should accept the restructuring proposal submitted in the Geoscience Working Group report to CACRS.

- Geoscience

CCRS acknowledges the effectiveness of the Geoscience Working Group in implementing joint projects and sharing information. These recommendations will be referred to the new Council.

3.10.2 That the Working Group on Ice continue its role as a forum for making valuable contributions to remote sensing in Canada. The Working Group provides:

- a unique body of expertise on which policy makers can draw for advice on Canadian ice remote sensing needs;

- liaison with groups concerned with other aspects of ice in Canada and abroad, such as NRC's Panel on Ice, the Sub-committee on Snow and Ice, International Glaciological Society, Arctic Petroleum Operators Association, Environmental Studies Revolving Fund's ice committees, ESA PIPOR group, NORDA and JPL ice research programs:

- promotion and co-ordination of multisensor experiments for ice remote sensing, to maximize the returns on aircraft and surface data gathering;

- organization of one- to three-day informational workshops aimed at the promotion of ice remote sensing for operational users (Calgary 1976, St. John's 1981, Calgary 1982, Burlington 1985, Ottawa FIDEX 1985); and

- surveys on ice remote sensing across Canada, such as updates of user's needs, or ice remote sensing in university courses.

- Ice

CCRS acknowledges the contribution of the Ice Working Group to the National Remote Sensing Program and will bring this to the attention of the new Council.

3.10.3 That the Working Group on Water Resources continue its role as a forum for co-ordinating and contributing to remote sensing developments in water resources in Canada. The Working Group provides:

- a body of expertise, representing water resource agencies across Canada, to provide advice on remote sensing needs in water resources:

- a forum for co-ordinating experiments to develop remote sensing applications in water resources (e.g. snow cover validation);

- organization of workshops or training sessions to promote remote sensing developments in water resources (e.g. Streamflow Forecasting Workshop, 1980 and 1982 DCP Workshops);

- to foster liaison and co-operation with the private sector in order to contribute to effective technology transfer; and

- to provide liaison with other groups interested in remote sensing in Canada and internationally.

- Water Resources

CCRS will bring this recommendation to the attention of the new Council.

3.10.4 J.S. Simpson, Manager of McElhanney Mapping Services, recommends that the national program establish an industrial advisory committee similar to that in operation in Ontario.

- Province of Ontario

This recommendation will be brought to the attention of the new Council.

3.10.5 That all members of CACRS should be or become members of the Canadian Remote Sensing Society.

- Canadian Remote Sensing Society

This recommendation will be brought to the attention of the new Council. The CRSS should reconsider their conditions of membership if they wish to include the broad range of professional interests among CACRS members.

3.11 **Emergency Services**

3.11.1 In light of the recent emergency in New Brunswick and the cut backs in the airborne program, that ways and means be found for the Federal Government to provide the Province with appropriate emergency remote sensing services.

- New Brunswick

CCRS cannot include emergency services as part of its operations. New Brunswick must go through Emergency Preparedness Canada to seek assistance. This has worked well in the past.

4.0 REPORT OF THE CANADA CENTRE FOR REMOTE SENSING

The Canada Centre for Remote Sensing (CCRS) was established in April 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 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 provide a detailed view where needed, and serve as research and development platforms for the 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.

Applications of remote sensing technology 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 and ocean monitoring.

APPLICATIONS TECHNOLOGY

Technology Enhancement Program

The objective of the Technology Enhancement Program (TEP) is to work with provincial governments to enhance their remote sensing capabilities for natural resource management purposes. To this end, the Canada Centre for Remote Sensing, with the support of other federal departments (e.g. Environment, Agriculture, Statistics Canada), enters into Memoranda of Understanding with provincial and territorial governments whereby projects, using proven remote sensing technologies, are undertaken jointly by personnel from provincial resource agencies and the Technology Enhancement Program Office (TEO).

The success of a TEP is measured by the profusion of remote sensing activities which follow after the full withdrawal of direct support from TEO staff specialists. Provincial remote sensing momentum can be measured in several ways including:

- provincial follow on projects
- acquisition of image analysis and other equipment
- remote sensing training
- private sector activity
- data purchases.

The Technology Enhancement Program of CCRS was started in November 1982, when the first provincial program began with the Government of Manitoba. In April 1983, CCRS undertook a second Technology Enhancement Program with the Maritimes as a region. The Manitoba TEP was completed in June 1984, and the Maritime Program in August 1985. The Manitoba Remote Sensing Centre now serves a broad spectrum of users from provincial and federal resource agencies, crown corporations and the private sector. Remote sensing activities continue in all sectors of the Maritime Provinces including strong educational programs, and initiatives by private companies.

Saskatchewan - Measures of Success

A Memorandum of Understanding (MOU) for Cooperation in Remote Sensing was signed between Saskatchewan and CCRS in January 1985. The MOU will remain in effect until June 30, 1987, recently extended from the original completion date of March 31, 1987. The Saskatchewan Research Council (SRC) is hosting and coordinating the Saskatchewan Technology Enhancement Program (STEP) at its laboratories in Saskatchewan. The CCRS contributions to the STEP include the full time services of a remote sensing specialist and a DIPIX ARIES II digital image analysis system. An SRC scientist has been assigned to the Program for at least 80 percent of his time.

The original portfolio of five joint projects has now been expanded to nine, and current status is as follows:

Department and Branch	Project	Status
Parks and Renewable Resources Forest Fire Control Branch	Forest Fuel Hazard Types	Final report drafted
Forest Management Branch	Mapping Recent Cutover/ Burned Over Areas	Final draft of report prepared
Wildlife Branch	Mapping Whitetailed Deer Habitat	Final report drafted
Agriculture Irrigation Branch	Mapping Crops Lost to High Salinity Soils	First draft of report prepared
Saskatchewan Water Corporation	Flood Forecast	First draft of report in preparation
Saskatchewan Crop Insurance Board	Areal Measurements of Fields Seeded to Insured Crops	First draft of report in preparation
Saskatchewan Research Council	Mapping Moose and Caribou Habitat	Report drafted
Statistics Canada/Agriculture Saskatchewan	Crop Classification	Report drafted
Ducks Unlimited/ Park and Renewable Resources	Discrimination of Wetland Cover Types	Analyses completed

The Saskatchewan Research Council will acquire digital image analysis equipment in 1987 in advance of completion of the TEP. The Department of Parks and Renewable Resources has acquired visual analysis equipment and a geographic information system for its forestry laboratories in Prince Albert.

Besides the joint projects undertaken for the TEP, SRC has completed projects under contract for a number of Saskatchewan clients, and are aggressively seeking additional work.

Newfoundland - Measures of Success

In June, 1986, a Memorandum of Understanding was signed with the Newfoundland Department of Development and Tourism which will run until March 1988. Six joint projects are underway and the current status is as follows:

Department and Branch	Project	Status
Department of Mines and Energy Mineral Development Division	Bedrock Geological Mapping: N. Labrador	Analysis progressing
Department of Mines and Energy Mineral Development Division	Surficial Geological Mapping: N. Labrador	Analysis underway
Department of Environment Water Resources Division	Watershed Analysis: Upper Humber River	Analysis underway
Department of Forest Resources Land Management Division	Land Use Mapping: S.W. Newfoundland	Analysis underway
Department of Culture, Rec. and Youth; Wildlife Division	Moose and Caribou Habitat Analysis	Analysis underway
Department of Forest Resources Forest Management Division	Cutover Mapping: Central Newfoundland	Analysis underway

Digital image analysis services are made available to the TEP from NORDCO Ltd. through a contractual arrangement between the Department of Development and Tourism and NORDCO.

Future Technology Enhancement Program Initiatives

Negotiations with the Northwest Territories for a TEP are in full swing and it is anticipated that an MOU will be signed with the Department of Renewable Resources in late 1987. Currently NWT officials have prepared a list of 10 projects, some or all of which will form the back bone of a portfolio of joint studies. When the MOU is put into force, the person year currently assigned to Saskatchewan will be moved to Yellowknife. As an additional assistance, a digital image analysis system will be loaned to the NWT for the duration of the TEP.

In the spring of 1986, the Yukon Prospectors Association, with the Assistance of the Yukon Territorial Government, purchased a micro computer-based digital image analysis system. A contract let to a consultant by the Association resulted in a service to provide air photo, geophysical and satellite data interpretation to prospectors. During the balance of the year a number of individuals and companies profitted from the service in their pursuit of precious metal deposits. The TEP has been active in providing assistance through consultation and workshops.

The Technology Enhancement Office will continue to work with provincial and territorial governments to assist resource managers in augmenting their expertise in the use of visible remotely sensed data. At the same time, and as the advent of space-borne radar data looms larger, efforts will be made to expose natural resources managers to these new data, and to the analysis techniques required to extract information from them, through workshops and joint studies.

Applications Development Program

During 1986, the Applications Technology Division advanced research activities toward operational objectives in a wide range of resource development, monitoring and management applications. Cooperative projects have been carried out with a number of federal governments, provincial agencies and with specialists from the private sector. The activities outlined in this report are representative of current remote sensing applications work being carried out in this division.

Agriculture

1) NOAA-Based Crop Information System

A pilot project run in cooperation with the Canadian Wheat Board, the Manitoba Remote Sensing Centre and industry was completed in March 1987. This project helped define the techniques necessary for an effective use of NOAA AVHRR data.

During 1987, a remote sensing pre-processing facility will be established in Winnipeg, with the cooperation of the Manitoba Remote Sensing Centre and the Wheat Board, to develop and maintain an archive of AVHRR data, to geometrically and radiometrically correct AVHRR data in a timely fashion, and to be able to incorporate SAR data with the present VIR data sources when the SAR data becomes routinely available in the 1990's. This facility should foster the use of remotely sensed data in those applications where timely data is required.

2) LANDSAT and SPOT Applications

a) A cooperative research project begun in 1983 between CCRS, the Quebec Ministère de l'Agriculture, des Pêches et de l'Alimentation (MAPAQ), and the Centre québécois de coordination de la télédétection (CQCT), was successfully completed in 1986. The objective of the project was to evaluate and demonstrate the value of TM data for mapping agricultural land use. As a result of the project, the methodology developed at CCRS has been transferred to MAPAQ staff for operational implementation. Early work with SPOT data was begun under this project and will be reported at the Eleventh Canadian Symposium on Remote Sensing in June 1987.

b) A demonstration project on the use of LANDSAT MSS data for the evaluation of winterkill has been completed, as an additional aspect of crop monitoring feasible using LANDSAT-type data, as opposed to NOAA-AVHRR or radar data. These results are ready for transfer to the user community.

c) A project is underway to study the potential of micro computer-based systems for agricultural applications at the township level. The project is carried out in cooperation with the Ontario Ministry of Agriculture and Food, the Ontario Centre for Remote Sensing and the University of Guelph.

3) SAR in Agriculture

A five year plan was established to develop procedures to use SAR data in agricultural applications, so that when these data become routinely available from satellites such as ERS-1 in the 1990's, Canada is in a position to use them effectively. This plan involves a coordinated effort among federal and provincial governments and universities using airborne SAR, satellite SAR (ESA ERS-1), visible and near-infrared (VIR) imagery, and ground-based microwave scatterometer measurements. An important aspect of this work will be the integration of remotely sensed data with other data sources, through a geographic information system (GIS), and the establishment of the necessary links to transfer data between the GIS and remote sensing image analysis systems. Another significant element of the research will be the integration of SAR and VIR data with meteorological data within crop yield models.

4) Alberta Rangeland Project

Work continued throughout 1986 on a joint rangeland project with the Alberta Department of Lands and Wildlife and the Alberta Remote Sensing Center. The original study area in the Foothills has been expanded to include the Parkland and Peace River areas. Range managers from throughout the region have participated in the evaluation of TM imagery for rangeland applications.

TM imagery has been demonstrated as effective to update range/pasture inventories; to monitor livestock impact and to assess brush species regrowth or encroachment on improved and native pasture. As a result of this work CCRS will consider the production of a standard TM/rangeland enhancement product.

Forestry

1) TM Enhancements

The results of a preliminary evaluation of TM information content for a variety of forest conditions across Canada were presented at the Tenth Canadian Symposium in Edmonton. The paper published in the Proceedings of that symposium serves as an interim user guide concerning potential uses of TM data for forestry.

The development of the algorithm and specifications necessary to make reflectance enhancements for forestry available as standard CCRS film products was completed, and four enhancements have been defined: mixedwood/mélangé, softwood/résineux, boreal/boréale, and leaf-off/défeuillaison.

It is expected that these enhancements will be of major value to foresters interested in the effective use, at low cost, of TM satellite data for forest management.

2) Insect Damage Mapping and Juvenile Stand Assessment

This project was expanded significantly in 1986. A wide area-spruce budworm mapping trial was flown with the MEIS sensor in New Brunswick, which covered 5 000 km in a single 3-hour flight. Data from this flight have been analyzed to confirm that with appropriate spectral bands, the MEIS sensor is capable of identifying conifers with current-year spruce budworm damage and distinguishing them from healthy conifers, from conifers with previous damage, and from deciduous trees. The project also identified areas of future development work to produce an operational system for spruce budworm damage mapping.

In British Columbia, this project was aimed at two problems: mountain pine beetle damage and juvenile stand assessment. MEIS II data acquired for mountain pine beetle damage mapping were found to be more sensitive for detecting dead trees than conventional aerial photography, and automated processing promisses potentially lower interpretation costs. A spatial resolution of 1.5 to 2 metres was found to be optional for mapping individual trees killed by mountain pine beetle. A detailed spectroscopic investigation of foliage from attacked and unattacked trees was carried out to determine those spectral regions showing the earliest evidence of attack. Significant differences in the response were found between current and older foliage. These spectroscopic studies will be used to identify the optimum MEIS bands for so-called pre-visual mountain pine beetle stress detection, and to guide our investigations in 1987.

MEIS data acquired for juvenile stand assessment were used to map conifer regeneration in plantations near Smithers, B.C. The data were analyzed to demonstrate that 1.7 metre resolution colour-infrared displays could identify areas of unacceptable competition from deciduous trees brush. Herbaceous ground cover areas of poor growing conditions, such as caused by compacted soil, could also be readily identified.

3) Alberta Forest Inventory

In 1986, the research effort concentrated on two key aspects: stratification of regeneration burns with TM data, and quantitative crown closure estimation from TM data.

Two maps of a burn north of Whitecourt were prepared, one using two-date (summer and fall) TM data alone, and one using TM data plus interpretation aids (small and medium scale colour photography, and the Alberta forest inventory maps).

The map prepared for TM data alone compared favourably with the map prepared using other aids.

An initial evaluation of the potential of TM for providing quantitative crown closure estimates was encouraging, with multi-variate regression analysis providing r^2 values of 0.79 for lodgepole pine stands and 0.64 for spruce stands.

Oceanography/Coastal Zone Management

1) Sea Surface Temperature (SST) and Water Quality

The Division took advantage of the ability of the MOSAICS Transcription System to provide absolute calibration of TM band 6 (thermal infrared), to investigate the use of such data for the establishment of Sea Surface Temperature (SST) maps of specific areas, more detailed than the current low resolution NOAA AVHRR maps.

Initial test have been very encouraging, and two joint projects have now been initiated with the federal Department of Fisheries and Oceans. The test sites selected for these SST experiments are the Bay of Fundy and the MacKenzie Delta. Thematic Mapper VIR bands will also be evaluated in these tests as a possible source of information on organic content in suspended sediments.

2) Seaweed Mapping

A pilot project has been successfully concluded using data from the Fluorescence Line Imager to map seaweed off southwestern Nova Scotia. Based on results from this study, DFO has initiated an extensive seaweed inventory program along the south coast of Nova Scotia.

Recognizing recent improvements in the narrow-band capabilities of MEIS II, the Application Technology Division (ATD) of CCRS has begun a similar seaweed mapping assessment project using the latter sensor.

Geology

The program of geological research in ATD continues to concentrate on the assessment and demonstration of PC-based image analysis as an effective vehicle for both research and operational applications of satellite remote sensing technology to geology. Approximately 90% of routine image analysis requirements in geological projects are now met by the MICROGAP PC system which was implemented in January 1986. Close liaison has been maintained with both potential users of such systems and with system developers to ensure rapid dissemination of results.

During 1986, five regional geologic demonstration projects were completed. The study sites are representative of a range of geological conditions. Applications which have been investigated include: mineral exploration; bedrock, structural and surficial geological mapping; and engineering and environmental geology. Results from these projects have been assembled in the form of packages and have been incorporated in a new geology workshop curriculum which has been presented twice during the past year. In the context of these demonstration projects two major research interests were advanced:

- Geological data integration involving a number of data sets, including maps and digital elevation models,
- Regional or 'background' geobotany, in support of the efforts of the CACRS Geoscience Working Group.

PC-based research projects are planned for 1987, which will extend these efforts and will expand activities to include two additional demonstration sites and investigation of the role of SAR imagery for regional geobotanical assessment.

Training Support

Division scientists have assisted provincial agencies and companies in providing curriculum materials, consultation and expertise for training programs in geology, forestry, agriculture and digital image analysis.

Last year, ATD established a project to provide more formal recognition of the importance of remote sensing training and to assist in the design, production and presentation of workshops. To date, new training packages have been completed for an introductory remote sensing workshop and for a geology workshop package. In 1987, efforts will continue to concentrate on providing support to the Technology Enhancement Program through the development and presentation of new training packages including: Thematic Mapper, SPOT, Radar and Digital Image Analysis/Knowledge-Based Systems.

International Support

CCRS has continued in 1986 to respond to requests for assistance from CIDA, IDRC and the Department of External Affairs in a variety of international development and trade activities. ATD hosted visiting scientists from the People's Republic of China and Thailand. Significant formal cooperation included the following activities:

1) Berlin, Remote Sensing for Development Symposium

At the request of CIDA, ATD undertook responsibility for developing the Canadian display at the Berlin meeting which was organized under the auspices of the Economic Summit nations. A series of applications demonstration posters and pamphlets were produced highlighting Canadian expertise in the assessment and application of remote sensing for development. Posters were also prepared detailing the strong capabilities of Canadian industry in the remote sensing manufacturing, services and consulting sectors. CCRS, through ATD, also prepared the Canadian 'country paper' for the meeting. This paper stressed the Canadian commitment to development assistance and our confidence in the applicability of remote sensing technology to help meet the related challenges. The paper also documented the close association between the national remote sensing program and CCRS and Canadian industry. Evidence of the excellence of Canada's remote sensing industry was also provided.

2) Global Change

There is increasing interest and concern over environmental changes at the continental and global scales, such as: climatic change, droughts, loss of arable land, etc. It is becoming clear that remote sensing from satellites will become a primary tool for monitoring environmental changes at these scales.

A new international effort, the International Geosphere - Biosphere Programme (IGBP), was approved in 1986 by the International Council of Scientific Union. The aim of this program is to build an understanding of how the earth changes and of the factors affecting its evolution.

As part of the Canadian participation in the study of global change, CCRS helped organize a group of remote sensing scientists who will chart a program of studies of the Canadian landmass, oceans and the atmosphere. In addition, an experimental program has been initiated to develop ways of monitoring changes in vegetation and soils with the aid of low resolution (NOAA AVHRR) and high resolution (LANDSAT) data, both archival and current. An effort is being made to ensure that valuable historical data, documenting global-scale changes over the recent past, are preserved as a vital archive for long term studies at global change.

User Assistance and Marketing

The User Assistance and Marketing Unit is responsible for providing information to users and potential users about the Centre and its activities and facilities. The unit also interacts with Canadian remote sensing companies as part of a continuing commitment to Canadian industry and to ensure the close integration of the technology with user needs.

During 1986, the Unit continued to respond to numerous user requests - over 3 000 contacts by mail and telephone, and several hundred visitors and members of tours. Activities related to marketing and promotion were again increased with the help of Communications EMR in accord with the recommendations previously made by CACRS.

An advertising campaign targeted to geology and forest professionals was put into effect in late 1986. As well, contacts with the media continued, with a number of major stories appearing in the local and national press. The Unit served as the contact point for the Canadian Geographic article on remote sensing, as well as for images provided to Quebec Science, Toronto Star, National Geographic, etc. Articles appeared in the Financial Post, Toronto Star, Quebec Science and other major publications.

CCRS was actively involved in Expo '86 (which showcased Canadian remote sensing technology), as well as in the World Congress on Education and Technology. CCRS also participated in Berlin '86, a meeting devoted to issues of foreign aid and education in remote sensing. 1986 saw the beginning of truly commercial satellite image poster production in the private sector.

Technical Information Service

CCRS has continued to develop and operate the Remote Sensing On-line Retrieval System (RESORS) in collaboration with Gregory Geoscience Limited. There are presently over 57 000 documents and 6 500 slides referenced in the databases. During 1986, over 7 000 information searches were carried out by RESORS staff, and an additional 4 000 searches were performed online by 80 account holders in

Canada, and by 30 account holders in the U.S., the U.K., Australia, the Netherlands, Israel, France, Finland, Botswana and Malaysia.

A number of newsletter publications regularly use RESORS in order to supply their readers with lists of recently published literature. Also during the past year, CCRS entered an agreement with the publishers of Remote Sensing Yearbook (U.K.), under which RESORS data is being supplied as basis for a comprehensive bibliography to be published in the 1987 Yearbook, and in subsequent annual editions.

DIGITAL METHODS

Methodology Research

Methods using computational algorithms and symbolic reasoning (Artificial Intelligence) are being investigated to extract the information contained in remotely sensed data. These methods employ technological resources which span the sciences of Pattern Recognition, Image-Processing, Physical Spectroscopy, and Computer Science. As the methods are developed, their performance is assessed on data taken from application areas such as Forestry, Geology and Agriculture.

For the classification of forest cover types and clearcuts, Thematic Mapper images, along with geographic information such as hydrology, digital elevation models (DEM) and thematic or classified area maps, are integrated with data from forest cover maps supplied by the British Columbia Ministry of Forests and Lands. This approach uses complex classification methodology which includes symbolic reasoning, in the form of knowledge-based expert systems. Research has led to developments in expert systems designed to assist in the classification exercise. The large software libraries of the LANDSAT Digital Image Analysis System (LDIAS) are interfaced with the image analyst through an expert system called the 'Analyst Advisor'. LDIAS is used for research and development in information extraction, to support the development of applications, and to understand the characteristics of airborne and satellite sensors.

The need for the interchange of geographic data from various sources of information has resulted in the definition and implementation of new standard formats for the transfer of spatial data.

Geological data is being integrated with remotely sensed data in a research effort which also includes knowledge-based systems. New filtering techniques developed through mathematical morphology are being investigated. Enhancement techniques are being developed for Thematic Mapper which are intended to detect geological outcrops in vegetated areas.

The Micro-Computer Based Image Analysis System (MCBIAS) is a research and development thrust into the use of personal computers as image analysis tools. Research includes the areas of task assignment for personal computers and main frame computers, development of a distributed image processing system and mass storage devices for personal computer-based image analysis systems, such as the optical compact disk and its formats. A read only compact disk containing remote sensing data was created. For potential users of remote sensing, more user-friendly procedures are required, and MCBIAS will use artificial intelligence to assist in image analysis and data integration.

Methodologies concerned with image segmentation and texture are being researched. These address the increased role which spatial data has in the classification and understanding of images. Resurgence of this interest has prompted increased effort into investigations using Fourier Transforms and neighbourhood classifiers.

Colour space processing is being investigated as an enhancement methodology where the normal additive colour primaries are replaced by psychophysical descriptions of colour, such as hue, saturation and brightness.

Sensor related radiometric research has centered on the radiometric limitations of LANDSAT TM image information content. Scene-related radiometric research was concerned with new developments that combine processing steps to avoid the non-commutative nature of previous solutions.

A method has been developed to automatically match synthetic aperture radar imagery and simulated imagery generated from Digital Terrain Models (DTMs).

New algorithms for geometric correction of TM show, in experiments, that planimetric accuracies of better than 17 metres can be realized. Studies of accuracy assessment algorithms for automated image classification have been undertaken.

Algorithms have been developed for the automatic generation of DTMs from SIR-B and SPOT data by digital correlation of image pairs. A LANDSAT MSS image and a DTM have been used to generate sequences of perspective views

showing features and details of the relief dynamically.

Satellite Data Processing Developments and Products

Two SPOT quicklook systems were completed in 1986 for the generation of 70 mm quicklook products, microfiches and catalogue information from SPOT data. One system was installed at PASS, and the second one at the Gatineau Satellite Station (GSS).

Facilities in Ottawa have continued to provide data processing support and products to the remote sensing community during 1986. The Time-Sharing System (TSS) supports the processing of satellite and airborne data together with quality assurance, image analysis, research and development, database and reporting systems. The TSS provided user access to the LANDSAT-1, -2, -3, -4, -5 Image Inventory Search and Summary (IISS) database for MSS, geocoded MSS and TM data. The on-line inventory contains all LANDSAT -1, -2, -3 data recorded, all existing colour film, DICS and TM products and, as of March 1987, all LANDSAT-4 and -5 data recorded up to February 1987. For SPOT data, the catalogue updates generated on the SPOT quicklook systems have been used to produce sorted listings, including cloud coverage and acquisition mode, of the SPOT images acquired over Canada. CCRS is planning to develop a new on-line image inventory system for SPOT and other satellites.

The TSS TRIAD image display subsystem has continued to be used extensively for quality control of digital products and for research projects. The TSS scanning microdensitometer black and white image production subsystem has been used primarily to image radar data (632 films from April 1986 to March 1987).

The satellite production in Ottawa between April 1986 and March 1987 has consisted of TMTS pseudo bulk corrected TM imagery: 686 CCT and film products. Production on DICS and TMTS terminated in 1986-87.

A total of 791 CCTs of SEASAT microwave signal data have been transcribed from HDDTs, corresponding to about half of the SEASAT archives acquired at Shoe Cove. There is no plan at the moment to transcribe and process the rest of the archives. A total of 87 SEASAT CCTs have been processed into images in 1986-87.

The Colour Image Recorder (CIR) generated 320 film products between April 1986 and December 1986. These were colour-on-demand, user customized tape-to-film, DICS film products, TM and airborne products. A new colour film recorder was phased into operation. Between September 1986 and March 1987 it has produced 239 images.

MOSAICS was operated at MacDonald Dettwiler & Associates (MDA) from the beginning of April 1986 until the end of November 1986. During this period, 848 colour films, 246 B&W film and 478 CCTs were produced in response to user orders. The MOSAICS system was installed and phased into operation at PASS in January 1987. For the January 1987 to March 1987 period, 317 MSS, TM and SPOT products have been generated on MOSAICS at PASS. It is expected that the LANDSAT and SPOT backlog will be processed by April 1987.

Airborne Data Processing Developments and Products

The present airborne VIR data processing system (AIR I) continued to be operational in 1986. A total of 744 CCTs (MEIS, MSS and FLI) were produced between April 1986 and March 1987. The digital Synthetic Aperture Radar System (C-SHARP) has continued to be fully operational in 1986; 136 SAR products were generated between April 1986 and March 1987.

In anticipation of the extra load from the airborne IRIS SAR and RADARSAT investigations requiring SEASAT data, C-SHARP was upgraded to increase the system throughput and processing capability. The upgrades, consisting of an additional array processor and disk space, increase system throughput by nearly 100%. In addition, the extra disk space allows the processing of a full 100 km by 100 km SEASAT scene. Work is progressing for the development of a VAX-based airborne data processing system (AIR II) to be phased into operation in 1987. AIR II will have the capability to transcribe MEIS, MSS, FLI, IRIS and the airborne scatterometer data from HDDTs to CCTs and to correct the images geometrically. In particular, AIR II will generate geocoded airborne products using the aircraft navigation data for image correction. The old AIR I, which has been in operation since 1974, will be terminated at the end of April 1987.

DATA ACQUISITION

Satellite Program

LANDSAT Satellite Program

The LANDSAT-4 and -5 satellites continue to provide Canadian MSS (LANDSAT-4 and -5) and TM (LANDSAT-5) coverage with only minor outages. Significant changes to the Canadian LANDSAT program were required due to budget cuts and

the addition of the SPOT program and are discussed below under "Reception Policy" and "Products and Prices".

The commercial operator of the LANDSAT Satellites, Earth Observation Satellite Company (EOSAT), was forced to phase out the development of new LANDSAT spacecraft, sensors, and ground systems as well as severely cut back its market development efforts in response to the withholding of scheduled FY1987 funding by the American Government. The funding issue, however, is not completely resolved: EOSAT expects further news in June of this year. There is a very real possibility that LANDSAT-5 will be removed from service (fail) before LANDSAT-6 is launched in 1990, with the concomitant loss of continuity of TM data.

SPOT Satellite Program

The SPOT-1 satellite has provided routine coverage since the June 16, 1986 start of the operational SPOT program in Canada. During the year it was found that operation of the sensors in single HRV panchromatic plus multispectral mode caused banding in the imagery due to crosstalk between the two systems. CCRS has discontinued the use of this sensor configuration. Also, Differential Pulse Code Modulation (DPCM) mode for panchromatic operation is now used for all Canadian acquisitions in PLA mode due to the extremely small radiometric range of the data obtained in linear mode. The spacecraft itself is in excellent condition with 10% greater power than anticipated and with less than 5% fuel usage to date, its expected lifetime has been increased to 3 years.

In the first 9 months of the SPOT program, 70 000 scenes were placed in the Canadian archive, of these about 8 000 were cloud free and an additional 4 600 scenes are deemed "usable". (This ratio of usable scenes to the total number of scenes acquired is also exhibited in the LANDSAT archive).

NOAA Satellite Status

NOAA 6 - This satellite is currently in standby status.

NOAA 9 - A recent failure in the MSU channel 2 and failed attempts to activate the ERBE-scanner (Earth Radiation Budget Experiment) have prompted a callup for NOAA-H launch.

NOAA 10 - Operational instruments are performing well.

NOAA-H - Due to the failure of NOAA-9, launch was been scheduled for October 29, 1987.

Satellite Sales Statistics FY 1986/1987

	Products	$(K)
MSS		
Photo	1648	126
Digital	146	106
TM		
Photo	993	208
Digital	214	327
SPOT		
Photo	1	1
Digital	5	10
Other Products and Services		77
		855 K

The following table compares the number of digital products delivered with geocoded products.

	Raw/Bulk Scenes	Geocoded Subscenes
MSS	128	18
TM	192	22
SPOT	5	0
	325	40

Program Changes

As a result of the recent budget cuts, CCRS has been forced to reduce the operating costs in the Satellite Program. While it was recognized that any change in the services offered by the Program would affect some segment of the user community, it was only possible to realize the required savings through the following:

- reduction in the number of final product types
- changes in the Reception Policy
- introduction of a reception fee.

These changes were implemented April 1, 1987.

Products and Prices

As of May 1, 1987, the contract production staff at PASS will be laid off. Until January 1, 1988, when the "commercialization" of the satellite data production is in place, term public servants and summer students will be used to operate MOSAICS to produce CCT and film products. (The contractor will still be

carrying out the reception archiving functions as in the past.) The level of staffing will allow the Centre to process raw, bulk, and systematic geocoded products. Because of the extra effort required to generate the precision geocoded products, these will no longer be offered. It is expected that many users will make use of the recently introduced systematic geocoded products. The final product will be master transparencies (colour or B&W) and CCTs. Enlargements and paper print products will be the responsibility of the customer. It should be noted that SPOT data is copyrighted and royalties payable to SPOT IMAGE of France apply to any subsequent product generation.

It is expected that after January 1, 1988, the Canadian Industrial Involvement Contractor will want to resume production of precision geocoded imagery and photographic prints.

Satellite Reception Policy

The reception and archiving of satellite data this year at both stations, Prince Albert and Gatineau, is estimated to cost in excess of $1.65M using the reception policy of past years. With the promise of more satellites and the continuation of those already in orbit, the tape consumption is going to expand continuously and, coupled with inflationary increases in tape costs, the present reception policy has become prohibitive. The following policy is being put into place to help reduce the volume of tape utilized and hence the cost of reception. This new policy, in conjunction with the screening and re-copy of the Archives which is underway, will assist in reducing the cost of operation significantly.

PASS Reception Schedule

NOAA - AVHRR

Reception to be on-demand between 15 April to 15 September. No reception during the winter period.

LANDSAT-4 MSS

Reception to be on-demand between 15 April to 15 September. No reception during the winter period.

LANDSAT-5-MSS/TM

Reception of all passes within the coverage capability and the SPOT reception constraints from 15 March to 31 October, and on-demand for the period 1 November to 14 March.

SPOT - HRV

Reception of all passes within coverage capability and LANDSAT reception constraints from 15 March to 31 October, and on-demand for the period 1 November to 14 March. SPOT will be granted 50% of the conflicts between SPOT and LANDSAT.

GSS Reception Schedule

SPOT - HRV

Reception of all passes within coverage capability from 15 March to 31 October and, on-demand for the period 1 November to 14 March.

EOSAT Reception Schedule (Goddard)

LANDSAT-4 MSS

Reception on-demand only of Canadian East Cost data between 15 March and 31 October. No reception during winter period.

LANDSAT-5-MSS/TM

Reception of all band passes over Eastern Canada in period 15 March to 31 October in exchange for Western U.S. reception. Reception on demand for the period 1 November to 14 March.

Reception Fee - Applicable to all Data Recorded On-demand

A reception fee has been implemented to discourage requests for routine reception to archive of data that would not otherwise be acquired because of the reception policy.

For each pass (or segment in the case of SPOT) recorded on-demand, the requesting agency shall pay a reception fee to offset the cost of high density digital tape.

- The requesting agency shall identify a target scene or several target scenes along the track.
- The requesting agency shall be provided with a fiche of the data recorded.
- If one of the target scenes has 10% or less cloud cover (or upon explicit instruction from the requesting agency) the tape shall be placed in archive, thereupon the requesting agency shall pay the reception fee.
- The requesting agency shall be credited up to amount of the reception fee, for subsequent orders placed within 120 days of reception, for data products from that spe-

cific tape. The credit shall be made only to the requesting agency and shall not be transferable.
- The reception fee shall be $100.

Airborne Program

Airborne Operations

The following table summarizes the utilization of the CCRS aircraft during the 1986-87 Fiscal Year in each of the four categories under which projects were flown, as well as their applications discipline and the province in which they were flown.

Category	No. of Projects Flown	Aircraft Hours
Internal	31	268
External	11	38
Co-op	6	136
	48	442
Discipline		
Agriculture	3	15
Atmospheric Environment	1	8
Forestry, Wildlife, Wildlands	9	38
Geography	1	7
Geology	12	39
Oceanography	7	195
Transport	1	3
Sensor Tests	11	107
Aircraft Tests	2	17
Crew Training	1	13
	48	442
Province		
British Columbia	2	14
Alberta	1	16
Saskatchewan	3	15
Manitoba	1	11
Ontario	21	165
Quebec	9	22
New Brunswick	1	7
Newfoundland	2	50
Nova Scotia	3	12
Yukon	1	19
Northwest Territories	1	93
Various Provinces	2	11
Other	1	7
	48	442

The total number of projects flown and the number of flying hours are down somewhat from the 1985-86 totals. This is due to further delays in commissioning of the new C-SAR in the Convair-580, and also to the fact that both the Falcon-20 and the DC-3 were removed from service as of October 31, 1986.

Some of the major tasks accomplished during the 1986-87 Fiscal Year:

- DC-3 Lidar Bathymetry survey of the Northwest Passage. A co-operative project with CHS using the Larsen-500 system to chart the approaches to Cambridge Bay and Simpson Strait. This is a continuation of the 1985-86 program.
- Falcon-20 Spruce Budworm mapping project in New Brunswick in co-operation with the New Brunswick Forestry Department using MEIS, MSS and RC-10 camera.
- A similar project in British Columbia in co-operation with the B.C. Forest Service to map Mountain Pine Beetle infestations.
- Falcon-20 project in co-operation with Environment Canada to study oil dispersant effectiveness over a controlled oil spill in the Beaufort Sea.
- Convair-580 joint Labrador Ice Margin Experiment (LIMEX) and Labrador Extreme Waves Experiment (LEWEX) off the east coast of Newfoundland using the C-band SAR and the C- and Ku-band scatterometers.

The Falcon-20 and the DC-3 are both being sold to the private sector. The DC-3 will be used as a platform for the Larsen-500 lidar bathymeter and it is hoped that the Falcon-20 will continue to be used for the CCRS electro-optical sensor package which will be made available to private industry under a loan agreement.

Number of CCTs Produced During Fiscal Year 1986-87

	Internal	External
MEIS	303	150
MSS	83	85
SCATT	8	0
FLI	0	38
C-IRIS	70	7
	464	280

Microwave Sensors

The new fully digital C-band SAR was delivered in 1986, and underwent laboratory testing and evaluation prior to its installation in the Convair-580 aircraft. Commissioning started, and included a comprehensive set of flight trials designed to evaluate all aspects of the system's performance. The imagery collected demonstrated the potential of the system, but there were problems with the high power amplifier and its reliability, which necessitated lengthy investigation and repair. These were resolved, and test flying recommenced early in 1987. Data was acquired on missions related to general terrain features in Quebec, Nova Scotia and New Brunswick, and over ice and ocean off the East Coast. In March, 1987, the Convair-580 with scientists from the Data Acquisition Division participated in the international campaigns, known as LIMEX (Labrador Ice Margin Experiment) and LEWEX (Labrador Extreme Wave Experiment), off the coast of Newfoundland, as part of the Radar Data Development Program. The C-band SAR acquired some of the best civilian airborne radar imagery ever collected. During the campaign, ten successful missions were flown, and provided data sets which amply demonstrated the excellent image quality and performance of the C-band SAR. In addition to the SAR data, Ku- and C-band scatterometer data were also acquired. Scientists from eight countries participated, with five aircraft, including the CCRS one, and three ships. The effort realized one of the most complete ocean and sea ice data sets collected that will provide not only basic oceanographic information but also data for ice and wave modelling, leading to improved wave and sea-ice forecast products.

The development of the C-band SAR has been continuing. Notwithstanding the reliability of the system as demonstrated during the March campaign, the high-power amplifier is being modified and repackaged to eliminate long down-times due to failures, and a lower power amplifier operating at either C- or X-band is to provide back-up. The existing antenna, from the earlier CV-580 SAR, has been redesigned to obtain a narrower beam-width (and will be retrofitted after the summer data acquisition program). The antenna will also be pressurized to allow the full power to be transmitted and to obtain the ultimate performance in the wide swath imaging mode. The concept has been tested successfully and the modifications required are proceeding.

The X-band SAR, a fully digital system with performance similar to the C-band SAR, is being developed by MacDonald Dettwiler & Associates under contract to CCRS. The development is on schedule, with the system in the final integration and testing stage at the contractor's facility. Delivery is expected in May, with installation in the aircraft planned for the summer of 1987.

As a continuing activity related to the calibration and validation of the radar systems, a calibration site was selected for long term use, and the ground-based calibration targets were maintained.

Visible and Infrared Systems

The airborne electro-optical package completed an extremely successful season in operation on the CCRS Falcon aircraft, with data acquired for over thirty research projects for the remote sensing community.

Data Acquisition Division projects included a major activity related to the evaluation of the MEIS for forestry, with pilot projects in New Brunswick and British Columbia and the acquisition of stereo and multispectral imagery using the forestry optimized spectral passbands. Other projects exploited the high spectral resolution capability of the MEIS, (e.g. for vegetation stress measurements) and its radiometric performance, (e.g. water quality and water depth measurements). Data sets were acquired on downwelling irradiance using the newly installed spectroradiometer, and are being used in the development of refined atmospheric correction algorithms. An important activity was the continuing evaluation and development of cartographic capabilities. Missions were flown with the MEIS and MSS imagers, and the image matching techniques were pursued to derive digital elevation models. Using data sets acquired simultaneously with the scanning lidar system and the MEIS, the potential of the former was assessed for measurements of tree heights and canopy density.

The airborne electro-optical facility made an important contribution to the Beaufort Sea Trial. This was a major campaign with participants from the oil industries and the regulatory bodies, and was organized to investigate the effectiveness of dispersants on oil spills. Other systems and aircraft participated, but the CCRS facility, with its proven reliability and performance, provided the only means of determining the results of the trial.

The CCRS Falcon flew its final project as a CCRS aircraft in October, 1987. As a result of budget constraints, it is being sold. The access to the electro-optical facility will be

available in a different manner starting in June, 1987. In order to promote and encourage the rapid development of commercial applications of the electro-optical technology, the electro-optical package has been offered for loan. A request for proposal has been prepared, to provide services to others in the remote sensing community; the response to the competitive bid is currently being evaluated.

Sensor developments during 1986 have included the introduction of the blue-shift-free filters to the MEIS operation, and their use on a routine basis. The design and implementation of these interference filters, with uniform spectral response across the field of view of the sensor, mark an important advance in the linear array imager technology.

The development was completed of the automated calibration facility for multi-element imaging sensors, and was used to provide the geometric and radiometric calibration of the new filter sets of MEIS, and to provide the means of precise and rapid evaluation of the sensor's performance. This again is an important development of the array imager for remote sensing research and operation.

The real-time display, Alice II for the MEIS and MSS was upgraded to provide the capability of user selectable enhancements, so as to provide preliminary data and image analysis onboard the aircraft without the need for post-flight transcription of the data tapes.

In the area of the active electro-optical systems, the detailed design of the laser fluorosensor was completed on schedule under contract to CCRS by Barringer Research Limited. This development had been funded by the Office of Energy Research and Development and was to provide a system to monitor chronic discharges in the Arctic and offshore regions, with emphasis on operational requirements. Unfortunately, as a result of budget cuts, the scope of the contract was reduced, and further work to complete the fabrication was cancelled.

The CCRS DC-3 aircraft has played an important part in the development of the active electro-optical systems, the laser fluorosensor and the lidar. It flew its last mission as a CCRS aircraft in October, 1987, in support of the Larsen (lidar) hydrographic survey in the Arctic. As a result of the budget constraints, it is being sold. The successful bidder for the aircraft is to continue to provide the platform as required to the hydrographic survey community.

RADARSAT PROGRAM

Introduction

The past year's effort has mostly involved activities resulting from a new Canadian Space Program announced in May, 1986, which included some components for further development of satellite remote sensing programs. The Space Program provided for continued planning for RADARSAT with the objective of reducing costs and obtaining financial involvement of private sector, provincial and foreign governments, and for submitting the revised RADARSAT proposal within one year. Further, it allocated $5 million per year to a fifteen-year remote sensing program, called Radar Data Development Program (RDDP). It also provided for expanded relationship with the European Space Agency (ESA) through continuing participation in its ERS-1 and other remote sensing programs. These and other developments are highlighted in this report.

RADARSAT Developments

SPAR Aerospace was directed to review the design and recommend options which would take account of the Space Program decision. The SPAR recommendations, arrived at through detailed consultations with the RADARSAT Project Office (RPO) including the major users, call for a SAR satellite in a dawn-dusk orbit with a novel SAR designed to provide a variety of data acquisition choice to users in terms of selecting swath-width, resolution and incidence angle. The SAR will now look to the right permitting coverage of the high Arctic (up to about 87°N). The whole of Canada will be covered by the SAR within a 3 day repeat sub-cycle with coverage over the Arctic, such as the Northwest passage available from several passes each day.

The main "operational" mode will still typically provide a swath-width of more than 100 km with a resolution of 28 m x 30 m with 4 looks. The selected swath can be one of seven from within an accessibility swath of 500 km covering incidence angles 20° to 49°. Two wide swath beams (approximately 150 km each) with approximately 40 m resolution at 4 looks, over incidence angles 20° to 40°, have been kept as well. Also retained are experimental beams over incidence angles ranging from 49° to approximately 60°. Two new and extremely useful SAR modes have been added; a "High Resolution" mode and a "Scan" mode. The "High Resolution" mode will provide a swath approximately 55 to 90 km, with a 1 look resolution as good as 8 m. A choice of

at least five such beams will be provided within the 500 km accessibility swath. The "Scan" SAR mode will provide very wide swaths (300 km and 500 km) with a resolution of approximately 100 m with 6 looks. This mode is intended to provide survey imagery (e.g. of ice areas) of the whole accessibility swath at one time.

The U.S.A. will still be contributing the launch and the U.K. will be providing the spacecraft bus. The U.K. may also provide sensors such as a Radar Altimeter (RA) and an Along Track Scanning Radiometer (ATSR); perhaps advanced versions of the ERS-1 sensors. The RADARSAT mission is now designed for five years and in-orbit servicing has been deleted to reduce costs. In light of all these changes Douserv-Econosult have been asked to provide another Economic Review and Assessment of the RADARSAT mission. Their study is due for completion shortly but the results indicate that the overall economic benefits of RADARSAT largely remain about the same with some changes due to the reduced mission life and the removal of the high resolution optical sensor which affects agriculture and forestry applications. However, the projected cost/benefit results seems to have enhanced due to a substantial reduction in costs and improved market penetration rate expected as a result of the RDDP announced in the last Space Program.

Application Developments and Radar Data Development Program (RDDP)

The development of SAR applications within the RPO has progressed well in the past year. This work has been undertaken by the Applications Coordinators for ice, ocean, land renewable and non-renewable resources groups with scientific and technical support provided under contract by F.G. Bercha & Associates (Ontario) Ltd.

The ice applications work has been primarily concerned with the analyses of available SAR data for establishing ice and iceberg signatures and with the development of an automated ice tracking method for use with SAR imagery. Two approaches have been tried for the ice motion monitoring algorithm, a technique using object descriptors and another employing an hierarchy structure which reduces data sizes. The latter approach has shown much promise in tests on Arctic winter ice SEASAT SAR imagery. The developed model is designed to handle rotation and signature changes and is being further refined and tested. Information on these and other relevant developments are provided to the ice user community through a regular newsletter published by the RPO with the support of the Atmospheric Environment Service (AES). This newsletter has been very well received and has achieved a wide international circulation to over 250 users.

The ocean applications work has been primarily concentrated in analyzing ship returns from available SAR imagery and in extracting ocean wave information from SAR data. Theoretical models of SAR imaging of ocean waves have been studied and compared, and software tools for correcting and analyzing SAR data of ocean waves have been developed. These have included techniques for estimating ocean wave spectra from SAR data.

In land renewable resources applications work, the primary emphasis has been on continuing investigations of available SAR data for crop type determinations, crop condition assessment, and establishing sensor and field/vegetation parametric effects on radar backscatter. These investigations have included analyses of multi-temporal SAR and combined SAR and VIR data sets as well as some preliminary assessment of the effect of snow on radar return from vegetation cover. Some work in forestry applications of SAR has also been conducted with the analyses of available SAR and other sensor data for monitoring clearcuts and regeneration, detecting and mapping tropical forest conversion processes, and delineating topographical effects.

The land non-renewable resource applications development work has been primarily concerned with stereo-SAR investigations, analyses of SAR imagery alone and in conjunction with other data sets for deriving geologic information, and development/evaluations of software tools for undertaking these analyses and displaying the results in different formats and projections. These investigations have included the use of texture in discriminating rock types, the evaluation of the effect of incidence angle, resolution size, and other parameters on SAR image quality and geological information content, and the demonstration of SAR mosaicking.

In undertaking the applications development work, the availability of rather limited C-band (the frequency band of the ERS-1 and RADARSAT SAR's) SAR data has been well recognized. Accordingly, plans have been developed to acquire C-band SAR data in each applications area as soon as the new CCRS SAR-580 system becomes operational. The first opportunity will be for ice and oceans data in major experiments being conducted offshore Newfoundland and Labrador. The Labrador Ice Margin Experiments (LIMEX) and the Labrador Extreme Wave Experiments (LEWEX) are part of a

long term scientific and applications development plan for the utilization of satellite SAR data for ice and ocean wave monitoring and forecasting. These SAR-580 experiments in March, 1987, are part of a large coordinated effort organized by the RPO Applications Coordinators for ice and oceans, involving other researcher/agencies from Canada (mainly AES and BIO) and the U.S.A. Extensive surface truth and associated data will be collected using three dedicated ships, as much as four other aircraft, and in-situ instruments.

Detailed plans have been formulated for continuing the applications development and other work under the RDDP. This remote sensing program calls for the development of advanced technologies and applications for the reception, processing and analysis of radar and other remote sensing data. The RDDP primarily pertains to radar data and technology and their utilization in ice surveillance, oceanography (including ship detection), agriculture, forestry, geology, hydrology, geography and other applications. This program is intended to provide support for radar data use, image processing and analysis to enable Canada to maintain its world lead in ground infrastructure using remotely-sensed data. The RDDP has recently been approved by the Treasury Board for commencement in April, 1987.

ERS-1 Developments

The continuing Canadian participation in the ERS-1 program of ESA has already resulted in a satisfactory industrial return and other benefits. Companies such as MDA, SPAR, and COMDEV are under contract to ESA to develop and supply significant hardware/software for ERS-1. For example, MDA is responsible for the whole receiving station at Kiruna, Sweden (the main ERS-1 ground station) and is also building the SAR ground-processor while SPAR is providing the telemetry equipment. In addition, Roy Ball & Associates and DIGIM (1983) Ltée have received contracts for applications development work.

As a major activity last year the Canadian proposals were coordinated and prepared, in response to the Announcement of Opportunity (AO) call for ESA for geophysical validation and scientific uses of SAR and other sensor data to be available from ERS-1 after its launch in 1989-90. Seven proposals were submitted to ESA involving researchers from across Canada. These were one each in the areas of ice, geology, agriculture/forestry and two each in ocean applications and sensor calibration. In addition, national data requirements for the ERS-1 mission are being compiled in consultation with the major user agencies/departments such as AES and DFO.

Conclusion

Much effort in the last year has been spent in connection with the revised RADARSAT proposal. This proposal is being prepared and will be submitted shortly. The Cabinet level review will begin in April and a decision should be announced soon afterwards. Furthermore, the radar applications and other development work at the RPO will be continued under the RDDP, in accordance with the plans developed last year. The already approved RDDP ensures continuing commitment to such work in preparation for the utilization of radar data to be available from ERS-1, RADARSAT, and other satellites starting in 1989-90.

5.0 HIGHLIGHTS OF THE REPORTS OF THE WORKING GROUPS

5.1 HIGHLIGHTS OF THE REPORT OF THE AGRICULTURE WORKING GROUP

The Working Group initiatives for 1986 were focussed on the work of three active sub-committees.

Rangeland

Development of a Canadian Range Remote Sensing Publication, a practically-oriented illustrated compendium on demonstrated uses of remote sensing for range management in Canada, was initiated in 1986, targetted to Canadian decision-making managers and field users, as well as the international range management community. This will be presented to the International Rangelands Congress in 1988.

Remote sensing holds much promise for current and future application in rangeland management programs in Canada and elsewhere, however incorporation into "user" programs continues to be very slow due to limited research and operational budgets and lack of commitment by decision-making managers. New initiatives are needed to resolve this problem. Future breakthroughs must involve improved resolution (e.g., SPOT, yet to be evaluated for range) and extraction of quantitative biomass information.

Radar

In 1986, the sub-committee considered three main topics: comprehensive super-sites, radar training, and the up-coming ERS-1 campaign.

Due to the increasing cost of collecting ground data, the sub-committee established criteria for the establishment of super-sites for remote sensing missions specific to agriculture/radar and requested proposals for new sites from the remote sensing community.

The sub-committee started an agriculture/radar workshop series to be part of the 11th Canadian Symposiun on Remote Sensing at Waterloo. The course would last for three days and cover radar fundamentals, SAR systems and SAR applications.

The sub-committee coordinated the submission of a proposal for a Canadian agriculture experiment using ESA's ERS-1 and to be coordinated by Ron Brown of CCRS.

CCRS has made a considerable number of SAR data sets available to universities and provincial centres. University researchers have already presented findings at the Edmonton Symposium and more are expected at Waterloo.

Crop Information

A pilot projet was carried out by Agriculture Canada, the Canadian Wheat Board and CCRS under contract to Intera Technologies Ltd. to pre-process NOAA AVHRR data and to deliver these data to the Canadian Wheat Board and Agriculture Canada. The results of this work has indicated what modifications to data selection and processing were necessary to be made to the procedures to better meet the operational requirement of agencies like the Wheat Board. The Crop Information Sub-committee supports the initiative that CCRS, Agriculture Canada and the Canadian Wheat Board have taken in this direction and the subsequent establishment of a remote sensing data preprocessing system in Winnipeg. This system is designed to meet the current and some future needs of agricultural users for remotely sensed data and in particular be capable of handling SAR data where it becomes routinely available from the ESA ERS-1 satellite and the proposed Canadian RADARSAT.

5.2 HIGHLIGHTS OF THE REPORT OF THE WORKING GROUP ON CARTOGRAPHY AND PHOTOGRAMMETRY

ACHIEVEMENTS DURING 1986

Operational application of space imagery: In the frame of the 5-year Change Detection and Map Revision Program using LANDSAT imagery which is being carried out by Gregory Geoscience for Topographical Survey of EMR, the following work has been completed: revision of 30 maps in 1:250 000 and change detection for 605 maps in 1:50 000. To date approximately 4.3 million square kilometers have been covered in this program. Approximately 7 600 km of aircraft field verification was accomplished and 1 780 oblique photographs were taken for feature verification.

NEW INITIATIVES DURING 1986

Preparation for SPOT: At NRC specific formulations for the Anaplot processing of stereo images from the European SPOT satellite have been completed. An original approach was adopted to formulate all needed geometric and cartographic relations with no loss of mathematical rigor for any expected geometric configuration of SPOT stereo images. As a result, a unique software library of about 40 subroutines and functions is now available for immediate applications. The preparatory work for the evaluation of SPOT image correction, map content and SPOT-generated DEM's using SPOT stereo imagery over the Kananaskis Valley and Ottawa test areas has been completed at the Topographical Survey (EMR). The investigations under PEPS (Preliminary Evaluation Program for SPOT) will continue in 1987. Various programs for the cartographic applications of SPOT imagery are in place at the University of New Brunswick, University of Toronto (Erindale), University of Calgary, Laval University, Cartographic Services of the Quebec Ministry of Energy, Mines and Resources, etc. All of these are awaiting the long overdue delivery of required SPOT imagery.

Large format camera studies: A number of organizations are testing the potential application of LFC photography to mapping. At the University of New Brunswick, a method for control extension has been developed. The obtained results indicate that, based on a dense control point field, the spatial position of well-defined features can be determined with a 7 m accuracy. With sparse control, the accuracy drops to 15 m. Similar studies have been initiated at Laval University yielding similar results. At the Topographical Survey (EMR), a project on the generation of DEM data from LFC photographs and on the generation of photomaps in 1:50 000 scale from LFC photographs is underway.

PROJECTS PLANNED FOR 1987

Photogrammetric evaluation of linear array scanners and space photography: Tests will continue with available imagery to establish the relative capabilities of various image acquisition systems to meet the photogrammetric and mapping requirements of extension of control, determination of elevations, and interpretation of features.

5.3 HIGHLIGHTS OF THE REPORT OF THE WORKING GROUP ON FORESTRY

ACHIEVEMENTS DURING 1986

The primary task of the Forestry Working Group (FWG) was editing and revising the Forestry Remote Sensing Videotape. The revised version has been presented to the annual meeting of CACRS in April 1987.

Research Priorities for the Future Decade

The FWG met and discussed research priorities and forestry remote sensing projects. Before the next decade is out and before the 21st Century, the following should be part of the forest management system:

1) Forest depletions should be constantly updated in all 10 provinces and territories. The rate of depletion should be known.

2) Restocking efficiency should be known.

3) Regeneration assessment should be accomplished using digital remote sensing techniques.

4) GIS should be an integral part of the forestry remote sensing system.

5) Dissemination of satellite data should be maximized through on-line access to satellite data base.

6) Integration of satellite monitoring with GIS should be maximized through on-line access to the provincial resource inventory data base.

The working group also recognized the important role of airborne remote sensing for site specific resource data acquisition at very large scales. In this aspect it supports the CFS proposed initiative in the development of an advanced linear array imager for forestry application.

5.4 HIGHLIGHTS OF THE REPORT OF THE WORKING GROUP ON GLOBAL ENVIRONMENTAL MODELLING AND MONITORING

MANDATE

At the 1986 CACRS Annual Meeting, the Global Environmental Modelling and Monitoring (GEMM) Working Group was given the mandate to:

- Create an inventory of those scientists in Canada who are working in the area of global monitoring and to identify their particular areas of interest.
- Recommend ways in which Canada could participate in the global change project of ICSU.
- To recommend follow-on terms of reference for the working group.

ACHIEVEMENTS DURING 1986

Letters were sent to the Chairpersons of the Geography, Earth Science and Biology Departments at Canadian Universities, and the principals from Government and Industry on the CACRS mailing list, requesting a summary of current and proposed research activities in global monitoring.

Eighty-two interested parties were identified: thirty-eight from government, five from industry, and thirty-nine from universities.

Two sub-committee members are helping develop Canada's involvement in the International Geosphere-Biosphere Programme (IGBP) sponsored by the International Council of Scientific Unions and coordinated in Canada by the Royal Society of Canada. Dr. Cihlar of CCRS is the leader of the Remote Sensing Technical and Resource Group of IGBP and Dr. LeDrew of Waterloo University is the deputy leader.

It is clear that the remote sensing community should be actively involved in the Global Change Program, and the GEMM working group can act as the interface between the remote sensing community and the IGBP program through its participation in CACRS.

PROJECTS PLANNED FOR 1987

The GEMM group will:

- select its objectives for the next year from the objectives specified for the Remote Sensing Technical Group of IGBP,
- identifty research needs and define future research programs in which remote sensing plays a critical role,
- identify potential funding sources and,
- seek for funding support.

5.5 HIGHLIGHTS OF THE REPORT OF THE GEOSCIENCE WORKING GROUP

ACHIEVEMENTS DURING 1986

The Working Group and its associate members have maintained an active program of research and coordination activities during 1986. The group maintains close contact with 26 additional Canadian specialists, 15 colleagues in the United States and 5 overseas researchers.

During 1986, activities have continued to focus on the topic of geobotany. In total, 25 projects were being carried out or supported by Working Group members. These activities have been reported in 15 papers in the scientific literature. Researchers have represented the Working Group at all major geological and remote sensing symposia and meetings in North America. Efforts have been made to provide information on a regular basis to the popular and industry press through articles and interviews. Two students working under Working Group members have successfully completed their graduate theses on geobotanical remote sensing during the last year.

1986 has been a year of steady technical and scientific progress in the area of geobotany. Regional geobotany using TM and DTM data have yielded consistent practical results in several environments. Analysis of MEIS data matured significantly due to improvements in data quality and development of analytical and data reduction techniques. Important results from several studies have confirmed the validity of the concept of airborne detection of mineral-induced stress in vegetation. Investigations were extended for the first time to the FLI with results that confirm the value of this sensor as an important tool for the interpretation of canopy spectral signatures relating to stressed and unstressed vegetation. Efforts have been made to standardize field data collection techniques to ensure compatibility of results. In particular, much valuable experience has been gained with collection and interpretation of field spectra. Progress in on-going research has encouraged members to embark on significant laboratory analysis programs involving laboratory spectral measurements, biogeochemical assays and metal injection experiments.

PROJECTS PLANNED FOR 1987

Under the coordination of the Working Group, and based on past experience, work will concentrate in the following areas as resources permit:

- Commercial implementation of image analysis and stress parameter methodologies. Initial emphasis will be placed on vegetation reflectance red edge interpretation methodology.
- Expanded investigation of FLI and MEIS for vegetation stress assessment and the analysis of plant and rock spectral characteristics.
- Assistance in the implementation of methods with operational potential on low-cost image analysis systems.
- Incorporation and assessment of SAR data for geological/engineering purposes relevant to Working Group expertise and activities.

5.6 HIGHLIGHTS OF THE REPORT OF THE WORKING GROUP ON ICE

ACHIEVEMENTS DURING 1986

AES Ice Branch:

- Integration and testing of systems and sensors on the new Ice Patrol aircraft was completed. The DASH-7IR (with CAL SLAR-100, Optech laser, and Zeiss camera) went into operation in the Beaufort Sea in July, and patrolled the Gulf of St. Lawrence in the winter of 1986.

- Contract to Miller Communications Systems Ltd. to design and build a system to transmit SLAR/SAR data from ice reconnaissance aircraft to the Ice Centre.

- An airborne imaging microwave radiometer (AIMR) is being built by MPB Technologies Inc., for fall 1987 delivery. It will have dual frequency and dual polarization. It will be used on an Ice Patrol Electra, and will be involved in the SSM/I validation.

Canarctic Shipping Ltd.:

- Contracted Intera's STAR-1 SAR to image 1.6 million square kilometres of the Arctic to produce an Arctic Marine ice Atlas.

Intera Technologies:

- Developed the STAR-2 SAR and integrated it in a Conquest turbo-prop aircraft. This sensor offers a choice of resolution and swath width (including 60 km width).

PROJECTS PLANNED FOR 1987

FIDEX II:

- A multisensor approach to sensing a full ice cover scenario in the Beaufort Sea is hoped for October 1987, probably involving AES (Dash-7IR with SLAR-100, laser, camera), CCRS (CV 580 with SAR, scat., camera), Gulf (surface vessel, STAR-1 or -2), DFO/CRL (dual polarized X-band surface radar), etc.

LIMEX:

- Pilot project for the Labrador Ice Margin Experiment in March 1987 off the east coast of Newfoundland. Participants are AES with four dedicated and four operational SLAR flights, International Ice Patrol with 2 to 4 SLAMR flights, CCRS C-SAR with six transit (en route to Labrador Extreme Waves Experiment), three sea ice, and one iceberg flights, vessel CHS Baffin for surface geophysical observations, NORDA/CRREL radiometers, C-Core/SPRI, JPL, and RADARSAT (initial results are very promising).

SSM/I:

- A validation experiment will be carried out by AES Ice Research and Development after launch of the DMSP satellite in May 1987. Coincident satellite, airborne, and shipborne ice observations will be involved.

5.7 HIGHLIGHTS OF THE REPORT OF THE IMAGE ANALYSIS SYSTEMS AND ARTIFICIAL INTELLIGENCE WORKING GROUP

ACHIEVEMENTS DURING 1986

Copies of the world's first remote sensing CD-ROM, developed by the Methodology Section of CCRS in cooperation with Hitachi Corporation of Japan, were distributed to members of the Group and plans were formulated for a wider distribution to interested users in Canada and elsewhere.

As a result of the group's recommendation, CCRS has clarified its software release policy to allow Canadian industry, government, and universities to exploit the transferred technology on a non-exclusive basis.

Work still in progress includes the preparation of a discussion paper on R&D priorities and strategies for the application of AI to resource management.

While on a trip to Japan, Joji Iisaka collected up-to-date information on writable optical disks and distributed them to some members of the group. WORM (Write Once and Read Many) technologies are now being investigated at CCRS using a 5¼" drive.

Recent communication technology has also contributed in building high speed communication links between micro-computers which have facilitated image transmission between a host computer and the workstations. Due to these complex linkages for both users and systems, standardization of interfaces is becoming more important. Technologies are changing so quickly that the activities of the sub-committee on micro-computing are mainly addressed to collection, evaluation, and forecasting the most recent technologies relating to micro-computer based image analysis, as well as to standardization of the interfaces of these systems.

An Image Analysis Data Base Formats Sub-Committee was formed in 1985 to review and standardize imagery and non-imagery formats and to exchange information on advanced digital storage architectures and advanced software methodologies, as they apply to image analysis systems. They have developed a capabilities matrix of over thirty database formats that are in use in Canada, and have reviewed in detail several of the major formats.

5.8 HIGHLIGHTS OF THE REPORT OF THE OCEANS WORKING GROUP

ACHIEVEMENTS DURING 1986

The Working Group formulated new terms of reference upon completion of the major report "Ocean Satellite Data Opportunities for Canada: A Long-Term View".

The major achievement during 1986 was to coordinate and write the two Canadian oceans-related responses to the ERS-1 Announcement of Opportunity in cooperation with U.S. investigators. Two themes were developed:

1) the use of ERS-1 wind/wave mode data in validating forecast models off the east coast of Canada and the United States;

2) the use of ERS-1 image mode and altimetry data to provide all weather mapping of ocean features such as internal waves, fronts, and current boundaries.

A study of oceanic remote sensing training in oceanographic programs of Canadian universities was completed under Mohammed El Sabh at the Université du Québec à Rimouski. The preliminary conclusions are that remote sensing training in oceanography in Canadian universities is rather thinly spread and that even some of the traditionally strong centres such as the University of British Columbia are in a state of flux.

The lack of educational opportunities for the training of oceanographers in remote sensing is a shortcoming which the Group is presently investigating and which could potentially have a serious impact on the ability to maximize the benefits of Canada's investment in ERS-1.

PROJECTS PLANNED FOR 1987

The Group will concentrate its activities on the development of projects related to the Radar Data Development Program of CCRS.

5.9 HIGHLIGHTS OF THE REPORT OF THE WATER RESOURCES WORKING GROUP

ACHIEVEMENTS DURING 1986

Inland Waters Directorate received two reports from A.J. Robinson & Associates on the Study of Methodologies of Streamflow Forecasting Incorporating Remotely Sensed Data. The first was a literature review. The second focussed on the implementation of operational remote sensing techniques in a streamflow forecasting model (the SSARR model). The techniques interfaced were snow cover extent using density slicing and digital techniques, snowpack water equivalent combining airborne gamma-ray flight surveys with snow course data, and land cover using a pseudo-digital technique.

Alberta Environment continued their demonstration study assessing the utility of computer processed NOAA imagery for snow cover mapping and streamflow simulation using the SSARR model. Lack of resources could limit operational implementation.

Hydrometeorology and Marine Division of AES has been carrying out a study to evaluate the ability of three satellite rainfall estimation techniques to derive daily, weekly and monthly precipitation estimates under Canadian conditions. The Division also conducted research on the determination of snow cover water equivalent using passive microwave radiometry, and contracted with PHD Associates for the development of a turn-key micro-based passive microwave image analysis system. The interactive system will use NIMBUS-7 SMMR or DMSP SSM/I data formatted on floppy disc.

Saskatchewan Research Council initiated a joint study with AES (Saskatoon, NHRC) on "The design of a western Canadian real-time system for integrated forecasting of basin specific floods and low flows". The study includes an examination of the use of remote sensing in integrated forecasting.

An interagency working group involving members of the Water Resources Working Group developed plans for the Prairie snow cover passive microwave validation experiment. The DMSP SSM/I is planned for launch in early 1987.

PROJECTS PLANNED FOR 1987

The hydrological modelling sub-group proposes to prepare a brief discussion paper or brochure which summarizes the state-of-the-art on the use of remote sensing in hydrological models, including discussion of related issues, and to prepare a brief strategy paper which makes recommendations on research, development and technology transfer. The microwave/snow cover sub-group will assist in the co-ordination of the inter-agency SSM/I validation experiment. The main experiment is planned for the 1987/88 winter.

The working group expects to complete the preparation of the slide set and accompanying text on the application of remote sensing to Canadian water resources.

5.10 HIGHLIGHTS OF THE REPORT OF THE WORKING GROUP ON THE PRELIMINARY EVALUATION PROGRAM FOR SPOT (PEPS)

The unique characteristics of the SPOT system and the great interest it has created in the field of remote sensing have prompted the Centre national d'études spatiales (CNES) and SPOT Image to organize a preliminary evaluation program for SPOT (PEPS), of which the primary purpose is to gain a better understanding of how these images can be used in the various fields of remote sensing application. Accordingly, in March 1984, the international remote sensing community was invited to submit suggestions for research projects.

Once the projects were chosen, they were given priority for data acquisition so that researchers could start their work immediately. Moreover, SPOT Image undertook to supply four images free of charge for each project chosen. Finally, to ensure as wide a distribution as possible of the results, an international symposium was planned for about eighteen months after launching of the satellite, or later in 1987.

Of the 132 projects selected, eight are Canadian and one is Franco-Canadian. SPOT was launched in late February 1986 and the first scenes were obtained in early spring. The Canadian researchers who has requested spring scenes (May-June) obtained them directly from SPOT Image. These scenes were recorded aboard the satellite, processed at Toulouse and sent directly. Subsequently, starting in mid-July 1986, the Canada Centre for Remote Sensing (CCRS) was able to record SPOT data in Canada.

Unfortunately, the CCRS did not succeed in developing a system for producing quick-looks at the start of operations, and this has delayed the production of SPOT images considerably. Despite this setback, several scenes ordered for the PEPS projects were delivered by the end of 1986. Nevertheless, the research projects have been seriously held up.

6.0 HIGHLIGHTS OF THE REPORTS OF THE PROVINCES AND TERRITORIES

6.1 HIGHLIGHTS OF THE REPORT OF THE INTER-PROVINCIAL/TERRITORIAL ADVISORY SUB-COMMITTEE OF CACRS (IPTASC)

There was a meeting of IPTASC held on 20-21 October 1986 in Ottawa. The sub-committee was given presentations on present and future remote sensing programs. Also included was a description of a proposal for a new organization which would replace CACRS and IACRS (Interagency Committee on Remote Sensing). It was explained that the new Advisory Council would be much smaller in numbers than the present CACRS and would be a high level group reporting directly to the Minister of State for Forest and Mines, EMR. The members would be appointed by the Minister, with the exception of provincial representatives. In principle, the new Council would not affect the operations of IPTASC. The Chairperson of IPTASC and possibly the Vice-Chairperson would be members of the new Council. In this light it was decided to carry on with established procedure and elect a new Vice-Chairperson. Jeff Whiting of Saskatchewan was elected by acclamation.

IPTASC members met in Ottawa on 21 April 1987 prior to the annual meeting of the Canadian Advisory Committee on Remote Sensing, held at Cornwall 21-24 April, 1987. Ivan Ford from Newfoundland was to become the Chairperson of IPTASC after the annual meeting in Cornwall, and Jeff Whiting of Saskatchewan, the Vice-Chairperson. However Ivan Ford withdrew his membership on IPTASC, and subsequently, the members elected Jeff Whiting as Chairperson. A Vice-Chairperson was not elected. An update on the developments of the new Council to replace the current CACRS was presented. The members emphasized their concern that the proposed provincial membership would result in inadequate input to the Council. The following recommendation was developed during the annual meeting:

- IPTASC recommends that the past Chairperson of IPTASC be added to the new Council to ensure regional representation and a national perspective.

6.2 HIGHLIGHTS OF THE REPORT OF THE MARITIME REMOTE SENSING COMMITTEE (MRSC)

MRSC held five meetings in 1986 and over the year there were a number of personnel changes; Ken Snow became Chairperson and Brent Rowley, Coordinator. The MRSC office was moved from Amherst to Halifax in November, 1986.

A questionnaire was sent to all known industry, university, and government groups involved in remote sensing to develop the database for a regional remote sensing directory, planned for publication in 1987, and annual update thereafter. Publication of the Maritime Remote Sensing Newsletter resumed in 1986 with two issues published.

A subscription for LANDSAT Thematic Mapper microfiche covering Atlantic Canada was placed and an archive is being developed at the Maritime Center for Remote Sensing in Amherst. MRSC is discussing plans for new joint demonstration projects with CCRS featuring SPOT and airborne SAR imagery.

MRSC created an Education Sub-committee in April, 1986, with John Wightman as Chairperson. This group, representing all regional educational institutions with an interest in remote sensing has taken the following initiatives:

- An agreement between the College of Geographic Sciences (COG) and Memorial University to give advanced standing to COG graduates towards a Master's degree at Memorial.

- A proposal for the establishment of a RADARSAT Applications Research and Development Center in the Maritimes.

6.3 HIGHLIGHTS OF THE REPORT OF THE PROVINCE OF ALBERTA

GENERAL

The net utilization of remote sensing in Alberta increased throughout the year. Digital continued to be the primary analysis method, supplanting to a large degree the optical analysis of imagery.

The Tenth Canadian Symposium on Remote Sensing was held in Edmonton. Three hundred and twenty-five persons registered from across Canada and 11 other countries. One hundred and thirty-four technical papers were presented. Thirty-four international displayers occupied 49 booths. The displays were free to the public and viewed by hundreds of persons.

ALBERTA REMOTE SENSING CENTER

The Alberta Center added a digitizing table to its ARIES digital analysis system to permit faster registration of image data to map coordinates and extraction of mapping detail for incorporation within a data set.

In Central Alberta, a storm caused extensive flooding. The Pembina River experienced a peak flow unsurpassed in its history. The flooded area was massive and damage was extensive. LANDSAT data of July 20 was ordered. Within 3 days CCRS provided imagery showing the flood's extent. Within 8 days, the image tape was analyzed to determine the area of flood and compared with ARSC archived 1983 imagery. A report was produced for engineering and hydrologic studies and briefings.

The Center supported remote sensing projects to assess new applications: Use of Helicopter-Borne Impulse Radar to Sound an Ice Jam on the Athabasca River; Remote Sensing of Seismic Lines and Other Disturbances Associated with Oil and Gas Development; and Alberta Rangeland Project - Phase III.

The Center produced four technical information publications: Remote Sensing Winter Wheat Crop Inventory; Remote Sensing of Seismic Lines; 1986 Remote Sensing Newsletter; and the Alberta Remote Sensing Center Review.

The Center's training program incorporated new techniques, and practical and potential applications: Remote Sensing of Ice (with NRC and University of Alberta); MEIS Applications Workshop (with CCRS, CFS, and REAP); Introductory Digital Image Analysis Workshops; technical seminars and lectures at Alberta universities and colleges; remote sensing course, Department of Forest Science, University of Alberta; the Center's display was staffed at many Provincial events.

The Center's ARIES system was in operational at near 100% capacity by multidisciplinary users from Western and Northern Canada. The optical analysis equipment was used to a lesser degree.

OTHER REMOTE SENSING AGENCIES

Alberta Forestry, Lands and Wildlife utilized remote sensing in its resource inventory, mapping, management, and planning activities. Fish and Wildlife Division carried out multidate visual interpretation of TM Color composites for vegetation covertype mapping for wildlife habitat. Public Lands Division continued investigations through MSS and TM imagery enhancements into mixed-grass and fescue rangelands, and Aspen Parkland ecosystems. Resource Evaluation and Planning Division and Alberta Forest Service evaluated various film types and scales for differentiation of hardwood tree species.

Alberta Agriculture, Field Services Division has been evaluating ARIES-processed NOAA imagery to monitor regional green-up and drought conditions in east-central Alberta.

The Northern Forestry Centre (NoFC) participated in an Alberta remote sensing and natural resources mapping pilot project for the Whitecourt test area in cooperation with REAP, AFS, CCRS, PNFI, and ARSC. NoFC is specifically analyzing high resolution MEIS data for generating enhancements to facilitate species discrimination in Mixedwood Boreal Forests, and developing PROCOM-2/LANDSAT depletion mapping techniques. The MEIS study addresses the hardwood differentiation problem.

COMMENTS

SPOT orders have remained unfilled, and failure to provide products or cummunicate problems has discouraged customers.

6.4 HIGHLIGHTS OF THE REPORT OF THE PROVINCE OF BRITISH COLUMBIA

The British Columbia Forest Service and Timberline, a forest inventory consulting firm, continue to use large-scale, fixed base, 70 mm photography for forest classification and sampling and for silvicultural applications.

In August, 1986 the British Columbia Forest Service and CCRS conducted a joint project in the Smithers, B.C. area to evaluate the use of airborne MEIS-II digital data for detecting and mapping mountain pine beetle damage (MPB) and for juvenile stand assessment. Preliminary results of the MPB study indicate that MEIS data clearly shows red attacked trees.

During the 1986 fire season, the British Columbia Forest Service contracted Conair Aviation Ltd. to fly a Daedalus 1268 Infrared Line Scanner for fire detection and fire mapping. The scanner was mounted on a Beech King Air 200 aircraft. A total of three fires were scanned and mapped and 16 missions were flown for fire detection.

The British Columbia Forest Service estimates that $324 000 per year can be saved on fireline mapping of large project fires as well as significant reductions of fire suppression expenditures.

The Ministry of Environment and Parks is completing an assessment of the mapping capability of LANDSAT TM data for mixed wetlands and forest. Preliminary results indicate that the resulting map accuracy compares favourably with existing mapping from fieldwork and interpretation of 1:20 000 aerial photos.

Additional work with other provincial agencies have shown the utility of using TM to map clay alteration zones, and have initiated the assessment of coastal grizzly bear habitat.

The British Columbia Forest Service continues to be very active in the application of both analogue and digital TM data for forest inventory, forest protection and for silvicultural applications. As a Beta Test Site for CCRS' LDIAS system, the Inventory Branch received an upgrade of the LDIAS software in 1986. The Inventory Branch has also integrated its image analysis system with PAMAP Graphics Ltd's microcomputer-based GIS, enabling the download of TM imagery to floppies which can be sent to regional and district offices. Updated forest cover maps can then be returned to the Branch for uploading to the inventory data base.

In 1986, MacDonald Dettwiler and Associates Ltd. launched the new MERIDIAN family of image processing and mapping systems, and several major contracts were signed including image analysis systems for Thailand, India and Australia; an IDIAS ice mapping system for Ice Centre Environment Canada, and a base mapping system for Ecuador. To date there are over 30 MERIDIAN/PC systems installed worldwide.

PAMAP Graphics Ltd. began a research project, to address the general exchange of information problem, specifically allowing a more complete integration of image data with GIS data. A prototype of this system is expected in late spring, with the final system available near the end of the calendar year.

6.5 HIGHLIGHTS OF THE REPORT OF THE PROVINCE OF MANITOBA

ACHIEVEMENTS DURING 1986

The 1986 Manitoba Crop Area Estimation Project was carried out in cooperation with Manitoba Agriculture, Manitoba Remote Sensing Centre (MRSC), and Statistics Canada. Area estimates were compiled for canola, cereal grains, and summer fallow. After carrying out these estimates for four consecutive years it has been well established that the remote sensing methods are equal to the Statistics Canada farm survey techniques with relation to accuracy of data. This work will be discontinued but the remote sensing methods perfected will remain as a viable alternative for crop estimating.

During the fall of 1986, Intera Technologies Ltd. surveyed the communities of Minnedosa, Neepawa, Beausejour, Lac Du Bonnet, Gimli, Virden and Souris with thermal infrared remote sensing. This completes Manitoba Hydro's seven year energy conservation program.

The Remote Sensing Centre carried out 16 projects for government departments and agencies to assist with various aspects of natural resources management.

The ink jet colour plotter acquired by the Remote Sensing Centre was put to good use during 1986. There were 1 500 colour maps produced from classified remote sensing data.

NEW INITIATIVES DURING 1986

A pilot project to inventory wetlands and upland cover types using TM data in S.W. Manitoba was conducted by the Manitoba Remote Sensing Centre and the Manitoba Wildlife Branch. Mapping is to be used for waterfowl habitat inventory and monitoring.

In June and August 1986 remote sensing surveys were flown in the Lynn Lake area. The sensors used were MEIS II and MSS at 20,000' AGL. There was also a low level 5,000' AGL detailed flight over the Farley Lake gold deposit. The purpose is to perfect remote sensing as an exploration option. This is a joint venture between the Manitoba Geological Services Branch, the Canada Centre for Remote Sensing and the University of Manitoba.

PROJECTS PLANNED FOR 1987

Problem Statement

At the request of the South Interlake Land Management Association, PFRA has been asked to provide assistance in the use of conservation tillage techniques at the local farm level. The Winnipeg Soil and Water Conservation Section initiated field work in fall 1986, to obtain ground verification data on existing post-harvest, ground cover conditions. Limited time and funding, as well as, a large project area have necessitated an alternative method for acquiring information on existing tillage practices. Recently, the Winnipeg PFRA regional office approached the Manitoba Remote Sensing Centre with regards to the possible application of remote sensing techniques in identifying crop residue conditions.

The Prairie Farm Rehabilitation Administration has requested an assessment of the land use/land cover for the Pasquia Land Settlement Project based on a September 1981 MSS computer compatible tape.

Plans are being formulated toward developing an operational crop monitoring program as part of Statistics Canada crop estimating procedures. The purpose will be to strengthen the yield prediction methods. It is planned that the Manitoba Remote Sensing Centre will participate in this project.

Status

The Manitoba Remote Sensing Centre is now an operation oriented centre. In Manitoba remote sensing is a proven credible technology that is here to stay with a bright future.

6.6 HIGHLIGHTS OF THE REPORT OF THE PROVINCE OF NEW BRUNSWICK

Spaceborne Remote Sensing

The University of New Brunswick was involved in three satellite remote sensing projects in 1986. These involved using Thematic Mapper imagery to 1) define changes in the Fundy National Park and to 2) compare potato acreage estimates with those using MSS data, and 3) to map linears and curvilinears in the Bathurst area for a number of different purposes.

Airborne Remote Sensing

Four flights were made across New Brunswick to investigate the feasibility of using MEIS for the wide-area mapping of budworm defoliation. A number of technical problems remain due to the large volumes of data involved.

Trial interpretations of the data have been made, making comparisons with existing sketch mapping techniques and 35 mm oblique photography.

New Initiatives

At the time of writing a project was initiated to demonstrate the feasibility of using the C-IRIS radar imagery for operational flood line mapping and ice jam reconnaissance. This year's flood has produced considerable ice damage and the radar imagery showed its ability to identify ice jams and give a synoptic view of the ice movements in a large river basin, like the Saint John River.

During the flood event, helicopters were used to collect video and photographic imagery of local ice jam events. Good coverage of this flood event is now available for research purposes.

Considerable attention was focused through the year on the Federal Space Program and its potential benefits for the province. Strong support was given to the RADARSAT program by way of committing to buy data when it becomes available.

6.7 HIGHLIGHTS OF THE REPORT OF THE PROVINCE OF NEWFOUNDLAND AND LABRADOR

TECHNOLOGY ENHANCEMENT PROGRAM

A Memorandum of Understanding between CCRS and the Department of Development and Tourism was signed in June, 1986 and the Technology Enhancement Program (TEP) got underway with the installation of an ARIES III image analysis system at NORDCO Limited. The main focus of the TEP has been six demonstration projects selected to illustrate a range of remote sensing applications to resource managers.

Seven courses in remote sensing and digital image analysis were given during the year as part of the TEP. In December, a two day workshop on forestry applications was held in Corner Brook, with over 30 people attending. Numerous presentations and demonstrations of the ARIES system have been given to representatives of government, industry, colleges and universities, both from Newfoundland and from outside Canada. Two graduate students from Memorial University have undertaken part of their thesis work using the ARIES system, with assistance from the TEP.

The initial projects should be completed during 1987 and a number of additional projects are now being considered. More short courses will be offered workshops; the next, dealing with geological applications, is planned for early in the new year. The TEP is scheduled to conclude at the end of March 1988.

Academic programs in remote sensing are available at Memorial University of Newfoundland in complementary offerings by the Faculty of Engineering and Applied Science and by the Department of Geography in the Faculties of Arts and Science. Undergraduate courses are available for credit towards B.Eng., B.A. and B.Sc. degrees, and graduate courses are offered in the M.A., M.Sc. and M.Eng. and Ph.D. programs.

In Engineering, 2 undergraduate and 3 graduate courses are offered, and facilities include a well-equipped remote sensing laboratory with optics, a scanning microdensitometer, a VP-8 image analyzer (Analogue) and a NORPAK image analysis system (digital). The lab is supported with a photographic processing facility which is fully integrated into undergraduate and graduate teaching primarily for electrical engineering students, but including biology, geography, earth science and forestry students (about 35 per semester).

In Geography, 2 undergraduate and 2 graduate courses are offered to students primarily in the Physical Geography and Cartography options. Principal support originates in the Memorial University of Newfoundland Cartographic Laboratory (MUNCL) which has a spatial data processing capability extending into the areas of geographic information systems and digital image processing. Students also may obtain access to an ARIES III image analysis workstation installed at NORDCO Ltd., a private research company in St. John's.

In summary, from initial responses by participants of the TEP, the future of remote sensing in Newfoundland looks positive. Our major problem appears to be in the uncertainty associated with collecting satellite data over the Province. The high frequency of cloud cover limits the possibility of collecting data from optical sensors. Hopefully RADARSAT will get government approval and solve this problem.

6.8 HIGHLIGHTS OF THE REPORT OF THE NORTHWEST TERRITORIES

ACHIEVEMENTS DURING 1986

The Department of Renewable Resources, Government of the Northwest Territories carried out several projects using remote sensing techniques in 1986.

A four year study to classify and inventory habitat in the Mackenzie Bison Sanctuary, N.W.T. was completed. This work will be published in 1987.

A study was carried out to census post-calving aggregations of Bluenose barren-ground caribou using radio telemetry and aerial photography.

In a pilot project, LANDSAT imagery was used to make predictions about habitat use by grizzly bears on Richards Island, N.W.T.

NEW INITIATIVES DURING 1986

The Department of Renewable Resources initiated a study to determine the feasibility of using remote sensing to identify potential falcon breeding habitat in the Northwest Territories. This project is to be completed in 1987.

As part of a two year resource inventory of Auyuittuq National Park Reserve on Baffin Island, visual interpretation of black and white aerial photographs and LANDSAT MSS images was used to classify biophysical map units.

PROJECTS PLANNED FOR 1987

Discussions are presently underway with CCRS to bring the Technology Enhancement Program (TEP) to the Northwest Territories beginning in the fall of 1987.

A variety of demonstration projects will be initiated once the TEP is in place in Yellowknife.

6.9 HIGHLIGHTS OF THE REPORT OF THE PROVINCE OF NOVA SCOTIA

In late 1986, all remote sensing activities of the Maritime Resource Management Service (MRMS) were consolidated and moved to newly renovated quarters at MRMS head office in Amherst, N.S. The result of this consolidation was the creation of the Maritime Center for Remote Sensing; an operational Remote Sensing center serving all of Atlantic Canada. The Center supports all digital and conventional remote sensing image analysis and interpretation, air photo processing and production, map and database compilation, a remote sensing library, Maritime air photo archive, and a free access microfiche archive of Thematic Mapper scenes for Atlantic Canada maintained by the Maritime Remote Sensing Committee.

The Department of Lands and Forests is continuing to monitor forest clear cuts. While LANDSAT MSS has not been reliable in monitoring clear cuts, in agriculture areas TM data has been successful. The Department hopes to use radar imagery for monitoring forest activity by means of a broad classification. A pilot project has been started. While awaiting SPOT imagery on a regular basis, simulations at 20 m resolution have been tested using the MEIS sensor.

Formerly known as the Nova Scotia Land Survey Institute, the College of Geographic (COGS), maintains a high level of activity in remote sensing. A class of 14 graduates completed their studies in August. The majority of these had secured employment by the end of the year and it is anticipated that all the class will be working by April of 1987. A new group of similar size was enrolled in September and by year end devised a broad range of cooperative projects with external agencies from across Canada.

In early March, through the cooperation of OCRS and CCRS, Mr. Vernon Singhroy conducted a two-day workshop entitled "Developments of Spectral Geobotany to Mineral and Hydrocarbon Exploration in Canada". This workshop was well attended by students and a good representation from government departments and private industry.

In late March COGS assisted in the organization of a special meeting of parties involved in remote sensing training and education in Canada. The resulting agency formed is known as the Canadian Remote Sensing Training Institute (CRSTI). COGS has a representative on the Board of Directors.

6.10 HIGHLIGHTS OF THE REPORT OF THE PROVINCE OF ONTARIO

The Ontario Ministry of Agriculture and Food (OMAF) continued to work toward a GIS for crop inventory. The Ontario Centre for Remote Sensing provided them with LANDSAT-derived crop rotation maps, and tested TM data for detecting changes in agricultural land use.

The Photogrammetry and Remote Sensing Section of the Ministry of Transportation and Communications contracted over 4 000 line-km of black and white and CIR aerial photography for mapping, mosaic compilation and remote sensing studies.

The Ontario Centre for Remote Sensing program of airborne and spaceborne remote sensing research, development and training included:

- geobotanical investigations for mineral exploration: correlation of ground spectral measurements, laboratory spectral readings and mineral content analysis of leaf ash, with airborne data from MEIS II and FLI scanners;
- preparation of LANDSAT-derived forest fuel maps for integration into a forest fire control GIS data base;
- testing of LANDSAT TM data for forest regeneration assessment;
- testing of LANDSAT TM data for change detection in agricultural land use and forestry;
- preparation of LANDSAT-based crop rotation maps as input to OMAF crop inventory GIS;
- continuation of work toward integration of LANDSAT data analysis with a GIS data base of the Ontario Geological Survey.

The Faculty of Forestry of the University of Toronto made improvements to the university's four-camera video sensor, and conducted video imaging application development projects.

A number of Ontario companies were active in remote sensing application and technology development.

Dendron Resource Surveys Ltd. continued airborne laser research with reference to biomass estimation and scanning lasers.

Gregory Geoscience Ltd. continued a major program of topographic map revision based on remote sensing data, used TM images to input forest clearcut information into a digital FRI data base, and used SPOT-1 data to define new streets at 1:50 000 scale.

Horler Information Inc. purchased a DIPIX ARIES II system and developed image processing software for analyzing MEIS II imagery for vegetation stress.

Moniteq Ltd. conducted a major program of image acquisition and analysis in Europe with Programmable Multispectral Imager, partly funded by the Ontario Ministry of the Environment.

PCI Inc. began developing software toward the creation of a system for processing airborne scanner imagery.

Ph.D. Associates Inc. used passive microwave data from the Scanning Multichannel Microwave Radiometer aboard the NIMBUS-7 satellite to study sea ice, wind speed and rain rate over open ocean, and snow-water equivalent and soil moisture over land.

A.J. Robinson and Associates Inc. employed LANDSAT data in land cover analysis and gamma ray surveys in snow-water equivalent studies and NOAA-7 imagery in snow cover mapping.

Télédétection International employed both LANDSAT TM and SEASAT data for the geological interpretation of an area in Quebec.

6.11 HIGHLIGHTS OF THE REPORT OF THE PROVINCE OF QUEBEC

ACHIEVEMENTS AND NEW INITIATIVES DURING 1986

Expansion of research and educational capabilities

In 1986, several new researchers in the field of remote sensing joined the teams of Sherbrooke and Laval universities. At the same time, digital processing units in educational research institutions increased substantially in number and diversity.

Research and development application projects

Many research and development projects were carried out in a variety of fields of application, including forestry, agriculture and geology.

Much of the methodological research and development work completed or under way has used LANDSAT TM data. In 1986, however, Quebec embarked upon actual SPOT projects and continued preparing for the future with a number of studies on the potential of RADAR imagery.

International involvement

All agencies participating in this report are involved in the international PEPS program and/or the PUIS program in Quebec (Programme d'utilisation des images SPOT au Québec [Program for the use of SPOT images in Quebec]), which comes under France-Quebec technical co-operation.

Besides these two programs, there are several projects involving co-operation and technology transfer with various countries: these are implemented by the CARTEL centre and the DIGIM corporation.

Development of image processing systems on microcomputer

There was much progress in 1986 in the development of software for digital processing on microcomputer. The Octographe corporation is preparing to market two versions of a system on microcomputer: Octimage (the basic system) and Graphimage (a more elaborate system).

PROJECTS PLANNED FOR 1987

The year 1987 should see the start-up of research and projects based on SPOT data.

The use of image processing systems on microcomputer could become increasingly widespread.

6.12 HIGHLIGHTS OF THE REPORT OF THE PROVINCE OF SASKATCHEWAN

ACHIEVEMENTS DURING 1986

Saskatchewan investigators conducted a vigorous program of airborne projects in the following areas: migratory bird habitat and population, data gathering for radar support, forestry, agriculture (irrigation, salinity, plant ecology, fertility). The agencies involved in the airborne activities include the Canadian Wildlife Service, Saskatchewan Water Corporation, Saskatchewan Institute of Pedology, Saskatchewan Parks & Renewable Resources, Ponteix Water Users Association and Saskatchewan Agriculture.

Canadian Wildlife Service studies include continued analysis of the value of prairie habitat in support of the North American Waterfowl Management Plan. The co-operating agencies are Lands Directorate, U.S. Fish & Wildlife Service, and Saskatchewan Parks & Renewable Resources with negotiations underway for Ducks Unlimited to join.

The results from the completed STEP projects are as follows: Deer Habitat Project (SPRR) - the Terrestrial Wildlife Habitat Inventory benefit/cost of using digital methods is at least 4:1 with varying accuracy in the five classes assessed (general accuracy - 82%); the Moose Habitat Project (SRC) overall accuracy varied between 60% and 98% depending upon the class (treed bog to water); the Burns and Cut-over Inventory (SPRR) burn accuracy was 99% compared to the fire inventory map with 18% geo-referencing error. The cut-over accuracy on individual cuts varied from 63% to 100% with geo-referencing errors of 91% to 7% depending upon the size and date of the cut. Therefore MSS burn assessment could replace present SPRR inventory procedures. The benefit/cost ratio was assessed to be 5:1.

The digital system on loan from CCRS has been very successful and demand for its use is high. Some 120 people have been trained in its use.

The Saskatchewan Research Council has been active in the following areas: geology, agriculture and hydrology. A cooperative project was initiated with France (INREA) on image analysis applied to Integrated Investigation of Mineral Exploration Data. New feature and theme maps were generated such as magnetic vertical gradient as a variant to economics or terrain. In another joint project with Saskatchewan Mining and Development Corp. and Mollard & Assoc., structural assessment of the Swift Current petroleum area was made with TM data. Additional assessment was also carried out in the Estevan area for petroleum reserves and gold in the La Ronge area under contract. The lineament structure in the Athabasca sandstone formation was also assessed to determine whether lineament caused the dis-jointed drainage pattern.

Tamarack Resources has been very active in both airborne and satellite contracts in support of environmental impact assessment, wildlife and agricultural studies. Saskatchewan Mining & Development Corp. (SMDC) has been involved in research of regional geological structures in Northern Saskatchewan.

PROJECTS PLANNED FOR 1987

Forest Fire Control (SPRR) is cooperating with SED Systems, CCRS and SRC into the feasibility of using near-real time NOAA data to find forest fire hot spots.

National Hydrology Research Institute (newly established in Saskatoon) is looking at the use of NOAA and NIMBUS for snow melt studies. In particular looking at the gradient from moist to dry ground.

STATUS

It is anticipated that the use of the remote sensing data in the province will double again during the next year (as it did from last year to this). The continued growth into 1987 will be uncertain until the STEP follow-on program is actually up and running.

6.13 HIGHLIGHTS OF THE REPORT OF THE YUKON TERRITORY

The Yukon Forestry Service initiated a project to attain 1:40 000 B/W IR coverage of the Yukon Territory south of 64° latitude.

They used LANDSAT to map fire distribution during the 1986 fire season onto existing cover maps, and are investigating using LANDSAT (MSS) imagery to assign fire hazard ratings to forest types. TM and SPOT are considered to provide more detail than necessary.

The Canadian Wildlife Service are using LANDSAT (MSS) to classify and map vegetation north of the tree line. In the summer of 1986 they surveyed 400 vegetation plots (visual classification), concentrating on distribution of willow.

The Prospector's Association have established a facility in Whitehorse for analysis of digital satellite data in conjunction with CCRS.

The Wildlife Branch (YTG) and the Department of Geography, Saskatchewan are using MSS and TM data to prepare moose habitat maps. Dr. D. Gauthier is conducting the study at the University of Regina.

Whitehorse Lands, Parks and Resources held a Remote Sensing Workshop sponsored by Renewable Resources and in conjunction with CCRS. The three day workshop on remote sensing applications featured a hands-on demonstration using a Perceptron Image Analysis System.

PROJECTS PLANNED FOR 1987

Ducks Unlimited and Wildlife Branch (YTG) propose using TM imagery to map and classify wetlands in Needle Rock area of Yukon, between Pelly and MacMilan Rivers along the Tintin Trench.

Agriculture Canada plans to map soil associations for the entire Territory at 1:1 000 000 scale using LANDSAT imagery. This project is part of a Canada wide effort being spearheaded by the Land Resource Research Centre (Ottawa). LANDSAT will be used where data is non-existent.

7.0 HIGHLIGHTS OF THE REPORTS OF THE SPECIALTY GROUPS

7.1 HIGHLIGHTS OF THE REPORT OF THE ATMOSPHERIC ENVIRONMENT SERVICE, ENVIRONMENT CANADA

ACHIEVEMENTS DURING 1986

The Ice Research and Development Division was transferred to the Centre for Research in Experimental Space Science at York University. The objective is to create a world-class centre of expertise in the use of microwave data from satellites in the study of the atmosphere, oceans, ice, and snow.

As part of a study of the relationship between remotely sensed data and hydrological models, special snow cover analysis of a portion of the Saint John River Basin covering the melt periods of 1984 and 1985 was carried out in 1986. Multispectral data from the NOAA satellite were analyzed using the divisions supervised digital classification scheme.

Equipment and software to receive data from the GEOS Data Collection System (DCS) were installed in Downsview and Vancouver. Both became operational in 1986.

A Meteorological Satellite Information System (METSIS) trial system was installed, consisting of one uplink at Downsview and 9 receiver sites across the country as Phase I. This system will receive bulk data from the Canadian Meteorological Centre (CMC) and the Satellite Data Lab (SDL), and weather charts from Ontario Region and distribute it using 56 kbps channels to receive-only earth stations.

NEW INITIATIVES DURING 1986

TOVS soundings produced from direct readout data in Toronto were sent to the Maritimes Weather Centre in Halifax for real-time evaluation during the Canadian Atlantic Storms Program (CASP) field experiment from 15 January to 15 March 1986. The soundings were produced using a statistical algorithm with locally generated regression coefficients based on simulated measurements. It is planned to make retrievals available for testing in numerical models during the coming year.

A comprehensive plan to validate the Special Sensor Microwave Imagery (SSM/I) sensor to be launched on a DMSP satellite in 1986 was completed.

The AES initiated a study on the options available to continue acquiring GOES data when the first in the next series of satellites is launched in mid-1986. The GVAR data format which will be associated with this GOES-Next series will require extensive changes to current AES GOES facilities.

PROJECTS PLANNED FOR 1987

The system to archive GOES data is in place and operational. The routine archiving of GOES-E data will commence with the launch of the new satellite which is expected in February, 1987. Visible and infrared data are archived every three hours for the full disk at 8 km and 32 km resolutions. Limited areas over southern Canada will be archived in full resolution during daytime hours. AES is designated as the sector processing centre for GOES-E as part of the WMO ISCCP.

The existing HRPT processing systems at Toronto and Edmonton are being replaced with state-of-the-art processing facilities. These facilities will be fully automatic, and allow direct digital and analog output on a number of ports. These facilities will be connected to the new satellite-based distribution system developed by AES' Computer and Communications Services Branch. This will allow direct broadcast of the data to users. Delivery of the two readout systems is expected in the autumn of 1987.

Technial definition studies will be completed for the AES GOES-Next data acquisition facilities.

7.2 HIGHLIGHTS OF THE REPORT OF THE LANDS DIRECTORATE, ENVIRONMENT CANADA

ACHIEVEMENTS DURING 1986

The Canada Land Use Monitoring Program continues to be one of the Directorate's major users of remote sensing. A project undertaken in 1986 to detect land use change along the agriculture-forest interface has focussed on the establishment of a consistent and reliable methodology for visual interpretation of LANDSAT Thematic Mapper (TM) imagery. A revised rural land classification system and user manual have been developed and tested (Canadian Land Use Monitoring Committee 1986). While only 10 TM images have been used to date, the Directorate is in the process of acquiring up to 100 more scenes in the April 1987 period to support this project.

The Land Use Monitoring Division initiated an integrated land use study of the St. Croix basin in New Brunswick using TM imagery.

The Directorate is cooperating with the Nova Scotia College of Geographic Sciences to conduct evaluation of SPOT imagery. A SPOT scene of the Truro, Nova Scotia area has been acquired. This project is also involving the Maritime Resource Management Service, the Nova Scotia Department of Municipal Affairs, and ACASI. Cooperative research with the College of Geographic Sciences continues including a study of the use of TM imagery for targetting areas at risk to soil erosion in the Montague River basin of PEI. A second project is evaluating TM imagery for establishing soil loss parameters related to vegetative cover and land management practices of the Wilmot Watershed in PEI.

Another major cooperative study has been completed entitled "Rural Land Use Project" between the Directorate and the Business Survey Methods Division of Statistics Canada. This project has focussed on development of methods for study in rural Manitoba. It has applied the national land over classification system and data for Manitoba. These data have formed the basis of a national land cover association map, currently in production jointly with the National Atlas Group, Geographic Services Division, Energy, Mines and Resources Canada. Acquisition of all data for this land cover project involved visual interpretation of over 1 000 LANDSAT MSS images with a detailed aerial photo validation methodology.

A major operational evaluation of LANDSAT-TM data for monitoring wetlands and associated land uses has been completed by BC Research jointly for the Lands Directorate and the Canadian Wildlife Service. This project has indicated that TM data for detailed wetlands and ecological monitoring is best utilized in a visual interpretation system using specially processed imagery.

A joint research project for counts and measures assessment of aquatic resources at risk in Quebec and Nova Scotia due to acid rain impacts is currently under development with Ducks Unlimited. Digital image analysis of selected TM scenes is expected to begin in about May 1987.

7.3 HIGHLIGHTS OF THE REPORT FROM THE INSTITUTE OF OCEAN SCIENCES, SYDNEY, B.C., FISHERIES AND OCEANS CANADA

Airborne Remote Sensing

The FLI imaging spectrometer has now shown the capability for mapping water surface chlorophyll distributions using the fluorescence signal at 685 nm. Observations over land have shown the value of its high spectral resolution, flexible spectral properties and high sensitivity for geobotany and forest type and stress classification.

A workshop was held in Ottawa to present results of the FLI programme and to discuss future work towards a space version of the instrument through new ESA initiatives. A joint sensor design study is being proposed by Moniteq and MBB of Germany.

Planned operation of the FLI in 1987 include British Columbia in late April as part of a DFO study on Marine Salmon Survival in Barkley Sound on the west coast of Vancouver Island.

Spaceborne Remote Sensing

One of the limitations of using satellite imagery in ocean research has been in transmitting satellite images, or maps derived from them, directly to ships at sea. The value of such real time data for research on jets of coastal surface water that have moved offshore, was demonstrated in 1986 using currently available communication links. Improvements are planned in 1987 using broader band digital links and simple direct (APT) satellite reception on board ship.

AVHRR imagery of the west coast was acquired in 1986 from both the UBC receiving station and the AES Edmonton station. This was used in a variety of physical and biological studies, showing the surface thermal patterns associated with mixing and upwelling.

Analysis of AVHRR imagery showing deformation and movement of Arctic ice patterns, continues using the correlation software developed on the image processor. Another project uses AVHRR imagery to examine ice movement near break-up in the summer that may correlate with under-ice acoustic spectral intensities. The goal is to discover an acoustic signature that will give warning of break-up.

Future Programs

A coordinated proposal was submitted to ESA to make use of radar imagery and other data of Canadian coastal waters, from the European ERS-1 satellite scheduled for launch in late 1989. Other sources of satellite data that are being examined include cloud cover from geostationary satellites and wind, wave and altimetric data from the U.S. GEOSAT.

7.4 HIGHLIGHTS OF THE REPORT OF THE PETAWAWA NATIONAL FORESTRY INSTITUTE

Application of airborne sensors will play an important role in the mapping and monitoring of Canada's forests in the future. Efforts at PNFI are concentrating on research necessary to develop forestry applications of linear array imager technology. The applications envisaged are: forest inventory mapping (as an alternative to aerial photography), insect and disease mapping and sampling, and forest inventory update. The high resolution, good radiometric quality and stereo capability of such sensors permit such applications to be possible. It is recognized that considerable applications research, processing and interpretation methodology and hardware development, and technology implementation must take place. As well, a new sensor system, with high spatial resolution and capability for a wide swath, must be developed in order for applications to be practical on an operational basis. Development of high throughput systems for geometric correction processing, a critical function, is needed.

PNFI is also investigating other airborne sensor technology such as infrared fire detection sensors, imaging spectrometers (Fluorescence Line Imager), combinations of radar/multispectral scanner data, and lidar systems for stand height and volume estimation. A program for developing satellite change monitoring systems is continuing.

Investigation of MEIS imagery for species discrimination in Alberta [a cooperative project with the Northern Forestry Centre, Alberta government (Resource Evaluation and Planning and Alberta Forest Service), and CCRS] has produced good enhancement for different species. Studies investigating linear array imager data for insect damage, stand height estimation and regeneration assessment are in progress. Analysis of field spectrometer data of individual trees has identified spectral bands appropriate for discriminating levels of spruce budworm defoliation. Narrow, well placed bands are important for detecting current defoliation. MEIS filters will be manufactured and tests of capabilities for assessing damage conducted.

Combined airborne radar/MSS data set was completed and analysis of the synergism of radar and visible/infrared data for forestry mapping has commenced. Radar data adds some useful information regarding softwood species discrimination.

A database of forest change for a seven township test area in eastern Algonquin Park was created and input into an ARC/INFO Geographic Information System. All areas of harvesting and planting from 1940 to present are included. This database will form the basis of a test area for developing satellite based change detection methods.

Several surveys of provincial inventory requirements and procedures were initiated. A compilation of forest inventory update requirements and procedures relevant to remote sensing and a survey of forest inventory map production procedures are being conducted.

The Fire Management Systems group, in cooperation with the Société de Conservation de l'Outaouais, the Quebec Ministry of Energy and Resources, CCRS, and Bomen Ltd. (Quebec City) are presently developing a design for an inexpensive (approximately $50 000) airborne non-imaging infrared forest fire detection instrument. The main use of the instrument will be to provide detection capability during critical fire situations when poor visibility caused by smoke and haze cause the grounding of conventional visual detection aircraft. Assuming suitable funding, construction of prototypes could begin during 1987.

7.5 HIGHLIGHTS OF THE REPORT OF THE SURVEYS AND MAPPING BRANCH, EMR

The Topographical Survey Division of the Surveys and Mapping Branch has been actively using LANDSAT imagery to receive 1:250 000 topographical maps and to monitor changes on 1:50 000 maps since 1980. This approach has not only been extremely cost effective but has made it possible to update in a few years over one fifth of all the 1:250 000 maps, a task that had been almost impossible before by conventional methods. Approximately 90% of this work is done on contract.

The trust of the Branch's R&D in remote sensing is directed toward the use of satellite data for the revision of topographic maps. A number of investigations or research projects have been undertaken towards that goal.

In 1985, the Surveys and Mapping Branch and the Institut Géographique National (IGN) of France signed an agreement to promote scientific and technical exchanges are are carrying out joint experiments with the following objectives:

- test the content of SPOT images in relation to 1:50 000 and 1:250 000 map specifications to determine accuracy of feature identification.
- test the planimetric accuracy of stereoscopic SPOT images.
- test the height accuracy of stereoscopic SPOT images.

It is planned to report the results of these experiments at a Colloquium especially organized for this in the spring of 1988 in Ottawa, however unless the needed SPOT data can be obtained early in 1987, it may not be possible to complete the experiments in time for a Colloquium to be held then.

The Surveys and Mapping Branch will also study the potential of SPOT images for topographic mapping and the revision of topographic maps at the scales of 1:50 000 and 1:250 000 through SPOT IMAGE's PEPS program. The methods and the instruments that will be used will be different from that used with the IGN, thus providing a comparison between different approaches to using SPOT data. As with the joint project with IGN, lack of data has seriously delayed this investigation.

Research toward semi-automated map revision will continue in 1987 with the integration of higher resolution SPOT imagery which may be suitable for the revision of some 1:50 000 maps. Airborne imagery such as that from the MEIS II scanner is also being investigated.

7.6 HIGHLIGHTS OF THE REPORT OF STATISTICS CANADA

ACHIEVEMENTS DURING 1986

Area estimates of potatoes were produced using LANDSAT Multispectral Scanner (MSS) data for both Prince Edward Island and New Brunswick. Potato area estimates were also made from a back-up airphoto project as cloud cover in previous years resulted in LANDSAT being somewhat unreliable for the work in Atlantic Canada.

Area estimates of major grains, summerfallow and rapeseed were produced for Manitoba and selected agricultural districts of Saskatchewan and Alberta. Again the work was accomplished through digital processing of LANDSAT MSS data.

NEW INITIATIVES DURING 1986

Some work was undertaken to investigate what have been called Uniform Productivity Areas (UPA's) in support of a joint research initiative by the Canada Centre for Remote Sensing and Agriculture Canada.

PROJECTS PLANNED FOR 1987

A major new intiative is being undertaken in an effort to establish a remote sensing program to monitor crop conditions and possibly provide crop yield estimates. The initial objective of this project is to provide timely statistical data on crop conditions using objective analytical methods with the final goal to supplement or replace conventional yield surveys. The first stage of the project is to establish an operational program by the summer of 1988 to provide qualitative information on crop conditions to compliment the current survey program. Planning for the subsequent stages will await the results of the developments from the first part of the project.

STATUS

The year 1986 was a period for review and evaluation of Statistics Canada's crop area estimation projects. From our Agency's point of view there were three drawbacks to current remote sensing technology, (1) project costs are high, (2) there is still much technical and scientific development work to be undertaken and (3) the available data is not yet complete enough to meet all the data needs concerns, the long-term benefits are real and we plan to continue our remote sensing program, although there will be a change in emphasis.

Area estimation will not be the focal point for research and development as it was in the past and program emphasis will be directed towards developing operational crop monitoring and yield estimation programs.

8.0 HIGHLIGHTS OF THE REPORTS OF THE REMOTE SENSING SOCIETIES

8.1 HIGHLIGHTS OF THE REPORT OF THE CANADIAN REMOTE SENSING SOCIETY

INTRODUCTION

The Canadian Remote Sensing Society (CRSS) functions to serve the interests of individuals and organization interested in various aspects of remote sensing in Canada. To do so, it produces the Canadian Journal of Remote Sensing, and co-sponsors the Canadian Remote Sensing Symposiums.

THE CANADIAN JOURNAL OF REMOTE SENSING

Currently, the Journal is published twice a year and averages five to eight articles per issue. The technical quality of the published papers is excellent, augmented by the exhaustive review process. The major complaints are 1) the lack of color plates to illustrate articles; b) the number of issues per year is considered too low, and c) the small number of papers actually submitted to the editor for consideration for publication. The rebuttals for these complaints suggest a) color plates are too expensive to include in the publication; b) more issues per year would cause an additional drain on society finances, and c) there are not enough submissions to the editor to warrant more than two issues per year. The Executive of the Society is currently examining the question of more issues of the journal.

THE CANADIAN REMOTE SENSING SYMPOSIUMS

1) The 10th Symposium: Edmonton, Alberta, May 1986

   Technically, logistically, socially, and publicly, the 10th Symposium was a smashing success. In the words of the organizers and the attendees it was a First Class Symposium. All those associated with the symposium are congratulated on their efforts. The symposium ran a $6 000.00 shortfall which was underwritten by CRSS and CASI.

2) The 11th Symposium: Waterloo, Ontario, June 22-25, 1987

   With the theme of "Education for the Future", the 11th Symposium is due to be held at the University of Waterloo, June 22-25, 1987. Over 150 papers have been selected to be presented verbally or seen as poster papers. Similar to past Symposium, all papers will be reviewed prior to publication of the symposium proceedings.

3) The 12th Symposium: Vancouver, British Columbia, July 1989

   The 12th Symposium will be a joint symposium in association with IGARSS (International Geographic and Remote Sensing Society) and will be held on the University of British Columbia Campus, July 10-14, 1989. IGARSS has a policy of printing proceedings prior to the symposium and distributing them at the time of the Symposium. The implications of this policy are due for further discussion by CRSS Executive.

GOLD MEDAL AWARD

The first remote sensing Gold Medal Award was given out at the 10th Canadian Remote Sensing Symposium. Dr. Larry Morley received it in recognition for a career of achievements in remote sensing. Our congratulations go out again to Dr. Morley.

PLANS FOR THE FUTURE: (Under Discussion)

1) There is a 2-year gap between the 11th and 12th Canadian Remote Sensing Symposium - which is perhaps too long. Discussions will be undertaken to set a more appropriate interval, and perhaps have symposiums on an annual basis.

2) Symposium proceedings should cease to be reviewed, and should be published prior to the Symposium.

3) It is highly desirable to reduce the cost of the Symposium.

4) It is highly desirable to increase the number of issues of the Canadian Journal of Remote Sensing to a minimum of four per year.

5) It is highly desirable that membership in the Society be increased.

8.2 HIGHLIGHTS OF THE REPORT OF THE ONTARIO ASSOCIATION FOR REMOTE SENSING

ACHIEVEMENTS DURING 1986

Three informative and well attended program meetings, dealing with subjects of Sea Ice, the integration of remote sensing data with GIS, and SPOT data acquisition and analysis were held during 1986.

PROJECTS PLANNED FOR 1987

Program meetings dealing with CCRS initiatives with the 'private sector', micro computer applications in image analysis, and international remote sensing activities and experiences, are planned through 1987. OARS will also be a co-sponsor of the 11th Canadian Symposium on Remote Sensing.

STATUS

The objectives of the Association are being met as is borne out by the continued interest and support of its members.

9.0 HIGHLIGHTS OF THE REPORTS OF THE UNIVERSITIES

9.1 HIGHLIGHTS OF THE REPORT OF THE UNIVERSITY OF ALBERTA

The Alberta Centre for Machine Intelligence and Robotics (ACMIR) was established at the University of Alberta in 1986 although a final funding proposal has yet to be accepted. Activities within the Centre are organized in four working groups: computer vision, intelligent systems, robotics and control, and integrated manufacturing. The Centre has members from the departments of computing science, electrical engineering, mechanical engineering, chemical engineering, psychology, applied science in medicine and others. The combined facilities for research and course listings of all these departments are far too extensive to be listed in this report. It is sufficient to note that a relatively large proportion of effort expended by members of the Centre is in the area of image analysis/processing.

The ACMIR publishes a monthly newsletter of upcoming events and recent acquisitions. Further information is available from the ACMIR Office, Biological Sciences Building, University of Alberta, Edmonton, T6G 2E3.

Environmental/resource based remote sensing activities continue in several departments across the university community including geography, geology, computing science, civil engineering, forest science, and soil science. Course offerings within these departments cover the concepts and techniques of particular interest and application within specific departments and programs. During 1986 there were approximately 25 graduate students working on image processing and/or remote sensing related research projects. The resources available range from optical equipment, through smaller stand-alone systems for digital analysis, to the university's mainframe facility.

During the past year attention has been given to the acquisition of micro-based image processing and spatial analysis systems. Many departments are developing a georeferenced thrust to research programs.

Although no formal coordinating body exists on campus to oversee all activities there has been considerable contact and cooperation between the various individuals, groups and departments concerned with remote sensing. This is evident by the sharing of resources, both physical and human, that takes place.

Mention should also be made of the many remote sensing activities and programs at a variety of post-secondary institutions across Alberta. Colleges and Institutes of Technology as well as other Universities (Calgary, Lethbridge) provide educational opportunities in this area. Their contributions should be recognized.

Major concerns of the academic community centre on the cost and availability of imagery (airborne and particularly satellite data) and the uncertain future of funding at the national level.

9.2 HIGHLIGHTS OF THE REPORT OF THE UNIVERSITY OF BRITISH COLUMBIA

GENERAL

The UBC Remote Sensing Council members coordinate graduate programs with a specialty in remote sensing which lead to either Master's or Ph.D. degree in Computer Science, Electrical Engineering, Geography, Geophysics and Astronomy, Forestry, Oceanography or Soil Science. Candidates enter the graduate program by admission as a Master's of Ph.D. candidate in one of the Departments, through the Faculty of Graduate Studies. Senior undergraduate and graduate level courses in various aspects of remote sensing are offered in each Department. The interdisciplinary approach to courses and research is encouraged. Currently there are nine Faculty members, over 30 graduate students, and seven Departments involved in remote sensing activities.

RESEARCH

Remote sensing research both by Faculty and graduate students is the heart of the remote sensing activities at the University of British Columbia. Research facilities are located across campus and currently there are seven laboratories which are dedicated to remote sensing image analysis and GIS activities. The facilities include:

a) the Laboratory for Computational Vision (LCV) in Computer Science;
b) the Satellite Oceanographic Laboratory in Oceanography;
c) the Electrical Engineering Laboratory;
d) FIRMS in the Forestry Remote Sensing Laboratory;
e) GIS in the Geography Laboratory;
f) a GIS-PMAP facility in Soil Science, and;
g) the Geophysics and Astronomy image Laboratory.

There is a strong interaction among the Faculty members and cooperative use of equipment by students from various departments. Networking has been used to link various labs, and currently, images, maps, and DTM's are regularly transferred between the LCV and FIRMS (both ways). Research studies range from theoretical development of remote sensing technology (including image analysis and sensor development) to specialized applications of remote sensing (including vegetation and land use analyses, GIS to meteorological and oceanographic studies). Unique facilities include the satellite tracking station in Oceanography, the Optronics C-4500 film scanner and writer in the LCV, and the network connections between laboratories.

CONCERNS

Our major concern rests with the uncertain funding picture that has currently emerged at the federal level, and the emphasis on research proposals by industrial participants.

We would like to express our regret at the demise of the CCRS airborne program since it was a necessary component of several research programs and these studies has to be terminated.

Research grants for "applications" projects are so small that they cannot afford the current private industry fees for collection of airborne data.

We foresee increasing emphasis on "space-station" style remote sensing. Every effort should be made by CCRS to support, and encourage cooperative remote sensing research with universities.

9.3 HIGHLIGHTS OF THE REPORT OF THE UNIVERSITY OF MANITOBA

The proposed establishment of an Institute of Imaging and Remote Sensing and a graduate program on Imaging and Remote Sensing has been placed on hold for 1986 as a result of the lack of secured external funding. As stated in the 1985 report, the infrastructure remains essentially in place and in position to go operational upon the procurement of the necessary funding.

Faculty Research in Imaging Analysis

Dr. Wooil Moon: Geophysics - Geological Sciences

- Integrated geophysical imaging

A theoretical framework for optimal integration of 3-D data volume is being developed.

- Integrated geophysical imaging experiment of Sudbury Basin

An integrated imaging experiment is continuing so as to reconstruct the geological structure of the Sudbury basin.

Dr. Richard Gordon: Botany and Radiology

- 3-D Digital Subtraction Mammography

The use of 3-D subtraction mammography to detect very small breast cancers from computed tomography scanner data.

- Focus-Free Digital Imaging for Microscopy, Photography, and Robotic Vision

The development of digital image techniques to provide focus-free imagery in microscopy, photography and robotic vision.

Dr. Micha Paznar: Geography

- Artificial Intelligence techniques in geographic problem solving

The development and application of Artificial Intelligence techniques for spatial commonsense reasoning and geographic problem solving. These techniques involve the areas of knowledge representation, control and search, as well as rule-based systems (e.g. expert systems), computer vision and machine learning.

Faculty Research in Remote Sensing

Dr. John Stewart: Botany

- Peatland Inventory of Manitoba using LANDSAT Thematic Mapper and SPOT Imagery

The enhanced spatial resolution of LANDSAT Thematic Mapper and SPOT imagery data will allow for greater accuracy and classification of Manitoba's peatlands with the interactive capability of the ARIES II system.

Dr. Larry P. Stene: Geography

- The Use LANDSAT imagery and hydrometric data in assessment of bankline erosion of the Jamuna River, Bangladesh

LANDSAT imagery combined with hydrometric and hydrologic data will possibly provide a means of predicting large-scale bank erosion along the Jamuna River.

Dr. Wooil Moon: Geophysic-Geological Sciences

- Applied geodynamic research using ERS-1 altimeter data

As part of the Canadian Scientific Investigation Team, the University of Manitoba Geophysics group will participate in geodynamics experiments involving the ERS altimeter data.

SHORT TERM GOALS

1. External funding for the UM Institute on Imaging and Remote Sensing will be sought in 1987.
2. Collaborative research projects among university departments, MRSC and the private sector will be encouraged.

9.4 HIGHLIGHTS OF THE REPORT OF THE UNIVERSITY OF SHERBROOKE

Centre d'applications et de recherches en télédétection (CARTEL), in co-operation with Laval University

INTRODUCTION

The teaching of remote sensing at the University of Sherbrooke is the responsibility of the geography department in the arts and humanities faculty, while the research aspect is managed by the Centre d'applications et de recherches en télédétection (CARTEL) in the same faculty. Throughout their studies, therefore, graduate students take part in research development through the linking of research and teaching.

The Department of Geography is responsible for all aspects of training. It has several professors who are specialists in remote sensing or whose research fields have some aspects requiring this discipline. For example, some professors specializing in areas such as Third World geography or urban geography use remote sensing as a work tool in their research.

The Centre d'applications et de recherches en télédétection (CARTEL) is composed of those professors in the Department of Geography who teach remote sensing, certain professors who are primarily specialists in other fields but use remote sensing, research associates, research assistants and associated researchers working in the private or public sectors.

CARTEL is currently one of the largest university remote sensing research centres in Canada, both in the number of researchers attached to it and in the diversity and quality of its achievements. Established in 1985, the Centre replaced the geography department's remote sensing laboratory, which had been in operation since 1972. In 1985, the laboratory received the status of a Centre in the University, with the participation of Laval University in the orientation council.

The Centre was chosen in 1985-86 to receive a grant of $1,309,000 over five years under the Programme des actions structurantes (Program of structuring measures) of Quebec's department of higher education, science and technology (MESST). This grant made it possible to hire three research associates (Dr. A. Condal, Dr. N. O'Neill and Dr. H. Granberg), award 12 student scholarships, provide two professional positions and improve the image processing equipment by moving to the DIPIX ARIES-III system, with a Microvax II as the computer calculator.

EQUIPMENT

The Centre has a DIPIX ARIES III image processing system based on the Microvax II, with the following peripheral equipment: an EIKONIX digitizer camera, an ACT-II ink jet printer, and ALTEK GENTIAN digitizer table and an IMAPRO photo printer. There are two workstations. Besides ARIES software pakcages, CARTEL has software developed at the Centre itself. In addition, the Centre has a mobile spectroradiometry laboratory, which is used essentially for radiometric or meteorological measurements during satellite passes. This station is provided with radiometers (Barnes PRT-5 and 10, Exotech, SPOT Cimel and balance radiometers), remote thermometers and thermistor sensors. The data are recorded analogically or digitally.

RESEARCH ACTIVITIES

Symposiums

Over the year, various researchers took part in important conferences or symposiums, including the 10th Canadian Symposium on Remote Sensing in Edmonton (five papers) and the 20th ERIM Symposium in Nairobi (three papers). In addition, the Director of the Centre was a participant late in the year at the SPOT/PEPS symposium in Toulouse, at which the situation regarding SPOT and various aspects of the PEPS program was discussed.

Coastal and marine studies

Seven research projects were completed or begun with MAPAQ (marine fisheries), Parks Canada, Groupe-Conseil Roche Ltée, Fisheries and Oceans Canada and other agencies on remote sensing applied to marine plant life, surface currents, crustacean larval drift and the coastal environment.

Atmospheric studies by satellite remote sensing and ground measurements

Several research projects were undertaken in the modelling of solar radiation reflected by the atmosphere and the earth in the visible and near infrared spectra; applications concerned the development of methods for atmospheric corrections and the study of LANDSAT image chronological series. Finally, research projects also continued in the areas of radar remote sensing of renewable resources, urban changes and the thermal properties of the earth's surface.

Pan-Canadian exhibition on remote sensing

CARTEL, in co-operation with the Musée du Séminaire de Sherbrooke, is promoting an exhibition on remote sensing, which will be held in Sherbrooke in the summer of 1987 and will travel across Canada from 1987 to 1989.

International involvement

CARTEL was involved in three training projects: a project sponsored by the IDRC, including training, concerned remote sensing applied to land use in the Dominican Republic; in co-operation with the DIGIM-Lavalin corporation, the Centre took part in a training program in image processing of Thai specialists from various disciplines; finally, the Centre welcomed a trainee from the soil sciences department of the Institut Agronomique Hassan II, Morocco, for a lengthy training session.

France-Quebec program

Late in the year, as part of France-Quebec co-operation in higher education and research in the field of remote sensing, the MESST approved an exchange program between CARTEL and the CRPE (Centre de recherches en physique de l'environnement, Paris VII). This three-year program includes training sessions and missions, and involves possible exchanges through prior agreement with associated laboratories, such as INRA (Avignon) and LERTS (Toulouse), and organizations such as DIGIM and Agriculture Canada. CARTEL, in co-operation with the CRCS (Centre de recherches sur les communications de Sherbrooke), is also a participant in a France-Quebec program with the Ecole nationale supérieure des télécommunications de Brest.

PEPS program

A team of CARTEL researchers was selected in an international competition for participation in the preliminary SPOT evaluation program (PEPS). Another group is part of a PEPS team from IFREMER.

9.5 HIGHLIGHTS OF THE REPORT OF THE UNIVERSITY OF WATERLOO

INTRODUCTION

Remote sensing activities take place in several departments across campus. It is a principal area of research in the Department of Geography and in the Departments of Systems Design Engineering and Civil Engineering. Remote sensing projects have also been undertaken in the Department of Earth Sciences.

There is considerable contact and cooperation between the different groups. As demonstrated in the report, there are joint research projects, students take remote sensing courses across campus, faculty participate on student advisory committees, and research equipment is shared when appropriate. There are seven faculty members and one post-doctoral fellow working directly in remote sensing.

RESEARCH FACILITIES

Image analysis facilities exist in four departments on campus. Although stand-alone equipment is available, a major emphasis at Waterloo is to create a research environment where there is good communications between different parts of a system so that files can be moved easily. This is gradually being achieved.

RESEARCH PROJECTS

A total of eleven projects have been identified, several of which have sub-projects associated with them. Six of the projects involve direct cooperation of faculty members and another three projects have an international element to them.

During 1986, funding from research grants in support of equipment and the research projects was in excess of $500 000.

GRADUATE STUDENTS

Eight graduate students completed Master's level theses during 1986. Four of them are continuing their remote sensing studies at the Ph.D. level. In 1986, there was a considerable increase in the number of students at the Ph.D. level. At the present time, fourteen students are registered in Ph.D. programs, while eight are studying for Master's degrees.

PUBLICATIONS AND PRESENTATIONS

Thirty-one remote sensing publications and twenty-one presentations were reported for 1986. Over half the publications were in refereed sources.

PROJECTS PLANNED FOR 1987

From June 22-25, 1987, the University of Waterloo will host the 11th Canadian Symposium on Remote Sensing. A total of 190 abstracts have been submitted for the Symposium. In addition to the Opening Ceremonies, the Technical Program Committee has planned five Plenary Sessions and five groups of Poster Sessions. The Organizing Committees hope to have a good turn out of remote sensing specialists for what promises to be an excellent technical program.

STATUS

Remote sensing at the University of Waterloo is in a strong and stable position. There is a good nucleus of research equipment, but maintenance costs are always a concern. At the present time, the majority of research projects are partially completed and funding for them is adequate. There is increased interest by graduate students to undertake studies at the Ph.D. level.

9.6 HIGHLIGHTS OF THE REPORT OF THE NOVA SCOTIA COLLEGE OF GEOGRAPHIC SCIENCES

The College offers an intensive, one year, three-semester, diploma program in the field of Remote Sensing Technology. Fourteen graduate students attended our College last year and received a multi-disciplinary training covering a wide range of applications including geology, agriculture, forestry, and environmental studies. Presently, 13 graduate students from various regions of Canada are enrolled in the program and pursuing academic and practical specialization in this field of endeavour.

The Remote Sensing program was integrated with other programs within the Department of Computer Programming as of last year. Consequently, specialization is offered in: a) resource management studies of b) computer programming and geographic information systems (GIS), utilizing remote sensing technology.

Cooperative projects arranged for this year vary from forestry applications using LANDSAT Thematic Mapper data to geologic mapping and mineral exploration. Test sites for student projects have been selected in various localities of Nova Scotia and in several other provinces as well.

The College has offered courses in digital image processing and geographical information systems to several international students. A student from Thailand completed a course in applications to geological investigation and mineral exploration. Also, two soil scientists from India recently attended our College and completed a six-week, intensive course which involved the utilization of digital image processing and GIS in soil science investigation and crop feasibility studies in a locality adjacent to the Gandhi Reservoir, India.

The following manuscripts have been submitted for publication at the 10th Canadian Symposium on Remote Sensing by Dr. Akhavi in association with his graduate students:

1) K.D. Kalicharren and M.S. Akhavi, Analysis of Airborne Infrared Data for Interpretive Geologic Mapping of the Brookfield Area, Nova Scotia.

2) T.R. McInnis and M.S. Akhavi, Integration of Radiometric and LANDSAT Digital Data for Geologic Investigation and Exploration, Guysborough Area, Nova Scotia.

A research proposal entitled "Geologic Mapping and Mineral Exploration in the South Mountain Batholith Area, Nova Scotia, Utilizing Airborne Digital Radiometric, Magnetic and LANDSAT Data" has been submitted to Energy, Mines and Resources.

Mr. Edward Wedler has returned from Malaysia and is supervising environmental and radar cooperative projects.