MINUTES OF THE ANNUAL MEETING OF THE CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING

APRIL 21-24, 1987
CORNWALL, ONTARIO

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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 Nous aimerions recommander au Centre canadien de télédétection de faire en sorte de pouvoir reporter à l'été 1987, et au même tarif, les survols commandés en 1986 et non réalisés par suite des mauvaises conditions climatiques. Le laboratoire de télédétection de l'Université du Québec à Chicoutimi (UQAC) a un important projet de climatologie urbaine et de thermographie forestière à compléter en 1987-88 à partir d'une commande de survols restée en suspens.

- 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 Le Centre québécois de coordination de la télédétection (CQCT) se trouve dans la position de devoir déplorer à nouveau les délais d'attente imposés aux clients des données de satellites. Par ailleurs, le CQCT demande au Centre canadien de télédétection de maintenir disponible toute la gamme de produits de satellites qui était offerte avant le 1er avril 1987 et ce tant que l'entente de privatisation ne sera pas réalisée.

- 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 Un des principaux obstacles à l'utilisation plus courante de la télédétection par satellite réside dans la rareté des bonnes images pour un territoire et une date déterminés. Il serait souhaitable de reconsidérer l'installation d'un capteur multispectral à bord de RADARSAT. Il contribuerait à rentabiliser ce futur satellite canadien.

- 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.

4.0 RAPPORT DU CENTRE CANADIEN DE TÉLÉDÉTECTION

Le Centre canadien de télédétection (CCT) a été créé en avril 1971 en tant que direction du ministère de l'Énergie, des Mines et des Ressources.

Le CCT se consacre à la mise au point et à la démonstration de systèmes, de méthodes et d'instruments qui permettent d'acquérir, d'analyser et de diffuser des données sur la gestion des ressources naturelles obtenues au moyen d'aéronefs et de satellites. Le vaste champ de vision des satellites et leur couverture régulière d'une région donnée grâce à leurs capteurs spécialisés offrent de nouvelles possibilités techniques et économiques pour la gestion des ressources, tandis que les aéronefs donne une vue détaillée aux endroits nécessaires et servent de plate-formes de recherche et de développement pour la mise au point de nouvelles applications.

Les techniques démontrées sont transférées à l'industrie et à l'ensemble des utilisateurs, en tant que contribution au développement de systèmes efficaces d'information et de gestion pour les ressources et l'environnement terrestres et océaniques du Canada.

Les applications de la technologie de la télédétection comprennent la gestion des forêts économiquement accessibles, leur protection contre les incendies, l'exploration minière, l'amélioration des pratiques d'exploitation des terres agricoles, la surveillance des cultures et les systèmes de préparation des rapports sur ces cultures ainsi que la reconnaissance des glaces et la surveillance des océans.

TECHNOLOGIE DES APPLICATIONS

Programme d'amélioration des techniques

Le programme d'amélioration des techniques (PAT) en matière de télédétection a pour but de susciter la collaboration avec les gouvernements provinciaux afin d'accroître leurs capacités de télédétection pour la gestion des ressources naturelles. A cette fin, le Centre canadien de télédétection, avec l'appui d'autres ministères fédéraux (par exemple, Environnement, Agriculture, Statistique Canada), conclut des protocoles d'entente avec les gouvernements provinciaux par lesquels des projets ayant recours à des techniques éprouvées de télédétection, sont entrepris conjointement par le personnel des organismes provinciaux de gestion des ressources et par le Bureau du Programme d'amélioration des techniques (BPAT).

Le succès d'un PAT se mesure par la profusion des activités de télédétection qui suivent le retrait intégral de l'appui direct apporté par les spécialistes du Bureau. L'essor des activités de télédétection dans une province est mesurable de diverses façons:

- poursuite des projets par la province
- acquisition d'équipement d'analyse d'images et autres
- formation en télédétection
- activité dans le secteur privé
- achats de données.

Le programme d'amélioration des techniques a été mis sur pied en novembre 1982, lorsque le premier programme provincial a été amorcé avec le gouvernement du Manitoba. En avril 1983, le CCT a entrepris un deuxième programme d'amélioration des techniques avec la région des Maritimes. Le PAT au Manitoba a pris fin en juin 1984 et celui des Maritimes en août 1985. Le Centre manitobain de télédétection répond à la demande d'un très grand nombre d'usagers, notamment les organismes provinciaux et fédéraux de ressources, les sociétés d'État et le secteur privé. Les activités de télédétection se poursuivent dans tous les secteurs des provinces maritimes, notamment par d'importants programmes de formation et des projets par les compagnies privées.

Saskatchewan - Réalisations

Un protocole d'entente de collaboration en télédétection a été signé entre la Saskatchewan et le CCT en janvier 1985. L'entente qui devait se terminer le 31 mars 1987 a été prolongée jusqu'au 30 juin 1987. Le Conseil de recherche de la Saskatchewan (CRS) administre et coordonne le Programme d'amélioration des techniques de la Saskatchewan (STEP) de ses laboratoires en Saskatchewan. La contribution du CCT au STEP comprend les services à temps plein d'un spécialiste en télédétection et un système d'analyse numérique d'images DIPIX ARIES II. Un chercheur du CRS a été affecté au programme et y consacrera au moins 80% de son temps.

Les cinq projets conjoints originaux sont maintenant passés à neuf. En voici la liste et l'état de chacun:

Ministères et Directions	Projet	État
Parcs et Ressources renouvelables; Direction de la luttre contre les incendies de forêt	Types de risques de combustibilité forestière	Rapport final rédigé
Direction de la gestion forestière	Cartographie des récents terrains déboisés et brûlés	Ébauche de rapport final terminée
Direction de la faune	Cartographie de l'habitat du cerf de Virginie	Rapport final rédigé
Agriculture: Direction de l'irrigation	Cartographie des cultures perdues à cause des sols à forte salinité	1e ébauche du rapport final
Saskatchewan Water Corporation	Prévision des inondations	1e ébauche du rapport en préparation
Saskatchewan Crop Insurance Board	Mesure de la superficie des champs semés par rapport aux cultures assurées	1e ébauche du rapport en préparation
Conseil de la recherche de la Saskatchewan	Cartographie de l'habitat de l'orignal et du caribou	Rapport rédigé
Statistique Canada/Agriculture Saskatchewan	Classification des cultures	Rapport rédigé
Ducks Unlimited/ Parcs et ressources renouvelables	Différenciation des types de couvert végétal des terres humides	Analyses terminées

Le Conseil de recherche de la Saskatchewan fera l'acquisition d'un équipement d'analyse numérique d'images en 1987, avant la fin du PAT. Le ministère des Parcs et des Ressources Renouvelables a fait l'acquisition d'un équipement d'analyse d'images visuelles et d'un système d'information géographique pour son laboratoire en foresterie de Prince-Albert.

Outre les projets conjoints entrepris dans le cadre du PAT, le CRS a terminé un certain nombre de projets sous contrat pour quelques clients de la province, et cherche activement à obtenir d'autres contrats.

Terre-Neuve - Réalisations

En juin 1986, le CCT et le Department of Development and Tourism ont signé un protocole d'entente de collaboration qui prendra fin en mars 1988. Les six projets conjoints suivants sont en cours. En voici la liste et l'état de chacun:

Ministères et Directions	Projet	État
Mines and Energy Mineral Development Division	Cartographie géologique de la roche en place/Nord du Labrador	Analyses en cours
Mines and Energy Mineral Development Division	Cartographie géologique des formations superficielles/ Nord du Labrador	Analyses en cours
Environment Water Resources Division	Analyse des bassin versants/ Rivière Humber supérieure	Analyses en cours
Forests Resources Land Management Division	Cartographie de l'utilisation des terres/Sud-ouest de Terre-Neuve	Analyses en cours
Culture, Recreation and Youth Wildlife Division	Habitat de l'orignal et du caribou/ N.O. de la rivière Gander et S.E. de la presque'île Avalon	Analyses en cours
Forests Resources Forest Management Division	Cartographie des coupes à blanc/ Centre de Terre-Neuve	Analyses en cours

La compagnie NORDCO Ltd., à la suite d'une entente contractuelle avec le Department of Development and Tourism, offre des services d'analyse numérique d'images.

Initiatives en matière de Programme d'amélioraton des techniques

Les négociations avec le gouvernement des Territoires du Nord-Ouest vont bon train pour l'obtention d'un PAT. Elles devraient aboutir à la signature d'un protocole d'entente en collaboration avec le ministère des Ressources renouvelables vers la fin de 1987. Les autorités du GTNO préparent actuellement une liste de dix projets, dont certains, sinon la totalité d'entre eux, constitueront la base d'un ensemble d'études conjointes. Lorsque le protocole d'entente sera en vigueur, l'année-personne attribuée en Saskatchewan sera transférée à Yellowknife. Comme aide supplémentaire, un système d'analyse numérique d'images sera prêté au TNO pour la durée du PAT.

Au printemps de 1986, l'Association des prospecteurs du Yukon, avec l'aide du gouvernement territorial du Yukon, a fait l'achat d'un système d'analyse numérique d'images piloté par micro-ordinateur. Par suite de la conclusion d'un contrat entre l'Association des prospecteurs et un expert-conseil, les prospecteurs peuvent désormais obtenir un service d'interprétation de photos aériennes, de données satellitaires et géophysiques. Pendant le reste de l'année, un certain nombre de prospecteurs indépendants et de compagnies ont pu profiter de ce service dans leur recherche de filons de métaux précieux. Le PAT a également été utile sur le plan des consultations et des ateliers.

Le Bureau d'amélioration des techniques continuera de travailler avec les gouvernements provinciaux et territoriaux dans le but d'aider les gestionnaires des ressources à accroître leur expertise dans l'utilisation des données télédétectées dans le domaine du visible. En même temps, puisque la venue des données recueillies par radar est de plus en plus rapprochée, on tentera, au moyen d'ateliers et d'études conjointes, de familiariser les gestionnaires des ressources à ces nouvelles données et aux techniques d'analyse nécessaires à l'extraction de l'information qu'elles contiennent.

Programme de mise au point des applications

En 1986, la Division des applications et de la technologie a orienté ses activités de recherche en vue d'atteindre des objectifs opérationnels dans une vaste gamme de projets de développement de ressources et d'applications se rapportant à la surveillance et à la gestion. Des projets ont été menés en collaboration avec des organismes fédéraux et provinciaux et des spécialistes du secteur privé. Les activités indiquées dans le présent rapport sont représentatives des travaux courants d'application de la télédétection dans cette division.

Agriculture

1) Système d'information sur les cultures basé sur les données NOAA

Le projet pilote mis sur pied en collaboration avec la Commission canadienne du blé, le Centre manitobain de télédétection et l'industrie privée s'est terminé en mars 1987. Ce projet visait à faciliter l'élaboration des techniques nécessaires à l'utilisation efficace des données AVHRR de NOAA.

Au cours de 1987, une installation de prétraitement de données télédétectées sera établie à Winnipeg, en collaboration avec le Centre manitobain de télédétection et la Commission canadienne du blé, pour créer et tenir à jour des archives de données AVHRR, pour faire la correction géométrique et radiométrique des données AVHRR en temps voulu et pour être en mesure d'intégrer les données ROS aux sources actuelles de données VIR, quand les données ROS deviendront couramment accessibles dans les années 1990. Cette installation devrait favoriser l'utilisation des données télédétectées dans les applications où il est essentiel d'obtenir les données à temps.

2) Applications des données LANDSAT et SPOT

a) Un projet de recherche conjoint, amorcé en 1983, par le CCT, le ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) et le Centre québécois de coordination de la télédétection (CQCT) s'est terminé avec succès en 1986. Ce projet avait pour objectif d'évaluer et de démontrer le potentiel d'utilisation des données TM pour la cartographie de l'utilisation des terres agricoles. Résultats: la méthodologie élaborée au CCT a été transférée au MAPAQ pour mise en application opérationnelle. Les premiers travaux à l'aide des données SPOT ont commencé dans le cadre de ce projet et feront l'objet d'un rapport en juin 1987.

b) Le projet pilote sur l'utilisation des données MSS de LANDSAT pour évaluer la destruction des semis par le froid est

terminé. Il s'agit d'un mode additionnel de surveillance des cultures faisant appel aux données de type LANDSAT et non à des données AVHRR de NOAA ou radar. Les résultats peuvent maintenant être transférés aux utilisateurs concernés.

c) Un projet, actuellement en cours, porte sur l'étude du potentiel des systèmes informatisés destinés à des applications agricoles à l'échelle des townships. Ce projet est mené en collaboration par le ministère de l'Agriculture et de l'Alimentation de l'Ontario, le Centre ontarien de télédétection et l'Université de Guelph.

3) Le ROS et l'agriculture

On a établi un plan quinquennal en vue d'élaborer des méthodes d'utilisation des données ROS pour des applications agricoles, de sorte que le Canada sera en mesure de les utiliser efficacement lorsque ces données deviendront couramment accessibles à partir de satellites, dont l'ERS-1, dans les années 1990. Ce plan repose sur les efforts conjugés des gouvernements fédéral et provinciaux et des universités qui utilisent les données des ROS aéroportés ou à bord des satellites (ERS-1 de l'ASE), l'imagerie dans le domaine du visible et du proche infrarouge (VIR) et les mesures au sol des diffusomètres hyperfréquences. Une des caractéristiques importantes de ce projet sera l'intégration des données télédétectées à d'autres sources de données, par l'intermédiaire d'un système d'information géographique (SIG), et l'établissement des liens nécessaires pour transférer ces données entre le SIG et les systèmes d'analyse d'images télédétectées. La recherche portera également sur l'intégration des données ROS et VIR aux données météorologiques dans les modèles de rendement des cultures.

4) Projet de gestion des grands pâturages en Alberta

Les travaux de gestion des grands pâturages se sont poursuivis en 1986 dans le cadre d'un projet conjoint mené par le Department of Lands and Wildlife de l'Alberta et le Centre albertain de télédétection. Au secteur original des avants-monts se sont ajoutés les terres du Parc et le secteur de la Rivière de la paix. Les gestionnaires des grands pâturages de la région ont participé à l'évaluation de l'imagerie TM en vue de l'appliquer à leur domaine d'activités.

L'imagerie TM s'est révélé efficace tant pour la mise à jour des inventaires des pâturages de grandes et très grandes superficies, pour la surveillance des dommages causés par le bétail et pour l'évaluation de la régénération ou l'empiètement des espèces arbustives. Pour donner suite à ces travaux, le CCT envisage la production d'un système normalisé d'accentuation TM des grands pâturages.

Foresterie

1) Accentuations du capteur TM

Les résultats de l'évaluation préliminaire des données TM pour un ensemble de conditions forestières au Canada ont été présentés au 10e Symposium canadien de la télédétection à Edmonton. La communication publiée dans les Actes de ce symposium sert de guide provisoire pour une utilisation éventuelle des données TM en foresterie.

La mise au point des algorithmes et des spécifications nécessaires à la production des accentuations de réflectance du couvert forestier, sous forme de films standards du CCT, est maintenant terminée. Quatre types d'accentuations ont été définis: mixedwood/-mélangé, softwood/résineux, boreal/boréale et leafoff/défeuillaison.

Nous prévoyons que ces accentuations seront d'une très grande importance pour les forestiers intéressés à l'utilisation efficace et peu coûteuse des données TM recueillies par satellite à des fins de gestion forestière.

2) Cartographie des dommages causés par les insectes et de l'évaluation des peuplements juvéniles

Ce projet a connu une expansion considérable en 1986. En effet, un essai de cartographie aérienne, à l'aide du capteur MEIS, des dommages causés par la tordeuse des bourgeons de l'épinette a été réalisé au Nouveau-Brunswick. Cinq mille km ont été couverts en un seul vol de trois heures. L'analyse des données obtenues a permis de confirmer que le capteur MEIS peut, dans les bandes spectrales appropriées, identifier les conifères endommagés par la tordeuse des bourgeons de l'épinette pendant l'année en cours et distinguer ceux-ci des conifères sains, des conifères qui ont subit des dommages antérieurs et des feuillus. De plus, le projet a permis d'identifier les secteurs de travaux de développement visant la création d'un système opérationnel de cartographie des dommages causés par cet insecte.

En Colombie-Britannique, le projet était concentré sur deux problèmes: les dommages causés par le dendroctone du pin ponderosa et l'évaluation des jeunes peuplements. Les données du MEIS II recueillies pour la cartographie des dommages causés par le dendroctone du

pin ponderosa ont permis un repérage plus facile des arbres morts que la méthode de photographie aérienne classique. De plus, le traitement automatisé d'interprétation des données coûte moins cher. La résolution spatiale de 1,5 à 2 mètres s'est révélée optimale pour la cartographie des individus d'un peuplement tués par le dendroctone. Une analyse spectroscopique détaillée du feuillage sur des arbres sains et malades a été effectuée en vue de déterminer les régions spectrales montrant les premiers signes de l'invasion. Des différences marquées de réponse ont été relevées entre le nouveau et l'ancien feuillage. Ces études spectroscopiques serviront à déterminer les bandes MEIS optimales pour la détection "pré-visuelle" des attaques par le dendroctone et serviront à orienter les recherches en 1987.

Les données MEIS recueillies pour l'évaluation des jeunes peuplements ont servi à cartographier l'état de régénération des conifères dans les plantations près de Smithers, C.-B. Les données ont été analysées en vue de démontrer que les affichages couleurs-infrarouge, avec une résolution de 1,7 mètres, permettaient d'identifier des zones où la compétition des arbustes caducifoliés était très forte. De même, il est plus facile d'identifier les couvertures herbacées des stations à conditions de croissance déficientes, comme celles où le sol est compacté.

3) Inventaire forestier en Alberta

En 1986, la recherche a porté sur deux aspects principaux: la stratification des brûlis en cours de régénération, d'après des données TM, et l'estimation quantitative de la fermeture du couvert des cimes dérivée des données TM.

Les chercheurs ont dressé deux cartes de brûlis au nord de Whitecourt. La première a été préparée uniquement à partir de deux groupes de données TM (été et automne), tandis que la seconde l'a été à partir de données TM et d'aides d'interprétation (photographies en couleurs à petite et moyenne échelles et cartes d'inventaire des forêts albertaines).

La carte dressée uniquement avec les données TM se comparait avantageusement à celle qui avait été établie avec d'autres aides.

Une première évaluation du potentiel des données TM en vue d'obtenir une estimation quantitative de la fermeture du couvert des cimes a donnée des résultats encourageants, l'analyse de régression à plusieurs variables ayant donnée des valeurs r^2 de 0,79 pour les peuplements de pins tordus et de 0,64 pour les peuplements d'épinettes.

Océanographie/gestion des zones côtières

1) Température de la surface de la mer (TSM) et qualité de l'eau

La Division s'est servi du système de transcription MOSAICS pour effectuer l'étalonnage absolu de la bande 6 du capteur TM (infrarouge thermique), et voir dans quelle mesure ce type de données peut être utilisé pour établir des cartes de température de la surface de la mer (TSM) dans des zones précises. Ces cartes sont d'ailleurs plus détaillées que les cartes actuelles du AVHRR à faible résolution de NOAA.

Les premiers essais ont été très encourageants. Deux projets conjoints ont élé lancés avec le concours du ministère fédéral des Pêches et des Océans. Les sites d'essais choisis pour mener les expériences TSM sont la Baie de Fundy et le Delta du MacKenzie. Au cours de ces essais, les bandes VIR du capteur thématique feront également l'objet d'une évaluation comme source possible d'information sur la teneur en matière organique des sédiments en suspension.

2) Cartographie des algues

Le projet pilote basé sur les données de l'imageur linéaire de la fluorescence pour cartographier les algues au large de la côte sud-ouest de la Nouvelle-Écosse s'est avéré concluant. A partir des résultats obtenus, le MPO a lancé un programme intensif d'inventaire de la population d'algues, le long de la côte sud de la Nouvelle-Écosse.

Forte de l'élargissement des capacités du MEIS en bande étroite, la Division a amorcé son propre projet d'évaluation cartographique des populations d'algues à l'aide du même capteur.

Géologie

Dans le cadre de son programme de recherche géologique, la Division continue de concentrer ses efforts sur l'évaluation et la démonstration des techniques micro-informatisées d'analyse d'images comme moyen efficace de recherche et d'applications opérationnelles dans le domaine de la télédétection par satellite appliquée à la géologie. Le micro-ordinateur MICROGAP, qui a été mis en service en janvier 1986, répond à environ 90% des besoins courants d'analyse d'images dans les projets en géologie. Des liens étroits ont été maintenus avec les utilisateurs potentiels et les réalisateurs de ce type de système dans le but d'assurer une dissémination rapide des résultats.

Au cours de 1986, cinq projets régionaux de démonstration d'activités géologiques ont été menés à terme. Les sites d'étude sont représentatifs d'une gamme de conditions géologiques. Les applications étudiées comprennent les aspects suivants: exploration minière, cartographie géologique de la roche en place, de la structure et des formations superficielles, géologie appliquée et environnementale. Les résultats de ces projets ont été rassemblés en cahiers et inclus dans le nouveau programme d'ateliers géologiques qui a été présenté deux fois au cours de la dernière année. Tous ces projets de démonstration débouchent sur deux principaux domaines de recherche:

- Intégration de données géologiques comprenant un certain nombre d'ensemble de données et de modèles numériques d'altitude.

- Géobotanique régionale ou "d'arrière-plan", à l'appui des efforts du groupe de travail des sciences géodésiques du CCCT.

Les projets de recherche micro-informatisés, prévus pour 1987, permettront d'accentuer les efforts dans les domaines susmentionnés, d'accroître les activités de manière à inclure deux sites de démonstrations additionnels et d'analyser le rôle de l'imagerie ROS dans le cadre de l'évaluation géobotanique régionale.

Aide à la formation

Les scientifiques de la Division ont apporté leur contribution aux organismes provinciaux et aux compagnies en fournissant matériels d'étude, consultations et conseils techniques pour les programmes de formation en géologie, en foresterie, en agriculture et en analyse numérique d'images.

Au cours de l'année dernière, la Division a mis sur pied un programme structuré en reconnaissance de l'importance de la formation en télédétection et pour aider à la réalisation, à la production et à la présentation des ateliers. Jusqu'à maintenant, de nouveaux modules de formation ont été complétés pour la présentation d'un atelier d'introduction à la télédétection et un bloc d'ateliers sur la géologie. En 1987, nous continuerons d'apporter notre contribution au Programme d'amélioration des techniques par le développement et la présentation de nouveaux modules de formation sur les sujets suivants: capteur TM, SPOT, RADAR et analyse numérique d'images/systèmes experts.

Aide internationale

En 1986, le CCT a continué de répondre aux demandes d'assistance de l'ACDI, du CRDI et du ministère des Affaires extérieures pour une variété d'activités de développement et d'échanges internationaux. La Division a accueilli des scientifiques de la République populaire de Chine et de la Thaïlande. Les ententes de coopération officielle importantes comprenaient les activités suivantes:

1) Berlin, Symposium sur le développement de la télédétection

A la demande de l'ACDI, la Division des opérations s'est chargée de la réalisation du stand canadien lors du symposium de Berlin, organisé dans le cadre du Sommet économique. A cette occasion, la Division a produit une série d'affiches et de brochures montrant des applications de la télédétection et mettant en lumière l'expertise canadienne dans l'évaluation de cette technique et son application au développement international. Des affiches ont également été créées pour démontrer le potentiel de l'industrie canadienne en matière de fabrication de matériel, de services et de consultations dans le domaine de la télédétection. Le CCT, par l'intermédiaire de la Division des opérations, avait également rédigé la communication canadienne présentée lors de la rencontre et qui soulignait l'engagement canadien dans l'aide au développement et la confiance du Canada dans l'application des techniques de télédétection pour aider à répondre aux défis à relever. Le document traitait également de l'étroite association entre le programme national de télédétection, le CCT et l'industrie canadienne. On apportait aussi des exemples de la maîtrise de l'industrie canadienne dans le domaine de la télédétection.

2) Changement global

Les experts se penchent de plus en plus sur les changements environnementaux aux échelles continentale et globale comme les changements climatiques, la sécheresse, les pertes de sol arable, etc. Il apparaît clairement que la télédétection par satellite deviendra un outil essentiel de surveillance des changements environnementaux qui se produisent à ces échelles.

En 1986, le Conseil international des unions scientifiques a approuvé la création du nouveau Programme international géosphère - biosphere (PIGB). Ce programme vise la connaissance des changements que connaît la terre et des facteurs qui influent sur son évolution.

En ce qui concerne l'apport canadien à l'étude du changement global, le CCT a participé à l'organisation d'une rencontre d'un groupe de scientifiques qui dressera un programme d'étude sur la masse continentale, les océans et l'atmosphère dans les limites territoriales canadiennes. De plus, un programme expérimental a été créé en vue d'élaborer des techniques de surveillance des changements relatifs à la végétation et au sol, à l'aide de données obtenues à faible résolution (AVHRR de NOAA) et à haute résolution (LANDSAT), tant archivées que courantes. Des mesures sont prise pour s'assurer que les données historiques importantes, décrivant les changements à l'échelle globale dans un passé récent, sont conservées en tant qu'archives vitales pour les études à long terme du changement global.

L'assistance à l'utilisateur

La Section de l'assistance à l'utilisateur est chargée de fournir à l'utilisateur actuel et potentiel des renseignements sur le Centre, sur ses activités et sur ses installations. Elle assure aussi la liaison avec les sociétés canadiennes de télédétection dans le cadre d'un engagement permanent envers l'industrie canadienne, en vue d'assurer l'intégration de la technologie aux besoins de l'utilisateurs.

En 1986, la section a continué à répondre aux nombreux besoins des utilisateurs - plus de 3 000 contacts ont été établis par courrier et par téléphone et plusieurs centaines de visiteurs et membres ont participé à des visites guidées. Les activités associées à la commercialisation et à la promotion ont été accrues grâce aux lettres de nouvelles d'EMR, conformément aux recommandations du CCCT.

Vers la fin de 1986, la Section a lancé une campagne de publicité à l'intention des professionnels de la géologie et de la foresterie. De même, les contacts avec les médias ont été maintenues grâce à la publication d'un certain nombre d'articles de fond dans les journaux locaux et nationaux. La Section a servi de point de liaison pour la rédaction de l'article sur la télédétection parue dans le Canadian Geographic et pour les images fournies à Québec Science, Toronto Star, National Geographic, etc. Des articles ont été publiés dans le Financial Post, le Toronto Star, Québec Science et d'autres publications importantes.

Le CCT a participé activement à Expo 86 (où les techniques canadiennes de télédétection ont fait l'objet de démonstrations) et au Congrès international de l'éducation et de la technologie. Le CCT a également participé à Berlin '86, rencontre consacrée aux questions d'aide internationale et à la formation en télédétection. C'est en 1986, que la production d'affiches d'images satellitaires a pris une ampleur commerciale dans le secteur privé.

Service de renseignements techniques

En collaboration avec la Gregory Geoscience Limited, le CCT a continué de perfectionner et d'exploiter le Système en direct de recherche documentaire sur la télédétection (RESORS). La base de données du système contient actuellement un répertoire de 57 000 documents et 6 500 diapositives. Au cours de 1986, le personnel de RESORS a répondu à plus de 7 000 demandes de renseignements, sans compter les 4 000 interrogations en direct effectuées par 80 abonnés au Canada et 30 abonnés dans les pays suivants: États-Unis, Royaume-Uni, Australie, Hollande, Israël, France, Finlande, Botswana et Malaisie.

Un certain nombre de Bulletins d'information utilisent couramment RESORS pour fournir à leurs lecteurs des listes d'ouvrages de publication récente. De plus, au cours de l'année dernière, le CCT a conclu une entente avec les éditeurs du Remote Sensing Yearbook (Royaume-Uni) stipulant que les données RESORS sont fournies comme base de bibliographie complète qui sera publiée dans le Yearbook de 1987 et dans les éditions annuelles subséquentes.

MÉTHODES NUMÉRIQUES

Recherches sur les méthodes

Des méthodes basées sur les algorithmes de calcul et le raisonnement symbolique sont actuellement à l'étude en vue d'exploiter les données de télédétection. Ces méthodes emploient des ressources technologiques qui couvrent la reconnaissance des formes, le traitement d'images, la spectroscopie physique et les sciences informatiques. Au cours de l'élaboration des méthodes, leur performance est évaluée avec des données prélevées dans des secteurs d'application comme la foresterie, la géologie et l'agriculture.

Dans le cas de la classification des types de couverture forestière et de coupes à blanc, les images du capteur TM, accompagnées d'informations géographiques comme l'hydrologie, les modèles numériques d'élévation (MNE) et les cartes de secteurs thématiques ou classifiés, sont intégrées aux données provenant des cartes de couverture forestière fournies par le Ministry of Forests and Lands de la Colombie-Britannique. Cette approche est basée sur une méthode complexe de classifica-

tion qui comprend le raisonnement symbolique sous forme de systèmes experts basés sur la connaissance. Les recherches se sont concrétisées par des développements dans les systèmes experts conçus pour faciliter la classification. Les grandes bibliothèques de logiciel du Système d'analyse d'images numériques (LDIAS) de LANDSAT sont reliées à l'analyse d'images par l'intermédiaire d'un expert appelé "Analyste-conseil". Le LDIAS est utilisé pour la recherche et le développement pour l'extraction d'information, pour appuyer le développement des applications et pour comprendre les caractéristiques des capteurs aéroportés et satellitaires.

La nécessité des échanges de données géographiques provenant de sources diverses d'informations a eu pour résultat la définition et l'application de nouvelles structures normalisées pour le transfert des données spatiales.

Les données géologiques sont en fait intégrées aux données télédétectées dans un programme de recherche qui fait également appel aux systèmes experts. De nouvelles techniques de filtrage élaborées par morphologie mathématique sont à l'étude. De nouvelles techniques d'accentuation sont actuellement mises au point pour les images du capteur TM destinées à la détection des affleurements géologiques dans les zones de végétation.

Le système d'analyse d'images assisté par micro-ordinateur (MCBIAS) représente une innovation en matière de recherche et de développement pour encourager l'utilisation d'ordinateurs personnels comme instrument d'analyse d'images. La recherche comprend les secteurs d'attribution de tâches pour les ordinateurs personnels et les ordinateurs à processeur central, l'élaboration d'un système de traitement d'images réparties et d'une mémoire de grande capacité pour les systèmes d'analyse d'images assistés d'un ordinateur personnel, comme le disque optique compact et ses disques pilotes. Un disque compact à mémoire fixe contenant des données télédétectées a été mis au point. Pour les utilisateurs potentiels de la télédétection, il faut absolument des méthodes plus faciles à utiliser et MCBIAS se servira de l'intelligence artificielle pour faciliter l'analyse des images et l'intégration des données.

On étudie actuellement les méthodes qui portent sur la segmentation et la texture des images. Ces méthodes mettent en relief le rôle accru des données spatiales dans la classification et la compréhension des images. Le regain d'intérêt pour ces méthodes a permis d'intensifier les recherches à l'aide des séries de Fourier et de classificateurs connexes.

Un projet est actuellement en cours pour étudier le traitement spatial des couleurs en tant que méthode d'accentuation lorsque les couleurs primaires courantes sont remplacées par des descriptions psychophysiques de couleur comme les teintes, la saturation et la brillance.

Les recherches en radiométrie associées aux capteurs ont porté sur les restrictions radiométriques du contenu d'information dans les images du capteur TM de LANDSAT. Les recherches en radiométrie associées aux scènes ont porté sur de nouveaux développements visant à combiner les étapes de traitement en vue d'éviter la nature non-commutative des solutions précédentes.

Une méthode a été mise au point pour permettre la concordance automatique entre l'imagerie obtenue par radar à ouverture synthétique et l'imagerie simulée d'après des modèles numériques de terrain (MNT).

Les nouveaux algorithmes utilisés pour la correction géométrique des capteurs TM indiquent, pendant les essais, que des précisions planimétriques supérieures à 17 mètres peuvent être obtenues. Des études ont été entreprises sur les algorithmes d'évaluation de précision pour la classification automatisée d'images.

Des algorithmes ont été établis pour la génération automatique de modèles numériques de terrain (MNT) à partir du SIR-B et des données SPOT par corrélation numérique de paires d'images. Une image MSS de LANDSAT et un MNT ont été utilisés pour générer des séquences de vues en perspective montrant de façon dynamique des caractéristiques et des détails du relief.

Développements et produits de traitement de données satellitaires

Les deux systèmes de visualisation rapide de données SPOT ont été entièrement mis au point en 1986 pour la génération de produits de visualisation rapide de 70 mm, de microfiches et d'informations cataloguées provenant des données SPOT. L'un des systèmes a été installé à la station de Prince-Albert, et l'autre a été installé à la station réceptrice de Gatineau.

Au cours de l'année 1986, les installations à Ottawa ont continué d'assurer le soutien et les produits de traitement de données dans le domaine de la télédétection à tous les intéressés. Le système en temps partagé (TSS) continue d'assurer le soutien du traitement des données recueillies par satellites et par aéronefs ainsi que la qualité, l'analyse

d'images, la recherche et le développement, la base de données et les systèmes de préparation de rapports. Le système en temps partagé a permis aux utilisateurs d'avoir accès à la base de données de recherche et résumé de l'inventaire des images (IISS) de LANDSAT 1, 2, 3, 4, et 5 pour les données du MSS, pour les données géocodées du MSS et pour celles du capteur TM. L'inventaire en direct contient toutes les données LANDSAT 1, 2 et 3 enregistrées, toutes les pellicules couleur existantes, le système de correction d'images numériques, les données du capteur TM et, depuis mars 1987, toutes les données de LANDSAT 4 et 5 jusqu'à février 1987. Quant aux données SPOT, les mises à jour du catalogue produites par les systèmes de visualisation rapide SPOT ont servi à produire des listes classées des images SPOT recueillies au-dessus du territoire canadien, dont la couverture nuageuse et le mode d'acquisition. Le CCT prévoit mettre sur pied un nouveau système d'inventaire d'images en direct pour SPOT et d'autres satellites.

Le sous-système d'affichage d'images TRIAD du système en temps partagé est encore largement utilisé pour le contrôle de la qualité des produits numériques et pour les projets de recherche. Le sous-système de production d'images en noir et blanc du microdensitomètre de balayage du scanner multibande a servi essentiellement à produire des images à partir de données radar (632 pellicules d'avril 1986 à mars 1987).

La production de données satellitaires à Ottawa, entre avril 1986 et mars 1987 a été la suivante: Imagerie TM pseudo-corrigée en vrac du système de transcription du capteur TM; 686 B.O. et produits photographiques. La production à partir du DICS et du système de transcription du capteur TM a pris fin en 1986-87.

Un total de 791 B.O. de données de signaux hyperfréquences SEASAT on tété transcrits à partir des BMHD, ce qui correspond à environ la moitié des données archivées recueillies à Shoe Cove. Pour le moment, il n'existe aucun projet pour transcrire et traiter la seconde moitié des archives. En 1986-87, un total de 87 B.O. de SEASAT ont été transformées en images.

L'imageur couleur (CIR) a produit 320 documents photographiques entre avril et décembre 1986. Il s'agissait de produits en couleurs à la demande, de films de bandes adaptées aux besoins des utilisateurs, de films du Système de correction des images numériques et de produits du capteur TM et de capteurs aéroportés. Le nouvel imageur de films en couleurs qui a été mis en opération a produit 239 images entre septembre 1986 et mars 1987.

Le système MOSAICS a été exploité dans les locaux de MacDonald Dettwiler & Associates (MDA) du début avril 1986 à la fin novembre 1986. Pendant cette période, 848 films couleurs, 246 films en noir et blanc et 478 B.O. ont été produits en réponse aux commandes des utilisateurs. Le système MOSAICS a été installé et mis en opération à PASS en janvier 1987. Entre janvier et mars 1987, MOSAICS a généré 317 produits MSS, TM et SPOT. On prévoit que l'arriéré des données LANDSAT et SPOT aura été traité pour avril 1987.

Développement et produits de traitement de données aériennes

Le système actuel aéroporté de traitement de données V & IR (AIR I) a été entièrement opérationnel en 1986. Au total, 744 B.O. (MEIS, MSS et FLI) ont été produites entre avril 1986 et mars 1987. Le système numérique du radar à ouverture synthétique (C-SHARP) a continué d'être entièrement opérationnel en 1986; 136 produits ROS ont été fournis entre avril 1986 et mars 1987.

En prévision de la charge supplémentaire occasionné par la demande de données SEASAT nécessaires aux missions du ROS IRIS aéroporté et RADARSAT, des travaux ont été effectués sur le C-SHARP pour améliorer son débit réel et sa capacité de traitement. Ces améliorations ont consisté à ajouter un processeur vectoriel et un espace disques supplémentaires ont permis d'accroître le débit réel du système de près de 100%. De plus, l'espace disques additionel permet de traiter des scènes SEASAT complètes de 100 km x 100 km.

La mise au point du système de traitement de données piloté par VAX, AIR II va bon train et le système devrait être mis en service en 1987. Grâce au système AIR II, les BMHD des données du MEIS, du scanner multibande, du FLI, de IRIS et du diffusomètre aéroporté pourront être transcrites sur B.O. AIR II fera la correction géométrique de l'imagerie et fournira notamment des produits de photogrammétrie aérienne géocodés, à l'aide des données de navigation de l'aéronef, pour effectuer la correction des images. L'ancien système AIR 1, en opération depuis 1974, sera mis hors service à la fin du mois d'avril 1987.

ACQUISITION DE DONNÉES

Programme de satellites

Programme LANDSAT

Les satellites LANDSAT 4 et 5 ont continué d'assurer la couverture du territoire canadien par MSS (LS-4 et 5) et TM (LS-5) avec seulement quelques perturbations mineures. Il a fallu apporter des changements importants au programme LANDSAT canadien en raison des coupures budgétaires et de l'addition du programme SPOT. Ces changements sont traités plus en détails sous les rubriques "Politique de réception" et "Produits et tarification".

La société EOSAT (Earth Observation Satellite Company), exploitant commercial des satellites LANDSAT, a été forcée d'abandonner progressivement le développement du nouvel engin spatial, des capteurs et des systèmes terrestres LANDSAT et de réduire considérablement ses efforts de commercialisation, en réponse à la suspension des fonds prévus pour l'année financière 1987 par le gouvernement des États-Unis. Toutefois, cette question n'est pas entièrement réglée et EOSAT attend d'autres nouvelles pour juin 1987. Il est très probable que LANDSAT 5 sera mis hors service (panne), avec les pertes de continuité de données TM que cela entraînera, avant le lancement de LANDSAT 6 en 1990.

Programme du satellite SPOT

Depuis le 16 juin 1986, date d'entrée en vigueur du programme d'exploitation SPOT au Canada, SPOT-1 a assuré une couverture régulière du territoire canadien. Au cours de l'année, les spécialistes ont découvert que l'exploitation des capteurs de l'instrument HRV en modes panchromatique et multibande causait une déformation de l'imagerie en raison de l'interférence entre les deux systèmes. De plus, le mode en modulation différentielle par code d'impulsions (DPCM) pour l'exploitation en panchromatique est maintenant utilisé pour toutes les acquisitions canadiennes en mode PLA (réseau linéaire panchromatique) à cause de la plage radiométrique extrêmement étroite des données obtenues en mode linéaire. Le véhicule spatial est en excellent état. Avec sa puissance de 10% supérieure aux prévisions et sa consommation de carburant de moins de 5% de sa réserve jusqu'à maintenant, la durée de vie du satellite a été prolongée jusqu'à trois ans.

Au cours des 9 premiers mois du programme SPOT, 70 000 scènes ont été introduites dans les archives canadiennes. De ce nombre, 8 400 scènes étaient exemptes de nuages et 4 600 autres ont été jugées "exploitables". (Ce ratio entre les scènes inutilisables et le nombre total de scènes apparaît également dans les archives LANDSAT).

État des satellite NOAA

NOAA-6 - Ce satellite est actuellement en attente.

NOAA-9 - Une récente défaillance de la voie 2 du MSU et les tentatives avortées de mise en marche du scanner ERBE ont fait devancer la date de lancement du satellite NOAA-H.

NOAA-10 - Les instruments d'exploitation fonctionnent bien.

NOAA-H - A cause de la défaillance du NOAA-9, le lancement a été prévu pour le 29 octobre 1987.

Statistique sur les ventes de produits pour l'année financière 1986-87

	Produits	$ (K)
MSS		
Photographies	1 648	126
Données numériques	146	106
TM		
Photographies	993	208
Données numériques	214	327
SPOT		
Photographies	1	1
Données numériques	5	10
Autres produits et services		77
		855 K

Le tableau suivant établit une comparaison entre le nombre de produits numériques livrés et les produits géocodés.

	Scènes brutes en vrac	Sous-scènes géocodées
MSS	128	18
TM	192	22
SPOT	5	0
	325	40

Modifications au programme

Suite aux récentes coupures budgétaires, le CCT s'est vu contraint de réduire ses coûts d'exploitation du Programme de satellites. Même si nous savions que toute modification des services offerts dans le cadre du Programme nuirait à une partie de la communauté des utilisateurs, il n'aurait pas été possible de réaliser les économies qui s'imposaient sans avoir pris les mesures suivantes:

- réduction du nombre de produits dans leur forme finale.
- Changement de politique de réception.
- Introduction de frais de réception.

Ces changements sont entrés en vigueur le ler avril 1987.

Produits et tarification

A compter du ler mai 1987, le personnel de production engagé à contrat à PASS sera mis à pied. Jusqu'au ler janvier 1988, au moment où le service de commercialisation des données satellitaires sera implanté, les fonctionnaires engagés pour une période déterminée et les étudiants stagiaires d'été aussureront l'exploitation de MOSAICS pour la production des B.O. et des films. (Comme par le passé, l'entrepreneur continuera d'assurer la réception et l'archivage). Le personnel en place permettra au Centre de traiter les produits bruts, en vrac et géocodés avec corrections systématiques. En raison du surcroît de travail que demande la réalisation des produits géocodés avec corrections de précision, ces produits ne seront plus offerts. Nous prévoyons que de nombreux utilisateurs opteront pour les nouveaux produits géocodés avec corrections systématiques. Les produits finals comprendront les diapositives originales (couleur ou noir et blanc) et les B.O. Le client devra se charger des agrandissements et des imprimés. Il est à noter que les données SPOT sont protégées par le droit d'auteur et que toute utilisation subséquente des produits SPOT fera l'objet de redevances à SPOT Image de France.

A compter du ler janvier 1988, nous prévoyons que l'entrepreneur responsable de la production, de la commercialisation et de la distribution des produits de données assurera également la production de l'imagerie géocodée avec corrections de précision et des pellicules photographiques.

Politique de réception des données satellitaires

Nous prévoyons que les coûts de réception et d'archivage des données satellitaires recueillies cette année par les stations de Prince-Albert et de Gatineau dépasseront 1,65 M$ si nous continuons d'appliquer la politique de réception des années passées. Avec la promesse de lancement de nouveaux satellites, sans compter la réception des données de ceux qu sont déjà en orbite, la consommation de bandes ne cessera de s'accroître et, compte tenu des augmentations inflationnistes du coût des bandes, la politique actuelle de réception est devenue prohibitive. La politique suivante est appliquée pour aider à réduire le volume de bandes utilisés et, par voie de conséquence, les coûts de réception. Cette nouvelle politique, appliquée conjointement avec l'épuration et le repiquage des archives actuellement en cours, aidera à réduire substantiellement les coûts d'exploitation.

Programme de réception à la station PASS

NOAA-AVHRR

La réception se fera à la demande entre le 15 avril et le 15 septembre. Il n'y aura pas de réception pendant l'hiver.

LANDSAT 4, Données MSS

La réception se fera à la demande entre le 15 avril et le 15 septembre. Il n'y aura pas de réception pendant l'hiver.

LANDSAT 5, Données MSS/TM

Réception de tous les passages, compte tenu des possibilités de couverture et des contraintes de réception SPOT, du 15 mars au 31 octobre, et à la demande entre le ler novembre et le 14 mars.

SPOT-HRV

Réception de tous les passages, compte tenu des possibilités de couverture et des contraintes de réception LANDSAT, du 15 mars au 31 octobre, et à la demande entre le ler novembre et le 14 mars. La réception des données SPOT et LANDSAT se fera à part égale.

Programme de réception de la station de Gatineau

SPOT-HRV

Réception de tous les passages, compte tenu des possibilités de couverture, du 15 mars au

31 octobre, et à la demande du 1er novembre au 14 mars.

Programme de réception EOSAT (Goddard)

LANDSAT 4, Données MSS

Réception à la demande des données de la côte est canadienne seulement, du 15 mars au 31 octobre. Il n'y aura pas de réception pendant l'hiver.

LANDSAT 5, Données MSS/TM

Réception de tous les passages couvrant l'est du Canada, entre le 15 mars et le 31 octobre, en échange des données de la partie ouest des États-Unis. Réception à la demande entre le 1er novembre et le 14 mars.

Frais de réception - pour toutes les données enregistrées à la demande

Des frais ont été établis pour décourager les demandes de réception courantes de données archivées qui ne seraient normalement pas acquises en raison de la nouvelle politique de réception.

Pour chaque passage (ou segment dans le cas de SPOT) enregistré à la demande, l'utilisateur devra payer des frais de réception pour compenser le coût des bandes numériques à haute densité.

- Le demandeur devra identifier une ou plusieurs scènes-cibles sur le parcours du satellite.
- Le demandeur recevra une micro-fiche des données recueillies.
- Si l'une des scènes-cibles comporte 10% ou moins de nuages (ou selon les instructions précises du demandeur), la bande sera archivée et le demandeur devra payer les frais de réception.
- Le demandeur se verra créditer un montant pouvant équivaloir aux frais de réception, pour les commandes subséquentes placées dans les 120 jours de la réception initiale, si les produits de données proviennent de la même bande. Le crédit ne sera accordé qu'au demandeur et n'est pas transférable.
- Les frais de réception sont de 100$.

Programme des opérations aériennes

Opérations aériennes

Le tableau suivant fait état de l'utilisation des aéronefs du CCT au cours de l'année financière 1986-87 pour chacune des quatre catégories de missions, ainsi que le genre d'applications correspondant à la mission et la province où les vols ont eu lieu.

CATÉGORIE	NOMBRE DE MISSIONS	HEURES DE VOL
Interne	31	268
Externe	11	38
Collaboration	6	136
	48	442

DISCIPLINE	NOMBRE DE MISSIONS	HEURES DE VOL
Agriculture	3	15
Environnement atmosphérique	1	8
Foresterie, faune		
Terres sauvages	9	38
Géographie	1	7
Géologie	12	39
Océanographie	7	195
Transport	1	3
Essais de capteurs	11	107
Essais d'aéronefs	2	17
Formation des équipages	1	13
	48	442

PROVINCE		
Colombie-Britannique	2	14
Alberta	1	16
Saskatchewan	3	15
Manitoba	1	11
Ontario	21	165
Québec	9	22
Nouveau-Brunswick	1	7
Terre-Neuve	2	50
Nouvelle-Écosse	3	12
Yukon	1	19
Territoires du Nord-Ouest	1	93
Autres	2	11
Divers	1	7
	48	442

Le nombre total de projets ainsi que le nombre d'heures de vol sont légèrement inférieurs aux totaux de l'année 1985-86. Cet écart est dû au retard dans l'installation du nouveau ROS à bande C à bord du Convair-580 et au fait que le Falcon-20 et le DC-3 ont été retirés du service le 31 octobre 1986.

Voici quelques unes des principales missions effectuées au cours de l'année financière 1986-87:

- DC-3 Levés bathymétriques au Lidar du passage du nord-ouest. Projet en collaboration avec le Service hydrographique canadien, à l'aide du système LARSEN-500, pour cartographier les approches de la Baie de Cambridge et du Détroit de Simpson. Il s'agit de la suite du programme commencé en 1985-86.

- Falcon-20 Projet de cartographie des dommages causés par la tordeuse des bourgeons de l'épinette au Nouveau-Brunswick, à l'aide du MEIS, du MSS et d'une caméra RC-10, en collaboration avec le ministère des Forêts du Nouveau-Brunswick.

- Un projet semblable a été mené en Colombie-Britannique en collaboration avec le Service des forêts de la Colombie-Britannique en vue de cartographier les dommages causés par le dendroctone du pin ponderosa.

- Falcon-20 Projet mené en collaboration avec Environnement Canada pour évaluer l'efficacité des dispersants d'hydrocarbures dans une zone de déversement contrôlé de la mer de Beaufort.

- Convair-580 Projet conjoint LIMEX (expérience sur la lisière des glaces au large des côtes du Labrador) et LEWEX (étude des vagues intenses de la mer du Labrador) au large de la côte de Terre-Neuve à l'aide du ROS en bande C et des diffusomètres en bandes C et Ku.

Le Falcon-20 et le DC-3 se verront vendus au secteur privé. Le DC-3 servira de plate-forme au bathymètre Lidar Larsen-500. Nous espérons que le Falcon-20 continuera de voler avec le module de capteurs électro-optiques du CCT qui sera mis à la disposition de l'industrie privée dans le cadre d'un contrat de location.

Nombre de B.O. produites au cours de l'année financière 1986-87

	Interne	Externe
MEIS	303	150
MSS	83	85
Diffusomètre	8	0
FLI	0	38
C-IRIS	70	7
	464	280

Capteurs à hyperfréquences

Le nouveau ROS en bande C entièrement numérique, livré en 1986, a été évalué et testé en laboratoire avant d'être installé à bord du Convair-580. La mise en service du système a été accompagnée d'une série complète d'essais en vol en vue d'évaluer tous les aspects de la performance du système. L'imagerie recueillie a permis de démontrer le potentiel du système, mais l'amplificateur à haute puissance et sa fiabilité ont posé certains problèmes qui ont nécessité de longues heures de dépannage et de réparation. Les essais ont repris au début de 1987. Des données ont été recueillies lors de missions d'étude de topographie générale au Québec, en Nouvelle-Écosse et au Nouveau-Brunswick et des caractéristiques de la glace et de l'océan au large de la côte est. En mars 1987, dans le cadre du programme de mise en valeur des données radar, des scientifiques de la Division de l'acquisition des données ont participé, à bord du Convair-580, à des campagnes internationales, connues sous les appellations LIMEX (expérience sur la lisière des glaces au large des côtes du Labrador) et LEWEX (étude des vagues intenses de la mer du Labrador), au large des côtes de Terre-Neuve. Les images recueillies par le ROS en bande C à bord du Convair-580 sont parmi les meilleures images jamais captées par radar civil. Au cours des campagnes, 10 vols ont été effectués avec succès, et les ensembles de données recueillies ont démontré avec certitude l'excellence qualité de l'imagerie et la performance remarquable du ROS en bande C. Des données ont également été recueillies avec le diffusomètre en bandes Ku et C. Des scientifiques de huit pays ont participé à l'opération à bord de cinq aéronefs, dont celui du CCT, et trois navires. Les ensembles de données recueillies à cette occasion sur les glace de mer et sur l'océan sont certainement parmi les plus complets. Ces données fourniront non seulement des informations océanographiques de base, mais serviront aussi à la modélisation de la glace et des vagues en vue d'obtenir une meilleure qualité de prévision des vagues et des glaces de mer.

Les spécialistes n'ont toutefois pas cessé d'améliorer le ROS en bande C. Nonobstant la fiabilité du système qui a été démontrée lors de la campagne de mars, l'amplificateur à haute puissance est actuellement en cours de modification et de reconditionnement en vue d'éliminer les longs temps d'arrêt causés par les défaillances. On a également ajouté un amplificateur d'appoint de moindre puissance en bande C ou X. L'antenne actuelle, qui était utilisée avec l'ancien ROS à bord du CV-580 et dont la conception a été modifiée en vue d'obtenir une largeur de faisceau plus

étroite, sera adaptée dans l'appareil après le programme d'été d'acquisition de données. L'antenne sera également pressurisée pour permettre l'émission de toute la puissance et d'obtenir une performance maximale en mode de bande de visée large. Les essais de la nouvelle antenne ayant été concluants, les techniciens procèdent aux modifications requises.

MacDonald Dettwiler and Associates, dans le cadre d'un contrat avec le CCT, travaille actuellement à la mise au point du ROS en bande X, système entièrement numérique dont la performance est semblable à celle du ROS en bande C. Le projet n'accuse aucun retard et le système est présentement en phase d'intégration finale et d'essai dans les locaux de l'entrepreneur. Le système devrait être livré en mai tandis que son installation dans l'aéronef est prévue pour l'été 1987.

Dans le cadre des activités courantes d'étalonnage et de validation des systèmes radar, un site d'étalonnage a été choisi pour une durée à long terme et les cibles d'étalonnage au sol ont été conservées.

Systèmes de capteurs à ondes du visible et de l'infrarouge

L'exploitation du module de capteurs électro-optiques installé à bord du Falcon du CCT a permis de recueillir une moisson abondante de données pour plus de 36 projets de recherche menés à l'intention des utilisateurs de produits de télédétection.

Au nombre des projets importants de la Division de l'acquisition des données figurait l'évaluation du MEIS appliqué à la foresterie, assortis de projets pilotes au Nouveau-Brunswick et en Colombie-Britannique, et l'acquisition d'imagerie stéréo et multibande à partir des bandes passantes spectrales optimisées pour la foresterie. D'autres projets ont porté sur la capacité de résolution spectrale élevée du MEIS (par exemple, la mesure de la compétition végétale) et sur sa performance radiométrique (par exemple, les mesures de la qualité et de la profondeur de l'eau). Des ensembles de données de l'éclairement solaire ont été acquis à l'aide du spectroradiomètre récemment installé à bord de l'aéronef. Ces données sont utilisés pour la mise au point d'algorithmes améliorés de correction atmosphérique. Un autre projet important a été la poursuite de l'évaluation et de la mise au point des capacités cartographiques des systèmes. Des vols ont été effectués avec les imageurs MEIS et MSS, et des techniques de mise en correspondance d'image ont été appliquées pour calculer des modèles numériques de hauteur. Les ensembles de données acquises simultanément par le système de balayage Lidar et le MEIS ont permis d'évaluer le potentiel du système Lidar pour la mesure de la hauteur des arbres et la densité du couvert forestier.

Le système électro-optique aéroporté a été très utile lors de l'essai dans la mer de Beaufort. Cette importante campagne, à laquelle ont participé des représentants de l'industrie pétrolière et des organismes de réglementation, visait à étudier l'efficacité de divers dispersants de déversements d'hydrocarbures. D'autres systèmes et aéronefs ont été utilisés, mais seule l'installation du CCT, dont la performance et la fiabilité sont établis, a permis de déterminer les résultats de l'essai.

Le Falcon du CCT, mis en vente en raison des contraintes budgétaires, a effectué son dernier vol pour le CCT en octobre 1986. Nous aurons quand même accès au capteurs électro-optiques, d'une façon différente, à compter de juin 1987. Dans le but de promouvoir et d'accélérer la mise au point d'applications commerciales de la technologie électro-optique, le module électro-optique a été offert sous forme de prêt. Une demande de proposition a été faite visant la prestation de services au CCT avec l'équipement prêté ainsi que la vente de tels services à d'autres utilisateurs de la communauté; les soumissions sont en cours d'évaluation.

Au cours de 1986, les capteurs ont été équipés de filtres anti-décalage vers le bleu pour l'exploitation du MEIS. La conception et la mise en application courante de ces filtres interférentiels, dont la réponse spectrale est uniforme sur toute la largeur du champ de vision du capteur, marque un pas important dans la technologie des imageurs à barretttes.

La mise au point de l'installation d'étalonnage automatique des capteurs-imageurs à éléments multiples est terminée. L'installation qui a servi à l'étalonnage géométrique et radiométrique du nouvel ensemble de filtres du MEIS constitue un moyen rapide et précis d'évaluer la performance des capteurs. Cette installation constitue un pas de plus dans l'exploitation des imageurs à barrettes en matière de recherche et d'opérations en télédétection.

Le dispositif d'affichage en temps réel Alice II du MEIS et du MSS est maintenant capable de produire un choix d'accentuations pour l'obtention des données préliminaires et l'analyse d'images à bord de l'aéronef sans

devoir procéder à la transcription après-vol des bandes de données.

En ce qui concerne les systèmes électro-optiques actifs, la conception détaillée du fluorodétecteur à laser s'est terminée conformément au calendrier, dans le cadre d'un contrat entre le CCT et Barringer Research Limited. Le projet qui a été subventionné par le Bureau de la recherche et du développement énergétique visait la création d'un système de surveillance de la pollution chronique dans l'Arctique et en haute mer, en portant une attention particulière aux exigences opérationnelles. Malheureusement, en raison des coupures budgétaires, la portée du contrat a été réduite et les travaux visant à terminer la fabrication du système ont été annulés.

Le DC-3 du CCT a joué un rôle important pour la mise au point du système électro-optique actif, du fluorodétecteur à laser et du lidar. Il a effectué son dernier vol en tant qu'aéronef du CCT en octobre 1986, lors des levés hydrographiques LARSEN (lidar) dans l'Arctique. L'appareil sera vendu en raison des contraintes budgétaires. L'adjudicataire continuera de fournir les services de plate-forme en vue de répondre aux besoins des utilisateurs de levés hydrographiques.

PROGRAMME RADARSAT

Introduction

La dernière année a surtout été marquée par des activités découlant du nouveau Programme spatial canadien annoncé en mai 1986 et qui comprenait certains aspects du développement de la télédétection par satellite. Le Programme spatial prévoyait la poursuite des travaux de planification du projet RADARSAT en ayant pour objectif la réduction des coûts, l'obtention d'aide financière du secteur privé et des gouvernements provinciaux et étrangers et la soumission d'une proposition révisée du projet RADARSAT en moins d'un an. De plus, il prévoyait un montant annuel de 5M$ pour un programme de télédétection d'une durée de quinze ans [Programme de développement de données radar (RDDP)]. Il prévoyait également un accroissement des relations avec l'Agence spatiale européenne (ASE) grâce à une participation suivie au programme ERS-1 et autres projets de télédétection. Tous ces aspects et autres développements sont mis en lumière dans le présent rapport.

Développement du projet RADARSAT

On a fait appel à SPAR Aerospace pour réviser la conception du projet et recommander des options qui tiendraient compte des décisions prises dans le cadre du programme spatial. Les recommandations de SPAR, qui découlentt de consultations approfondies avec le Bureau de projet RADARSAT (BPR) et les principaux utilisateurs, préconisent l'utilisation d'un satellite en orbite hélyosynchrone équipé d'un ROS amélioré capable d'offrir une variété de choix d'acquisition de données en termes de largeur de bande de visée, de résolution et d'angle d'incidence. Le ROS sera maintenant orienté vers la droite en vue de permettre la couverture de l'Extrême-Arctique (jusqu'à environ 87°N). Il assurera la couverture de l'ensemble du Canada, dans un sous-cycle répétitif de trois jours, et celle de l'Arctique, notamment du passage du nord-ouest, en effectuant plusieurs passages quotidiens.

Le principal mode "d'exploitation" continuera d'assurer une bande de visée de plus de 100 km avec une résolution de 28 m x 30 m et quatre angles de visée. La bande de visée pourra être choisie parmi un groupe de sept bandes couvrant un couloir de 500 km, à des angles d'incidence de 20° à 49°. On a également retenu deux larges bandes (environ 150 km chacune) avec une résolution de 40 m, 4 angles de visée avec des angles d'incidence de 20° à 40°, ainsi que des faisceaux expérimentaux avec des angles d'incidence variant de 49° à environ 60°. Deux modes ROS nouveaux et extrêmement utiles ont été ajoutés: un mode "Haute résolution" et un mode "Balayage". Le mode haute résolution assurera une bande de visée d'une largeur approximative de 55 à 90 km, avec une résolution de près de 8 m. Un choix d'au moins cinq de ces faisceaux sera assuré dans la bande de visée accessible de 500 km. Le mode ROS "balayage" assurera de très larges bandes de visée (300 km x 500 km) avec une résolution d'environ 100 m et 6 angles de visée. Ce mode permettra d'obtenir de l'imagerie de levée (par exemple de zones de glace) sur la totalité du couloir en une seule fois.

Comme prévu, les États-Unis assureront le lancement et le Royaume-Uni fournira la plate-forme. Le Royaume-Uni pourra également fournir des capteurs dont un altimètre radar (AR) et un radiomètre à balayage longitudinal (ATSR) et, peut-être, des versions améliorées des capteurs ERS-1. La mission RADARSAT est maintenant conçue pour une période de 5 ans, l'entretien en orbite ayant été annulé en vue de réduire les coûts. A la lumière de ces changements, on a demandé à Douserv-Econosult de reprendre l'analyse économique et l'évaluation de la mission RADARSAT. Cette étude qui devrait être bientôt terminée montre déjà que les avantages économiques globaux sont sensiblement les mêmes, sauf pour quelques changements occasionnés par la durée de vie réduite

de la mission et le retrait du capteur optique à haute résolution qui auront une incidence sur les applications en agriculture et en foresterie. Toutefois, les résultats coûts/bénéfices prévus semblent plus importants en raison de la réduction substantielle des coûts et du taux de pénétration prévu du marché à la suite de l'annonce du RDDP dans le dernier programme spatial.

Développement des applications et Programme de développement de données radar

La mise au point des applications du ROS par le Bureau du projet RADARSAT a connu des progrès intéressants au cours de l'année qui vient de s'écouler. Ces travaux ont été entrepris par les coordonnateurs des applications portant sur la glace de mer, les océans et les ressources terrestres renouvelables et non renouvelables; l'appui scientifique et technique a été fournie sous contrat par F.G. Bercha and Associates Ltd. (Ontario). Les travaux d'application sur les glaces ont porté particulièrement sur l'analyse des données ROS disponibles en vue d'établir des signatures de glace et d'iceberg et sur la mise au point d'une méthode de repérage automatique des glaces pour utilisation avec l'imagerie du ROS. La mise au point des algorithmes de surveillance du mouvement des glaces a procédé suivant deux voies: la première étant une technique utilisant des descripteurs d'objets et la deuxième employant une structure hiérarchique qui a pour avantage de réduire les volumes de données. Cette dernière technique a donnée des résultats des plus prometteurs lors des essais effectués sur l'imagerie ROS de SEASAT de la glace de mer dans l'Arctique. Le modèle élaboré, actuellement affiné et vérifié, est conçu pour rendre compte des mouvements de rotation et des changements de signature. Les utilisateurs de données sur les glaces peuvent obtenir de plus amples informations sur ces projets et autres développements connexes dans le Bulletin publié régulièrement par le BPR avec le concours du Service de l'environnement atmosphérique (SEA). Ce bulletin a reçu un très bon accueil et est distribué à plus de 250 abonnées à travers le monde. Les travaux du groupe de travail sur les applications océaniques ont porté particulièrement sur l'analyse des retours radar de navire apparaissant sur l'imagerie ROS et sur l'extraction d'informations sur les vagues océaniques d'après les données ROS. Les experts ont procédé à l'étude et à la comparaison de modèles théoriques d'imagerie ROS des vagues océaniques et à la mise au point de logiciels de correction et d'analyse des données ROS pour ce type de vagues. Les travaux comprenaient également la mise au point de techniques d'évaluation des spectres des vagues océaniques à partir des données ROS.

Quant aux travaux sur les applications relatives aux ressources terrestres renouvelables, l'accent a porté sur la poursuite des recherches de données ROS disponibles pour l'établissement des types de culture, l'évaluation des conditions de culture et l'établissement des effets paramétriques des capteurs et des terres/végétation sur la rétrodiffusion radar. Ces études comprenaient l'analyse d'ensembles de données ROS multi-temporelles et ROS et VIR combinées ainsi qu'une évaluation préliminaire de l'effet de la neige sur le retours radar de la couverture végétale. Le ROS a également servi à certains travaux en foresterie dont l'analyse des données ROS disponibles ainsi que celles d'autres capteurs pour la surveillance des coupes à blanc et de la régénération, la détection et la cartographie des processus de conversion des forêts tropicales et le traçage des effets topographiques. Les travaux de développement des applications relatives aux ressources non renouvelables ont porté essentiellement sur des études ROS en stéréo, des analyses de l'imagerie ROS seule et avec d'autres ensembles de données en vue d'obtenir des informations géologiques, de mettre au point et évaluer les logiciels permettant d'entreprendre ces analyses et d'afficher les résultats en divers formats et projections. Ces études incluaient l'utilisation de la texture dans la discrimination des types de roche, l'évaluation de l'effet des angles d'incidence, la valeur de la résolution ainsi que d'autres paramètres sur la qualité de l'imagerie radar, l'importance de l'information géologique et la démonstration de la construction en mosaïque des données ROS.

Dès le début, les chercheurs ont reconnu qu'on ne disposait pas de données ROS en bande C suffisantes (bande de fréquence du ERS-1 et du ROS de RADARSAT) pour entreprendre des travaux de développement des applications. C'est pourquoi des plans ont été élaborés pour acquérir des données ROS en bande C dans chaque domaine d'application dès que le nouveau système ROS-580 du CCT sera mis en opération. La première occasion de cueillette des données sur la glace et les océans se présentera lors des expériences importantes qui seront menées au large de Terre-Neuve et du Labrador. L'expérience sur la lisière des glaces au large des côtes du Labrador (LIMEX) et l'étude des vagues internes de la mer du Labrador (LEWEX) s'inscrivent dans le cadre d'un plan de développement des applications pour l'utilisation des données ROS satellitaires en vue de la surveillance et de la prévision des glaces et des vagues océaniques.

Les expériences effectuées à l'aide du ROS-580 en mars 1987 font partie d'un grand projet conjoint organisé par les coordonnateurs des applications relatives aux glaces et aux océans, et incluant d'autres chercheurs et organismes du Canada (essentiellement SEA et BIO) et des États-Unis. Une grande quantité de données de surface et connexes seront recueillies à l'aide de trois navires équipés aux fins de l'expérience, de quatre aéronefs et d'instruments in situ.

Des plans détaillés ont été établis pour assurer la poursuite du développement des applications et autres travaux sous la direction du RDDP. Ce programme de télédétetion fait appel au développement de la technologie et des applications de pointe pour la réception, le traitement et l'analyse des données radar et autres données télédétectées. Le RDDP s'intéresse particulièrement à la technologie radar et à l'utilisation des données connexes pour la surveillance des glaces, l'océanographie (incluant la détection de navires) l'agriculture, la foresterie, la géologie, l'hydrologie, la géographie ainsi que d'autres applications. Ce programme a pour but de fournir un appui à l'utilisation des données radar, au traitement et l'analyse d'images en vue de permettre au Canada de maintenir son leadership international dans les infrastructures terrestres qui utilisent des données télédétectées. Le RDDP qui vient d'être approuvé par le Conseil du Trésor, entrera en opération en avril 1987.

Développements du ERS-1

La participation constante du Canada au programme ERS-1 de l'ASE a déjà permis de profiter des retombées industrielles satisfaisantes ainsi que d'autres avantages. Des compagnies comme MDA, SPAR et COMDEV sont sous contrat avec l'ASE pour la mise au point et l'approvisionnement de matériels et de logiciels destinés au ERS-1. Ainsi, la compagnie MDA assume l'entière responsabilité de la station de réception à Kiruna (Suède) (principale station terrestre ERS-1) et fabrique également le processeur au sol des données ROS tandis que SPAR fournit l'équipement de télémétrie. De plus, des contrats ont été accordés aux compagnies R. Ball & Associates et DIGIM pour des travaux de développement d'applications pour ce système.

Au nombre des activités qui se sont déroulées l'année dernière, une place importante a été accordée à la coordination et à la préparation des propositions canadiennes en réponse à l'Avis de participation de l'ASE pour la validation géophysique et l'utilisation scientifique des données ROS et celles d'autres capteurs qui seront fournies par ERS-1 après son lancement en 1989-90. Les chercheurs canadiens ont soumis sept propositions à l'ASE. La glace, la géologie, l'agriculture/foresterie ont chacune fait l'objet d'une proposition tandis que les applications océaniques et l'étalonnage des capteurs ont fait l'objet de deux propositions chacune. De plus, les besoins de données nationales pour la mission ERS-1 sont actuellement établis, en consultation avec les principaux ministères et organismes comme le SEA et le MPO.

Conclusion

Au cours de la dernière année, on a consacré beaucoup de temps à la proposition révisée de RADARSAT. Cette proposition est en cours de préparation et devrait être soumise très bientôt. Le Cabinet en commencera la révision en avril et une décision devrait être annoncée peu de temps après. De plus, les applications radar et les autres travaux de développement au Bureau du projet RADARSAT se poursuivent dans le cadre du RDDP, conformément aux plans élaborés l'année dernière. Etant donné qu'il est déjà approuvé, le RDDP assure la continuité dans la poursuite de ces travaux, en préparation de l'utilisation des données radar qui seront recueillies par ERS-1, RADARSAT et d'autres satellites dès 1989-90.

5.1 REPORT OF THE WORKING GROUP ON AGRICULTURE

Agriculture/Radar Sub-Committee

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

Due to the increasing cost of collecting ground data, the sub-committee considered the establishment of supersites for remote sensing mission specific to agriculture/radar. The following criteria were established: strong commitment to collection of detailed, well-coordinated ground data; areas amenable to multi-disciplinary studies; efforts to establish a ground calibration system similar to US for SIR-B; a central agency to sponsor each site (ensuring accessible of data); standardization of data collection. It was suggested that more sites are needed in addition to the existing sites in western Canada. Proposals are been requested from the remote sensing community. Proposals should contain detailed background information (soils, topography, geology, land use, etc) together with current remote sensing interests and activities.

In order for more scientist to take advance of radar technology, the sub-committee started work on a workshop series to be part of the next Canadian Remote Sensing Symposium at Waterloo. The workshop will be geared towards individuals with agricultural-related interests who had assimulated knowledge or who are currently working in optical remote sensing. The course would last for three days and cover radar fundamentals, SAR systems and applications.

The sub-committee co-ordinated the submission of a proposal for a Canadian experiment using the European Space Agency (ESA) European Resources Satellite (ERS-1) radar satellite. The team of scientists from across Canada will be co-ordinated by Ron Brown of CCRS. The project will look at unique crop management and soil-climatic areas of Canada. The objective of the proposal is the imlementation of SAR with crop information system (CIS) - crop identification and area estimation, crop condition and yield estimates, and catastrophic events. The location of the experiments will be Oxford, Ont., Sherbrooke, Que., Carberry and Fannystelle, Man., Swift Current/Outlook/ Melfort, Sask.

Distribution of Data Sets: CCRS has made a considerable number of SAR data sets available to Universities and Provincial Centres. University researchers have already made presentation of their findings at the lastest Canadian Remote Sensing Symposium in Edmonton and more are expected at the next symposium. The sub-committee is pleased with the results, the increase in knowledgeable scientists and use of good CCRS data.

Ground Microwave Experiment: The CCRS contract with the University of Saskatchewan is continuing but without the financial support of Canada Agriculture as specified in the DSS contract. The first two electrical engineering graduate students in this program will be presenting their theses in the Spring of 1987.

Recommendations:

The sub-committee recommends that:

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,

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

Sub-Committee Members:

Jeff Whiting (Chairman)
Saskatchewan Research Council
15 Innovation Blvd.,
Saskatoon, Sask.
S7N 2X8
306-933-5423

Dr. M.S. Akhavi
Nova Scotia Land Survey Inst.
P.O. Box 10
Lawrencetown, Nova Scotia
B0S 1M0

Dr. Ron Brown
Can. Centre for Remote Sensing
2464 Sheffield Rd.,
Ottawa, Ont.
K1A 0Y7
613-993-9873

Dr. Peter Crown
Soil Sciences Dept.,
University of Alberta
Edmonton, Alberta
T6G 2E3
403-432-2886

Hugh Gwyn
Faculté des arts
Université de Sherbrooke
Sherbrooke, P.Q.
J1K 2K1

Dr. M. Hamid
Electrical Engineering Dept.,
Univ. of Manitoba
Winnipeg, Man.
R3T 2N2
204-474-9641

Dr. Phil Howarth
Faculty of Environmetal Studies
University of Waterloo
Waterloo, Ont.
N2L 3G1
519-885-1211

Alex Mack
Dept. of Agriculture
CEF Building 74
Ottawa, Ont.
K1A 0C6
613-995-5011

Dr. Dick Protz
Land Resources Sc.
University of Guelph
Guelph, Ont.
N1G 2W1
519-824-4120

Rangeland Sub-Committee

TERMS OF REFERENCE

The mandate of the Rangeland Subcommittee is to examine and report to CACRS on the following issues:

1) The current operational use of remote sensing in rangeland application in Canada;

2) The estimated total potential for the use of remote sensing in rangeland application in Canada;

3) The steps which need to be taken in Canada to realize that potential; and

4) The estimated market for the technologies developed in Canada in other countries (especially third world).

The Subcommittee was set up in 1984 with a lifetime of two years. This was extended in March 1986 for an additional two years. The members of this Subcommittee include representatives from provincial "user" agencies, private industry users, and federal and provincial researchers, with emphasis on representation from the four western provinces.

Airborne Remote Sensing

CIR and panchromatic aerial photography continue to be used by range managers as basic tools (e.g., existing CIR photography is preferred by range inspectors in southern Alberta range over MSS products).

Spaceborne Remote Sensing

A limited amount of research is continuing in the application of Landsat MSS and TM to rangeland management. The major program is being carried out by CCRS in Alberta, to evaluate the application of TM data in the fescue grasslands. Results show that it can be used effectively for evaluation of pasture "quality", but not for quantative biomass estimates. No rangeland research using SPOT is yet underway, but is recommended.

Current use of spaceborne remote sensing for rangeland applications includes:

1. Landsat MSS
   - 1 scene used by PRFA for pasture planning in 1986
   - some data used by Ducks Unlimited for wetlands
   - about 10 scenes (enhanced) used by Alberta Agriculture in southern Alberta.
2. Landsat TM
   - used extensively by Ducks Unlimited for wetlands inventory.
   - under investigation by Saskatchewan Crop Insurance for forage inventory.
   - small study in Manitoba by PFRA for pasture management.
3. NOAA-AVHRR
   - evaluation by Alberta Agriculture begun in central Alberta for inventory of drought-stricken areas, with promising results and planned use for 1987.
   - interest expressed by Saskatchewan Crop Insurance for use in evaluating soil moisture related to forage growth.

Thus, although interest in the use of spaceborne remote sensing is continuously expressed by existing and potential user agencies, most are unable to continue programs or undertake new initiatives, due to limited budgets (few of which include research and development funding) and available labour. A serious decline in overall research commitments by Agriculture Canada was noted. There are now only two range research scientists in Canada, research program funding is very low, and university research is moving to biotechnology and away from rangeland management. Training programs and workshops offered by agencies such as the Saskatchewan Research Council (Technology Enhancement Program) and the Alberta Remote Sensing Center have been well attended and generally raised the level of interest. Range managers as remote sensing users are willing to use products if they are inexpensive but still want to obtain quantitative biomass information.

International Programs

Current programs outside of North America were briefly reported on in 1986 in order to more effectively evaluate the potential for extending Canadian remote sensing technologies to other world rangeland regions. Australia's programs appear current and well-established, with much attention also focussed by international aid agencies in Africa (although there is a serious Landsat coverage problem due

to lack of receiver stations in Africa). Programs in China, India and other areas are usually carried out in the context of general land use programs and not reported as rangeland remote sensing programs per se, but Landsat data are being utilized.

New Initiatives

Two major initiatives were identified for the extended two-year term of the Subcommittee:

1. RANGELAND INVENTORY FOR CANADA

An estimated 40-60% of Canadian rangeland is in fair to poor condition. The Subcommittee will support an initiative by Alberta Agriculture to promote and carry out an inventory of the extent of rangeland in western Canada, including identification of the intensively grazed range within this area using MSS and TM data. Such a benchmark data base would then be used for monitoring future changes in range, down to the section level.

2. CANADIAN RANGE REMOTE SENSING PUBLICATION

The task of preparing a practical illustrated compendium on the demonstrated uses of remote sensing for rangeland management in Canada was undertaken in 1986. Its target audience would be Canadian decision-making managers and field users, plus the international range management community, with the objective of providing enough practical information that they can evaluate the application of such techniques to their own requirements.

Conclusion and Forecast

Remote sensing continues to hold promise for current and future application in rangeland management programs in Canada and elsewhere. This has been demonstrated in several programs over the past few years, but incorporation into "user" programs has been generally very slow due to limited budgets, and lack of commitment by decision-making managers. Future break-throughs in the application of remote sensing for range management will require improved satellite resolution (e.g., SPOT, not yet evaluated) and extraction of quantitative biomass information. The recommendations for 1987 are made with these conclusions in mind.

Recommendations

1. 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.

2. The RSC 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 RSC 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 RSC in early 1987.

3. The RSC 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 assessment

4. The RSC recommends that the AWG, 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.

Appendix 1. List of Subcommittee Members

RANGELAND SUBCOMMITTEE OF THE AGRICULTURE WORKING GROUP

March 1986 - March 1988

Diane Thompson, Chairman
INTERA Technologies Ltd.
1200, 510 5th Street S.W.
CALGARY, ALBERTA T2P 3S2
(403-266-0900)

Ian Sutherland
Alberta Remote Sensing Center
11th Floor, Oxbridge Place
9820 106th Street
EDMONTON, ALBERTA T5K 2J6
(403-427-2381)

Monique Bernier
Canada Centre for Remote Sensing
2464 Sheffield Road
OTTAWA, ONTARIO K1A 0Y7
(613-993-9881)

J. Kent Watson
International Remote Sensing Surveys
120, 643 McBeth Place
KAMLOOPS, B.C. V2C 5V9
(604-372-0958)

Dr. Alex R. Mack
Agroclimatology Section
Land Resource Research Institute
Agriculture Canada
Building 74, C.E.F.
OTTAWA, ONTARIO K1A 0C6
(613-995-5011)

Duane H. McCartney
Melfort Research Station
Agriculture Canada
P.O. Box 10
MELFORT, SASKATCHEWAN S0E 1A0
(306-752-2776)

Hugh Cook
Prairie Farm Rehabilitation Administration
1901 Victoria Avenue
REGINA, SASKATCHEWAN S4S 0B1
(306-780-5159)

Barry Adams
Public Lands Division
Alberta Energy and Natural Resources
3rd Floor, Sun Center, Bag 3014
530 8th Avenue South
LETHBRIDGE, ALBERTA T2J 2J8
(403-329-5486)

Don Gayton
Soils & Crops Branch
Saskatchewan Agriculture
Walter Scott Building, Room 133
3085 Albert Street
REGINA, SASKATCHEWAN S4S 0B1
(306-787-7712)

Crop Information Sub-Committee

Crop Information System Initiative

A pilot project 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 were necessary to be made to the procedures to better meet the operational requirement of agencies like the Wheat Board. For the processing carried out in 1985 and 1986 it was required that the scenes be essentially cloud free for the radiometric correction procedure to work effectively. However, it has been found that the approach where a composite image is generated such that, for a particular area, the clearest pixel for the week is output to the composite image, is a better approach. The Crop Information Subcommittee 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 which will go a long way towards introducing remotely sensed data into the operational activities of agriculturally related agencies.

The basis for the specification of this system was a report produced by CDA, CWB, SC, AES and CCRS for a senior management steering committee. This system is designed to meet the current and 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.

Crop Information System Subcommittee Members

Dr. A.R. Mack (Acting Chairman)
Agrometeorology Section
Land Resource Research Institute
Department of Agriculture
Arboretum Building No. 74, C.E.F.
Ottawa, Ontario
K1A 0C6

Dr. Josef Cihlar
Applications Technology Division
Canada Centre for Remote Sensing
1547 Merivale Road
Ottawa, Ontario
K1A 0Y7

Mlle Mireille Therrien
Direction de protection du géographe territoire agricole
Ministère de l'Agriculture, des Pêcheries et de l'Alimentation
Gouvernement du Québec
200 - A, chemin Ste-Foy, 2e étage
Ste-Foy, Québec
G1R 4X6

Mr. G. Oliver Code
Agriculture Statistics Division
Statistics Canada
Main Building, Tunney's Pasture
Ottawa, Ontario
K1A 0T6

Mr. Mervin Ross
Saskatchewan Crop Insurance Corporation
2240 Albert Street
Regina, Saskatchewan
S4P 2J3

De. Michael Dillon
Department of Agriculture and Rural Development
P.O. Box 6000
Fredericton, New Brunswick
E3P 5B1

Dr. Brian Halstead
Manitoba Crop Insurance Corporation
25 Tupper Street North
Portage La Prairie, Manitoba
R1N 3K1

Dr. Peter Crown
Department of Soil Science
University of Alberta
Edmonton, Alberta
T6H 2E3

Mr. J.C. Henein, Director
Applications Technology Division
Canada Centre for Remote Sensing
1547 Merivale Road
Ottawa, Ontario
K1A 0Y7

5.2 REPORT OF THE WORKING GROUP ON CARTOGRAPHY AND PHOTOGRAMMETRY

The primary objective of the Working Group is the investigation on the applications to cartography of spaceborne imaging systems and airborne non-photogrammetric imaging systems. These applications include pictorial, graphical and digital cartographic products as well as geographically referenced data bases.

In the course of 1986, the activities of the Working Group encompassed the operational applications of Landsat imagery and Lidar Bathymeter data, and investigations related to the use of Metric Camera and Large Format Camera photography, and SPOT MEIS and SAR imagery.

OPERATIONAL APPLICATIONS

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 7600 km of aircraft field verification was accomplished and 1780 oblique photographs were taken for feature verification.

Terra Surveys Ltd., has in operational use a highly successful airborne survey technique for measuring water depths in coastal waters. The technique is based on the Larsen 500 Scanning Lidar Bathymeter System which incorporates a fully computerized shoreline mapping capability. The system was developed through the combined efforts of the Canadian Hydrographic Service, the CCRS and the private sector.

PRISM Information and Mapping Services Division of Gregory Geoscience Ltd., used Landsat TM data to map logging roads and forest changes at 1:10 000 scale. Output compared with data from photogrammetric plotting from 1:20 000 photography indicated position errors of 7 m and area differences of 1-2%.

GEOMETRY AND RESOLUTION OF IMAGING SYSTEMS

In the research work related to on-line photogrammetric systems, conducted in the Photogrammetric Research Section (PRS) of NRC, the emphasis continued to be placed on the development of algorithms applicable to geometries for non-standard, time-dependent imaging systems represented by line scanners and linear array sensors. These systems require a significantly modified approach to the real-time control of positioning of images in on-line photogrammetric systems. An extensive theoretical analysis was completed and successful feasibility tests conducted to prove the viability and practical value of these new generalized formulations.

Specific formulations for the Anaplot processing of stereo-images from the European SPOT satellite have been completed and are ready to be tested.

To ensure the high accuracy of the SPOT geometric evaluation, considerable effort was spent in 1986 to define and program and extensive set of auxiliary transformations between image-, model- and ground coordinate systems involved in the process of on-line measurements. 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 stereoimages. As a result, a unique software library of about 40 subroutines and functions is now available for immediate applications. The modular character of the developed software facilitates a straight-forward programming of any relevant photogrammetric tasks. Efficient solutions to all major problems have been derived and proven reliable in numerous simulations of practical applications.

Experiments with on-line processing of LFC imagery and their evaluation are in progress at PRS.

The evaluation of the metric potential of MEIS imagery using two low altitude lines flown over the NRC Sudbury Test Area is continuing in collaboration between PRS and CCRS.

At CCRS the Kananaskis Valley test area was re-flown with the MEIS stereo, laser profiler and GPS receiver systems to acquire data for the evaluation of all three systems. Similar flights were flown in cooperation with the University of Georgia.

A CCRS Forestry and DTM project was flown with MEIS stereo but no laser or GPS systems. Simultaneously acquired

photography has been processed by the Topographical Survey (EMR). The MEIS imagery will be processed in the near future at CCRS.

The new airborne SAR has been undergoing commissioning trials at CCRS. High quality imagery has been obtained.

CONTROL IDENTIFICATION AND EXTENSION

Investigations were conducted at the University of New Brunswick (UNB) into the accuracy obtainable for control extension utilizing Large Format Camera photography using ground control data obtained from the Surveys and Mapping Branch of Energy, Mines and Resources Canada, the locations of 118 ground control points (x,y,z) were identified on a strip of 9 photographs taken during orbit 38 of Space Shuttle mission 41G, October 1984. The strip, of approximate scale 1:788 000 extends over a 400 km track from Empress to Rockglen in Saskatchewan, Canada. The ground control points used were road intersections for which coordinates could be obtained from terrestrial observations. Photograph coordinates were measured in an OMI AP-2C analytical plotter.

The following computations were carried out:

- image refinement (including use of observed reseau);
- analytical model formation;
- independent model aerotriangulation;
- bundle aerotriangulation; and
- space resection of single images, and subsequent reprojection of photo coordinates.

It was concluded 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. Dense control meant 20 to 25 points per stereomodel, occupying an area of 110 by 180 km. Six ground control points used for adjusting a strip of 5 models covering an area of 400 by 180 km was regarded as sparse control.

Visual interpretability test of LFC photography is in progress at UNB with special emphasis on cultural and natural features shown on 1:50 000 topographic maps, and investigation will commence into the role and utilization of digital terrain models as ancillary data in digital image processing and analysis.

At the Laval University studies continued with Metric Camera photographs over Canada (scale: 1:837 000) obtained in two short strips covering areas in the provinces of Alberta and British Columbia - 1983 photography (strips of 3 and 7 photos, respectively).

Similar studies also continued with the Large Format Camera photographs over an area in the province of Quebec, (scale, 1:1 190 000) obtained in two strips - 1984 photography (one strip of 10 black & white photos and one strip of 3 colour infrared photos).

A large number of measurable points on these photos were identified on topographic maps (in scales 1:50 000 and 1:20 000), whose ground coordinates were transformed into 3-D geocentric system. Special emphasis was placed on two areas: (a) an area of Alberta (for MC photos) containing a triple overlap and, (b) an area in Quebec (for LFC photos) containing a quintuple overlap.

All measurements were made at the Wild STK-1 Stereocomparator and/or the Wild BC-1 analytical plotter. The typical pointing errors (deviations) in these are: 8 to 14 μm for the MC photos and 3 to 6 μm for the LFC photos.

Separately, self-calibration of the imaging systems were made, programs for which were being developed. These have been tested with success.

Additional LFC photographs covering areas in the NW part of Africa (Morocco-Algeria) were obtained.

The self-calibration program used at Laval University on the LFC photographs yielding a one-step solution containing both inner and outer (relative and absolute) orientations showed satisfactory results. Certain data like the focal length were in excellent agreement with the calibrated values provided by NASA. The elements of exterior orientation showed very realistic values e.g., standard deviations of the camera station coordinates, average being less than 70 m. The ground coordinates at observed points showed very encouraging results, e.g., standard deviation of any coordinate being less than 17 m.

At the Topographic Survey, EMR, an investigation is in progress into generation of DEM data from LFC photographs, and into control point

identification for correction of space imagery.

DEVELOPMENT OF TECHNIQUES AND SYSTEMS

Research in the Department of Surveying Engineering at the University of Calgary in remote sensing is continuing to focus in several directions. The first area involves application of specialized enhancement techniques with Landsat data e.g., Fourier filtering and spatial filtering, and automated digital correlation for information extraction in surveying and mapping.

The second area involves the development of methodology which will enable the updating of major features on topographic maps with the latest satellite imagery e.g., SPOT, etc. The methodology will be tested with recent imagery and in terms of the Alberta provincial map series. The report will classify achievable accuracy for certain features together with percentage reliability of interpretation. This work is funded by the Alberta Bureau of Surveying and Mapping of the Alberta Energy Mines and Natural Resources.

The third area involves the synthesis and integration of remote sensing data with other types of survey and mapping data into land-related information systems e.g., the development of a comprehensive LRIS of the Kananaskis Valley using Landsat data and, also, evaluation of computer storage methods for Landsat-derived raster data.

Research on the integration of image analysis with geographic information systems commenced in 1986 at the Department of Survey Science of the University of Toronto (Erindale). This work, with internal funding from the University of Toronto, will continue through 1987.

The Department has submitted a proposal to the Canadian International Development Agency to develop a geographic information system, with remote sensing content, for soil erosion management in China. Survey Science is participating with the Department of Geography on this proposed project, which is planned to extend over three years, and will have specific responsibility for the remote sensing aspects of the GIS development.

In cooperation with DIPIX Systems Ltd., the Photogrammetric Research Section of NRC is developing a Photogrammetric Digital Image Processing System for metrology of digital images with a facility for processing and analysis of stereo-images.

The CCRS geometric correction system for airborne line imager data known as AIR-II is nearing completion. The system is being built by Moniteq in Toronto. This is a dedicated system for the transcription and processing of airborne imagery in a production environment.

The CCRS has a contract in place with the University of Calgary (Surveying Engineering) to modify the Wild AC-1 Analytical Stereoplotter software to enable it to accept geometrically corrected line imager data on film. These modifications will enable the AC-1 to generate standard cartographic output products. Further ground processing techniques are being investigated at CCRS for cartographic applications of the new airborne SAR system.

MacDonald Dettwiler and Associates Ltd. has developed two essential techniques in its quest to produce cartographic-standard maps from remote sensing satellite imagery, and is continuing development of the various techniques that will be required for operational map production and revision. The developed technology is encapsulated in the company's MERIDIAN family of computer-based mapping systems.

The two essential techniques are operational geocoding and Digital Terrain Model (DTM) extraction. Geocoding transforms an image so that its pixels represent earth surface regions of uniform size, and align with the coordinate grid of a chosen map projection. The required process for Landsat and SPOT imagery was developed and implemented in the Multi-Observational Satellite Image Correction System (MOSAICS) recently delivered to the Canada Center for Remote Sensing. Further work is proceeded on operationally geocoding Synthetic Aperture Radar (SAR) imagery.

DTMs are essential for deriving topographic base maps using a computer-based system. MacDonald Dettwiler has successfully proved the concept of using computational vision techniques for extracting DTMs from Landsat and SPOT imagery with accuracies approaching those required by cartographic standards. This system is now being developed for the MERIDIAN ELEVATION subsystem.

At MacDonald Dettwiler, progress has been also made on two automated methods for identifying and classifying image features. The first of these involves identifying features by their spectral signatures, and the second uses artifical intelligence techniques to provide computer-based systems with rules for identifying features. These two classification techniques are being incorporated in the MERIDIAN BASE-MAP system.

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.

SPOT

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 Topographical Survey (EMR). The investigations under PEPS (Preliminary Evaluation Program for SPOT) will continue in 1987 when the needed SPOT imagery becomes available.

The development of a system for extraction of DTM's and for digital mapping from SPOT imagery is continuing at Photosur/DIGIM Ltd.

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 Service of the Quebec Ministry of Energy and Resources etc. All of these are awaiting the long overdue delivery of required SPOT imagery.

RECOMMENDATION

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.

APPENDEX I
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APPENDEX II
LIST OF MEMBERS

M.M. Allam
Energy, Mines and Resources
615 Booth Street
Ottawa, Ontario
K1A 0E9

Dominique Bruger
Ministère de L'énergie et des resources,
Service de la cartographie
1995, Boulevard Charest ouest
Sainte-Foy, Québec
G1N 4H9

J. Chyurlia
Kenting Earth Sciences
280 Hunt Club Road
Ottawa, Ontario
K1G 3N3

R. Depper
Terra Surveys Ltd.
2060 Walkley Road
Ottawa, Ontario
K1G 3P5

E. Derenyi
University of New Brunswick
Surveying Engineering Department
P.O. Box 4400
Fredericton, New Brunswick
E3B 5A3

S.K. Ghosh
Laval University
Department of Photogrammetry
Sainte-Foy, Quebec
G1K 7P4

J.R. Gibson, (Secretary)
Data Acquisition
Canada Centre for Remote Sensing (CCRS),
2464 Sheffield Road
Ottawa, Ontario
K1A 0Y7

G. Gracie
Erindale College
University of Toronto
3359 Mississauga Road
Mississauga, Ontario
L5J 2S5

A. Gregory
Gregory Geoscience
1750 Courtwood Crescent
Ottawa, Ontario
K2C 2B5

Z. Jaksic, (Chairman)
Division of Physics
National Research Council of Canada,
Montreal Road
Ottawa, Ontario
K1A 0R6

V. Kratky
National Research Council of Canada,
Photogrammetric Research Section
Montreal Road
Ottawa, Ontario
K1A 0R6

G.D. Lodwick
University of Calgary
Surveying Engineering Department
2500 University Drive N.W.
Calgary, Alberta
T2N 1N4

R.A. O'Neil
Data Acquisition
Canada Centre for Remote Sensing (CCRS),
2464 Sheffield Road
Ottawa, Ontario
K1A 0Y7

A.E. Peterson
Room 304C
Civil, Electrical Bld.
University of Alberta
Edmonton, Alberta
T6G 2G7

M.A.G. Toomey
Bureau of Surveying and Mapping
Alberta Energy and Natural Resources
50th Street Atria
4949-94B Avenue
Edmonton, Alberta
T6B 2T5

5.3 REPORT OF THE WORKING GROUP ON FORESTRY

Introduction

Forests in Canada are being depleted at an unknown rate. The efficiency of forest restocking of denuded lands is unknown (Pearse, Lang and Todd 1986). Remote sensing is the only tool that can provide the answers. Remote sensing does things which are not possible to do by traditional tools. The longer the traditional tools are used the greater is the amount of money wasted. The Forestry Working Group of CACRS is a means of disseminating the remote sensing tool.

The Role of the Forestry Working Group is:

1. to promote cooperation between existing agencies;

2. to demonstrate the effectiveness and efficiency of remote sensing through projects;

3. to educate professional, technician and manager;

4. to advise on forestry matters relative to the national policy on remote sensing, and

5. to propose research.

The above are the essential components in the dissemination of the tool. It is not merely chance that has made forestry the first application field to see significant operational application of remote sensing. Currently the B.C. Ministry of Forests and Lands buys satellite data at a rate of $100,000 per year - and indications are it will soon be $200,000 per year. To preach the role of the working group, and to affect National Policy in Forestry Remote Sensing, the members of working group need to have a vision of the future. To have that vision, they need an understanding of remote sensing, a knowledge of direction and goals for the future, and the capability for critical decisions. The status quo has to be analyzed, and unless drastic action is taken, forest management will continue to waste money. The Forestry remote sensing videotape educates through application, and tells forestry a new, cost-effective direction can be taken in forest management. Credibility of remote sensing application in forestry is evident through the operational use of remote sensing. However a lot more needs to be done.

Achievements During 1986

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

Recommendations

The FWG 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.

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List of Forestry Working Group Members

Dr. Peter A. Murtha, Chairman
Faculty of Forestry
University of British Columbia
2357 Main Mall
Vancouver, B.C.
V6T 1W5

Dr. Frank Ahern
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario
K1A 0Y7

Mr. Jean Beaubien
Service Canadien des Forets
1080 route du Vallon
P.O. Box 3800
Sainte-Foy (Quebec)
P.Q. G1V 4C7

Mr. Frank Hegyi
Director, Planning & Inventory
B.C. Ministry of Forests
1319 Government Street
Victoria, B.C.
V8W 3E7

Dr. Don Leckie
Canadian Forestry Service
Petawawa National Forest Institute
Chalk River, Ontario
K0J 1J0

Dr. Larry Morley
York University
20 Wellesley Avenue
Toronto, Ont.
M4X 1V3

Mr. Victor Zsilinszky
Associate Director
Ontario Center for Remote Sensing
880 Bay Street, 3rd floor
Toronto, Ontario
M5S 1Z8

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

INTRODUCTION

At the 1986 CACRS Annual Meeting, the Geography 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.

These objectives follow from a review of the International Satellite Land Surface Climatology Project (ISLSCP) given by Professors Bonn and LeDrew at that Annual Meeting.

At the Tenth Canadian Symposium in Edmonton in May of 1986, an informal meeting of interested scientists proposed that the name of the working group should be changed to the Global Environmental Modelling and Monitoring Working Group (GEMM) to more realistically reflect the new mandate. This proposal was accepted by the Director-General of CCRS and the GEMM Working Group was struck with the following membership:

Dr. Josef Cihlar, CCRS
Dr. David Goodenough, CCRS
Dr. Barry Goodison, AES
Dr. Ellsworth LeDrew, University of Waterloo, Chair
Dr. Alain Royer, Université de Sherbrooke

ACTIVITIES FOR 1986-87

To address objective one, a letter was drafted and 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. In that letter, we requested the names of persons who may be interested in the objectives of the GEMM working group and asked for a summary of current and proposed research activities and names of relevant articles. The scientists were informed that these data would be collated into a directory that would be the first step in fostering an informal liaison. It would also provide information for co–ordination of research activities. The scientists would be provided with feedback as research themes proposed by the GEMM working group were identified and international efforts in the area developed.

By January of 1987, eighty-two interested parties were identified. Thirty-eight were from government, five were from industry and thirty-nine were from universities. The data have been gathered in a directory submitted as an appendix to this report. The scientists have not yet been given an opportunity to verify and amend the data. The directory should therefore be considered a working draft. This verification will be done during the summer months.

Objective two has been addressed in part through Dr. Cihlar's active involvement as the CCRS representative on the International Geosphere-Biosphere Programme (IGBP) sponsored by the International Council of Scientific Unions and coordinated in Canada by the Royal Society of Canada. He is the leader of the Remote Sensing Technical and Resource Group of IGBP and Dr. LeDrew is the deputy leader. The overall objective of the IGBP is:

> "To establish an International Geosphere–Biosphere Programme: A Study of Global Change to describe and understand the interactive physical, chemical and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human actions." (The Royal Society of Canada, "Global Change Program: Mandate of Working Groups", working paper, 1987)

The mandate and priorities of the Canadian contribution to IGBP have been developing over the past year by the Royal Society of Canada. Each working group is charged with the following:

1/ Define the nature and scale of natural and anthropogenic change as it applies to their region;
2/ Develop specific objectives of a Global Change Program in their region;
3/ Outline what observations, measurements and analyses must be carried out to achieve these objectives;
4/ Summarize in accessible form the level of activity needed for the achievement of these objectives:
- •list all active researchers working on projects pertaining to the Global Change program,
- •describe briefly all current projects and those in an advanced state of planning,
- •determine what data are now available and where and how they can be accessed;

5/ Define new or redesigned projects to augment the Canadian effort, by:
- •identifying research needs and how new projects integrate with existing activities,
- •assigning priorities,
- •identifying project leaders and facility and support requirements,
- •developing a schedule for new and existing projects;

6/ Identify existing sources of funds and outline the overall funds and other resources needed for a viable Canadian program in their region;
7/ Propose workshops, symposia and other activities needed to plan and develop projects and how these may be integrated with other parts of the Canadian and International program;
8/ Develop other ideas and initiatives considered necessary or desirable for a successful program, nationally or as part of the global effort. (The Royal Society of Canada, "Global Change Program: Mandate of Working Groups", working paper, 1987).

It is clear that the remote sensing community should be actively involved in the Global Change Program. In the deliberations of the scientists involved in the planning of the program, remotely sensed imagery was specified as an important data set for monitoring and measuring the surface characteristics with the appropriate spatial resolution and coverage, and temporal resolution. The GEMM working group can act as the interface between the remote sensing community and the IGBP program through its participation in CACRS.

PROPOSAL FOR 1987-1988:

The GEMM working group has already created the directory of interested scientists requested in the IGBP mandate and has established the communication network. In light of the clear interest by the GEMM working group in the IGBP, and the overlap of activities, the working group proposes that:

• The GEMM group will select its objectives for the next year from the objectives specified for the Remote Sensing Technical Group of IGBP

• The GEMM group will work towards achieving those objectives as far as is reasonable given the available resources.

• Of particular interest will be:

-the identification of research needs and definition of future research programs in which remote sensing plays a critical role,

-identification of funding sources and,

-application for funding support.

5.5 REPORT OF THE WORKING GROUP ON GEOSCIENCE

STATUS

The Working Group and its members have maintained an active program of research and coordination activities during 1986. In addition to its formal members, the group maintains close contact with 26 additional Canadian specialists, 15 colleagues in the United States and 5 overseas researchers. These corresponding members have been very helpful in providing advice and support for the group's activities.

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.

Research activities of the Working Group fall into 4 categories:

- satellite experiments;
- airborne remote sensing,
- image processing, algorithm and methodology development; and
- field and laboratory experiments.

The geological objectives of the Working Group's research efforts are:

- to map surficial materials, rock types and structures in terms of vegetation associations;
- to detect evidence of geochemical stress in vegetation in mineral and hydrocarbon environments; and
- to demonstrate current capabilities of high-resolution satellite, airborne and field sensors.

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 compatability 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.

FUTURE PLANS

Technical Plans:
Work to date has demonstrated that geobotanical associations can be recognized and exploited to yield lithological and structural information, and that vegetation spectral anomalies related to severe geochemical stress can be detected using current airborne imaging technology.

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 high-resolution airborne spectral and spatial mode data for vegetation stress assessment.
- Further definition of the role of MEIS technology in a viable exploration methodology based on analysis of plant and rock spectral characteristics.

- Further definition of sensor capabilities and needs with regard to engineering geology applications in vegetated environments.

- Assistance in the implementation of methods with operational potential on low-cost image analysis systems.

- Promotion of basic research related to geological aspects of vegetation stress assessment.

- Incorporation and assessment of SAR data for geological/engineering purposes relevant to Working Group expertise and activities.

- Expanded investigation of satellite VIR data to include assessment of SPOT imagery.

- Continued efforts to support image analysis experiments through standardized laboratory and field investigations.

Organizational Plans:
The principle issue discussed at the 1986 annual Working Group meeting was the future organization and role of the Geoscience Working Group vis-a-vis CACRS. A detailed membership survey has subsequently been conducted and the results summarized as part of this formal report.

SURVEY RESULTS

- The real value of the Working Group does not lie exclusively with its relationship with CACRS, since members represent all sectors of the geoscience community in Canada and internationally.

- All current members are to maintain their role in the Working Group regardless of the implications of planned changes to the organization and function of CACRS.

- Members support the concept of extending membership to a wider audience of "corresponding members." Immediate efforts will be made to contact interested parties to invite their participation.

- Members are unanimous in their assessment of the importance of maintaining the scientific and coordinating roles, as well as the advisory role of the Working Group in the future.

- While members are in favour of maintaining advisory responsibilities with CACRS, it is clear that channels outside CACRS must be explored and exploited to more fully accomplish the objectives of the Working Group. The Working Group will proceed actively to develop links with professional organizations such as CRSS, GAC, PDA, ASTM, IUGS and the Geosat Committee.

- The Working Group will investigate opportunities to publish an annual state-of-the-art review, including current research results reported at an annual technical workshop organized by the Working Group.

- Efforts should be made to assist researchers to coordinate activities and requests for funding support. This is necessary to encourage greater funding for geobotany research and to minimize competition for resources among researchers.

- Members see the necessity of broadening Working Group activities to provide interest group representation to decision-makers in government and industry in matters affecting geological remote sensing activities in Canada.

ORGANIZATION PROPOSED

In order to more effectively serve and inform the geoscience community and provide a continuing link with CACRS, the revised organizational structure diagrammed below has been approved by members for implementation in 1987.

1986 RECOMMENDATIONS

- A Geoscience advisory group must 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 Working Group restructuring proposal submitted as part of this report.

TABLE 1

AGENCY	SENSORS	ALGORITHMS	METHODOLOGY	APPLICATIONS	FIELD	LABORATORY	EXPLORATION	ACID RAIN	REGION
Barringer	■	■	■	■	■	■	■		Various
CCRS	■	■	■	■	■	■	■	■	Sudbury, Mazinaw L., & others
CIMMER			■	■	■	■	■		Swayze Belt, Ont.
COMINCO			■	■	■	■	■		Pine Point, N.W.T.
GSC		■	■	■	■	■	■	■	Wollaston L., Sask Algonquin, Ont. Thetford Mines, Quebec Calabogie, Ontario Ludlow, New Brunswick Star Lake, Sask.
Horler Information		■	■	■	■	■	■		Cameron L.. Ont.
Manitoba Energy, Mines				■	■	■	■		Lynn L., Manitoba
Univ. of Manitoba				■	■	■	■	■	Lynn L., Manitoba
MONITEQ	■	■	■	■	■	■	■	■	Ontario, Germany Vermont
OCRS			■	■	■	■	■		Natal L., Ont. White L., Man.
OGS			■	■	■	■	■	■	Natal L., Ont. Montreal R., Ont.
Ont. Ministry Northern Dev. & Mines			■	■	■	■	■		Arnprior, Ont.
Utah Mines				■	■	■	■		Chibougamau, Que.
U. of Waterloo			■	■	■		■		Natal L., Ont.
York Univ.	■	■	■	■	■	■	■	■	Ontario Various
Ont. Petroleum Laboratory			■	■	■	■	■		Willey Pool, Ont.
BP Selco			■	■	■		■		Cape Breton, N. S.
PCI		■	■	■			■		White L., Man.

TABLE 2
GEOBOTANY PROJECTS 1986

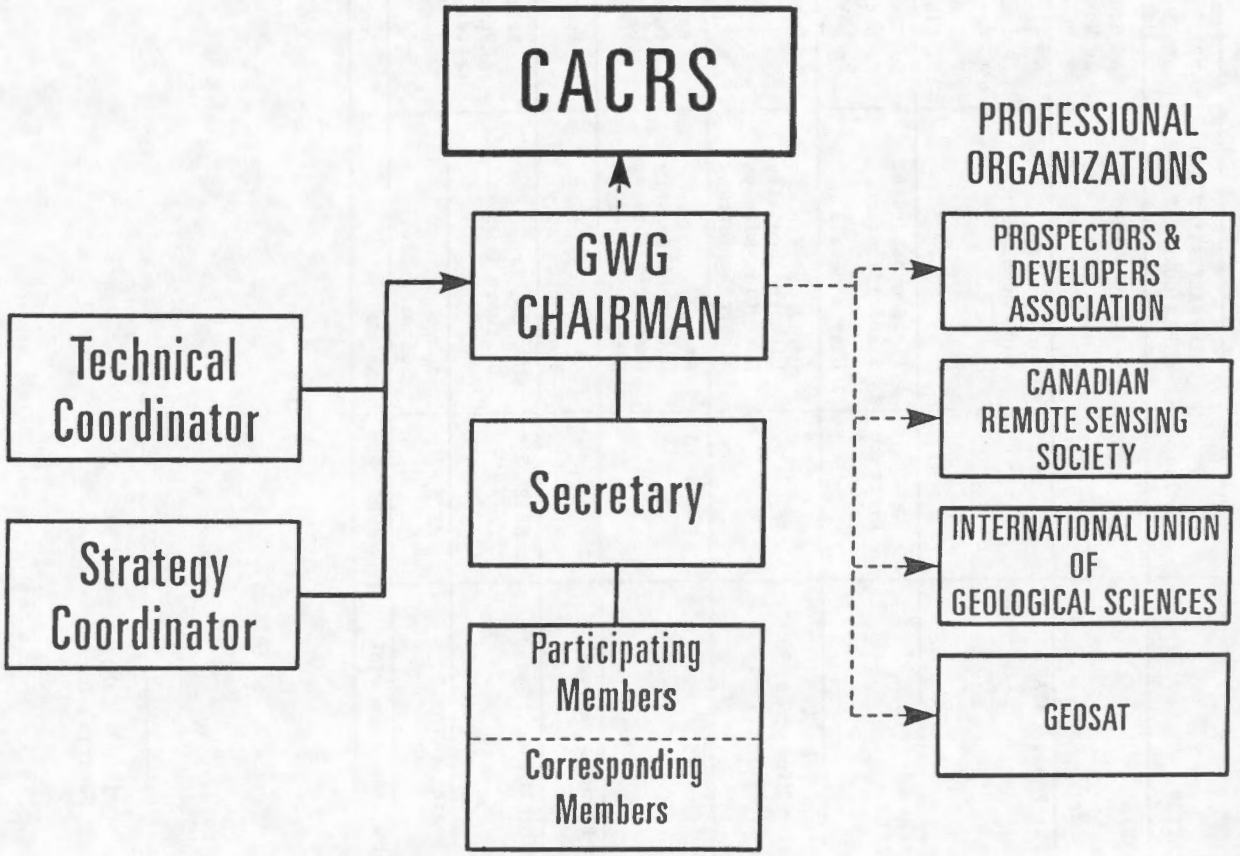
LOCATION	SENSOR	MINERALIZATION AND OTHER CONCERNS	PRINCIPAL INVESTIGATORS
White Lake, Manitoba	MEIS, TM MSS, GS*	Cu, Zn, Au, Ag. Biogeochemistry	R. Stanton-Gray; Perceptron V. Singhroy, OCRS
Natal Lake, ONTARIO	MEIS, MSS GS, PMI	Cu, Pb, Zn, Au, Ag Biogeochemistry soil & rock geochemistry	V. Singhroy, OCRS E. Sado, OGS C. Wagner, U. of W.
Cameron Rowan Lake, Ont.	MEIS, TM MSS, GS	Au, Software, Development, Lithogeobotany & structural geology	D. Horler; Nuinsco Resources
Chibougamau, QUEBEC	MEIS, GS	Cu, biogeochemistry	G. Lipton; Utah Mines
Batchawana Mt./Cowie Lake/Barbara Lake, ONTARIO	MEIS, TM	Au & Environmental Stress/Acid Rain Lithogeochemistry Humus	J. Fortesque, E. Grunsky, OGS
Arnprior, ONTARIO	MEIS, MSS, TM	Pb, Fl, Ba, Zn Biogeochemistry	J. Springer, OGS V. Singhroy, OCRS
Algonquin Park, ONTARIO (several sites)	MEIS	Rare Earths	A. Rencz, GSC
ONTARIO (several sites)	MEIS, MSS Thermal	Cu, Fe, Pb, Zn & Software Development Metal Injection Exp. Canopy Morphology Exp.	J. Miller, E. Hare, M. Boyer, et al, York U. Moniteq, G. Edwards, U. of Sask.
Suayze, Greenstone Belt Several Sites	MEIS, MSS, TM, GS	Au, Ag, Cu, Pb, Zn Biogeochemistry/soil & rock geochemistry	T. Beswick et al Laurentian Univ.
ONTARIO, Several Sites	MEIS	Sensor Development Evaluation & Data Analysis, Software PMI Development	R. Gauthier, S. Till, B. Neville, CCRS J. Miller, et al, York U.
Several Sites, ONTARIO, U.S., Germany	PMI	PMI Data Evaluation Analysis, and Software Development	Moniteq
Pine Point, NWT Yellowknife	MSS, TM MEIS Radar	Cu, Zn	R. Stanton-Gray, Cominco
Lynn Lake, MANITOBA	MEIS, TM	Au, Ag.	M. Fedikow, Manitoba Energy & Mines D. Anderson, U. of Manitoba
YUKON	TM/MSS	Au	B. Bruce, CCRS J. Hornsby, Intera
Sudbury Basin, ONTARIO	TM/Radar	Litho-geobotany Structural Geology	B. Bruce, CCRS McYergeau, U. of Sherbrooke Hornsby, Intera
Mazinaw Lake, ONTARIO	TM/Radar	Lithogeobotany Structural Geology Digital Terrain Models	B. Bruce, CCRS J. Wood, CCRS J. Hornsby, Intera J. Harris, Bercha & Assoc. V. Singhroy, OCRS A. Rencz, GSC

TABLE 2
GEOBOTANY PROJECTS 1986
(continued)

LOCATION	SENSOR	MINERALIZATION AND OTHER CONCERNS	PRINCIPAL INVESTIGATIONS
CYPRUS	MSS	Lithogeobotany	B. Bruce, CCRS J. Hornsby, Intera A. Zuniga, Equador
Willey-Pool, ONTARIO	GS, MEIS	Hydrocarbon Microseepage	R. Trevail, Ont. Petroleum Laboratory R. Lett, Barringer Magenta V. Singhroy, OCRS J. Fischer, OCRS
Several Sites, ONTARIO	GS Airtrace	1 Field measurement Standardization 2 Clay minerals	J. Gladwell R. Lett, Barringer Magenta P. Lawrence
Harrison Lake & Carolin Mine Area, B. C.		Au Lithogeochemistry Base Line surveys Biogeochemistry	C. Dunn, GSC
Star Lake	MEIS, TM	Au Lithogeochemistry & Gamma-ray surveys biogeochemistry	Rencz, Bonham-Carter C. Dunn, GSC Belanger, GSC
Casa Beradi, Quebec		Au Biogeochemistry	C. Dunn, GSC
Thetford Mines, Quebec	MEIS	Ni, Co, Cr Software Dev.	Belanger Rencz, Bonham-Carter, GSC
Calabogie, ONTARIO	MEIS	Au Software Dev.	Rencz, GSC
Ludlow, New Brunswick	MEIS	Sn, W	Rencz, GSC

* GS = Field & Laboratory Spectral Data

PROPOSED REVISED STRUCTURE FOR GEOSCIENCE WORKING GROUP



CANADA CENTRE FOR REMOTE SENSING
GEOBOTANY TASK FORCE
MEMBERSHIP LIST

Vernon Singhroy. Chairman
CCRS Geoscience Working Group
Ontario Centre for Remote Sensing
Ministry of Natural Resources
880 Bay Street. 3rd Floor. Toronto, Ontario M5S 1Z8 Tel: (416) 965-8411

W. D. (Bill) Bruce. Secretary
CCRS Geoscience Working Group
Canada Centre for Remote Sensing
1547 Merivale Road, Ottawa, Ontario K1A 0Y7 Tel: (613) 952-2722

(Dr.)
Don Anderson
Dept. of Earth Sciences
U. of Manitoba
Winnipeg, Manitoba R3T 2N2

Tony Beswick
Centre in Mining & Mineral
Exploration Research
F330 Laurentian U.
Sudbury, Ontario P3E 2C6

Collin Dunn
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

Mark Fedicow
Dept. of Energy and Mines
Government of Manitoba
535-330 Graham Avenue
Winnipeg, Manitoba R3C 4R3

John Fortescue
Ontario Geological Survey
77 Grenville Street, Rm. 712
Toronto, Ontario M5S 1B3

David Gladwell
Ray Lett
Barringer Research Ltd.
304 Carlingview Drive
Toronto, Ontario M9W 5G2

David Horler
Horler Information Inc.
116 Albert Street, Rm. 801
Ottawa, Ontario K1P 5G3

Greg Lipton
Utah Mines Ltd.
4 King Street West
Toronto, Ontario M5C 1Y2

Don Leckie
Petawawa Natnl. Forestry Inst.
Chalk River, Ontario K0J 1J0

John Miller
Physics Department
York U.
4700 Keele Street
Downsview, Ontario M3J 1P3

Larry Morley
Centre for Research in Experimental
Space Science
York U.
4700 Keele Street
Downsview, Ontario M3J 1P3

Bob Gauthier
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario K1A 0Y7

Andy Rencz
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

Janet Springer
Ontario Geological Survey
Min. Northern Development & Mines
199 Larch Street, 4th Floor
Sudbury, Ontario P3E 5P9

Ms. Roberta Stanton-Gray
Perceptron Computing Inc.
80 Bloor Street West, 11th Floor
Toronto, Ont. M5S 2V1

Jim Stewart
BP Selco
55 University Avenue
Toronto, Ontario M5J 2H7

Dr. Susan Till
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario K1A 0Y7

Bob Trevail
Petroleum Resources
Ministry of Natural Resources
458 Central Avenue
London, Ontario N6B 2E5

Victor Ward
Moniteq Ltd.
630 Rivermede Road
Concord, Ontario L4K 2H7

PUBLICATION LIST 1986

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Rencz, D.F., F.G. Bonham-Carter, C. Van der Grient, J.R. Miller, E.W. Hare. Preliminary Results from Modelling Vege -tation Spectra Derived from MEIS Data, Algonquin Park, Ontario. Proceedings, 10th Canadian Symposium on Remote Sensing, Edmonton, 8 pp.

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Singhroy, V., R. Stanton-Gray, J. Springer. Spectral Geobotanical Investigations of Mineralized Till Sites. Proceedings, 5th Thematic Conference on Remote Sensing for Exploration Geology, Reno, Nevada, ERIM, Ann Arbor, Michigan, 20 pp.

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5.6 REPORT OF THE WORKING GROUP ON ICE

Airborne Remote Sensing

Flight testing of the CCRS C-band SAR has continued throughout 1986, although to date no ice-related projects have been flown. Good quality imagery along the Ottawa Valley test line augers well for ice imagery; anticipated tests will occur over the Gulf of St. Lawrence in February 1987 and during LIMEX off Newfoundland in March.

Airborne tests to downlink radar data from aircraft to land- or marine-based stations have been successful. Miller Communications Systems Ltd. has produced systems for the AES Ice Branch on the SLAR Dash-7IR and INTERA Technologies Ltd. STAR-1 aircraft. An S-band transmitter and receiver can handle 8-bit data, and is rugged and relatively portable.

A field trial was carried out at Fort McMurray, Alberta in April 1986 using the C-Core impulse radar on a helicopter, to test the sounding of river ice jams. CANPOLAR Consultants Ltd. performed the contract for the Alberta Remote Sensing Centre. As expected, the thickness of the solid ice cover was measured easily; it may be possible to resolve some of the uncertainties in the data collected to measure the ice jam thickness.

Canarctic Shipping Ltd. contracted the INTERA STAR-1 to fly 20,000 miles over the Arctic in 12 days of November. An Arctic Marine Ice Atlas will be produced for the 1.6 million square kilometres imaged, and the SAR will be flown again to image areas where the ice is dynamic in the winter.

Surface Remote Sensing

FIDEX I: Although the experiment was not as multisensor as anticipated, a successful test of the Department of Fisheries and Oceans/McMaster University Communications Research Laboratory X-band radar occurred in November 1986. Mounted on the MV Arctic, Canarctic Shipping Ltd., the dual polarization proved invaluable in detecting icebergs and multiyear ice. The cross-polarized display enhanced the hazardous ice types, such that the vessel now considers bright targets beyond 0.5 to 1.0 nm to be a hazard that should be avoided. The smallest target detected was a growler of about 1 m freeboard and 15-20 m length, distinguished from rough first-year ice at 2.0 nm. The vessel also received NOAA thermal IR and INTERA STAR-1 SAR on board during this time period.

Sonar: Under contract to Transportation Development Centre (TDC), Canarctic Shipping Ltd. (with Canadian Astronautics Ltd. and Seatech as subcontractors) conducted experiments on the MV Arctic in July to test sonar equipment in ice-covered conditions, for detectability and range of targets.

Acoustics: Arctic Sciences Ltd. performed feasibility studies for the detection of icebergs by in-air acoustics, for DSS/TDC/CCG/DFO. The sound direction and ranging (SODAR) experiments were land- and sea-based in Sidney, B.C., and first indications were positive.

New Initiatives

SAR: During 1986 INTERA integrated and installed their second airborne SAR, STAR-2, in a Conquest turbo-prop aircraft. It can produce high resolution (5 m) imagery over a 16 km swath or low resolution (18 m) imagery over a 60 km swath. Data will be available in film or paper hardcopy form, and HDDT or CCT digital form after transcription. Operational service began in February 1987.

SSM/I: A validation of the special sensor microwave/imager is planned after its launch on board a DMSP satellite in May 1987. AES Ice Research and Development (René Ramseier) will co-ordinate this program for ice and also wind remote sensing, using airborne and shipborne ice observations and other satellite data (NOAA, Landsat, etc.), and specific field experiments involving Canadian icebreakers and the FS Polarstern.

AIMR: The airborne imaging microwave radiometer system is being built by MPB Technologies Inc. for AES Ice Branch, with delivery expected in fall 1987. The dual frequency, dual polarization sensor will be flown on an Ice Patrol Electra in winter 1987/88 and will assist in the SSM/I validation.

GBR: A single frequency (37 GHz), dual polarized ground-based radiometer will be mounted on the CCGS Louis St. Laurent icebreaker during February 1987. Microwave signatures of sea ice will be collected to test the use of a shipboard radiometer. The system will operate simultaneously with remote sensing overflights by the AES Electra or Dash-7IR SLAR, CCRS CV 580 C-SAR, and INTERA STAR-1 SAR.

User Liaison

The WGI maintains a mailing list of 52 consultant, industry, and government groups, who receive invitations to attend WGI workshops, minutes of all meetings, and other information. The Twentieth meeting in Edmonton, 05 May 1986, was attended by 12 members, two non-members, and a joint session was held with members of the Working Group on Oceanography. The latest meeting, in Ottawa on 27-28 January, 1987 was attended by 11 members and 11 non-members, and included a tour of the AES Ice Centre facilities.

Training

For the second year the National Research Council Cold Regions Engineering School held a post-graduate course on "Remote Sensing of Ice", 28 April to 02 May, 1986, at the Faculty of Extension, University of Calgary, Alberta. The course was well received by 21 attendees from Canada, U.S.A., and India. Instructors were René Ramseier and Bruce Ramsay of AES Ice Branch, Ray Lowry of INTERA, James Rossiter of CANPOLAR, and Ian Sutherland of Alberta Remote Sensing Centre Applications Section.

Recommendations

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.

2. With the development 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.

3. The Working Group on Ice should continue its role as a forum for making valuable contributions to remote sensing in Canada. The WGI 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 Subcommittee 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;
   - organisation 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.

Appendix I

Current Bibiliographies

For current bibliographies of ice research contact Simon Ommanney, (306) 975-5751. Recent Canadian projects in ice remote sensing are included in "Ice" (International Glaciological Society publication), contact J.P. Nadreau, (709) 737-8371.

Several Environmental Studies Revolving Fund (ESRF) reports listed below concern remote sensing of ice, and are available from Infopoll, Pallister Resource Management Ltd., (403) 236-2344.

The Assessment of Marine Radars for the Detection of Ice and Icebergs, by Viatec Resource Systems, Inc., ESRF Report 008, August 1985

Assessment of Airborne Imaging Radars for the Detection of Icebergs, by CANPOLAR Consultants Ltd., ESRF Report 016, September 1985

Enhancement of the Radar Detectability of Icebergs, by Viatec Resource Systems Inc., ESRF Report 022, January 1986

Further Studies on the Assessment of Marine Radars for the Detection of Icebergs, by Viatec Resource Systems Inc., ESRF Report 035, June 1986

Iceberg Detection by Airborne Radar: Technology Review and Proposed Field Program Report 045, September 1986

Appendix II

List of Group Members and Addresses

Dr. J. Addison
Department of Physics
McGill University
3600 University Street
Montreal, P.Q.
H3A 2T8
514-392-5150

Ms. L.D. Arsenault
Cold Regions Remote Sensing
Box 526
Stittsville, Ontario
K0A 3G0
613-836-4003

Dr. L. Gray
Data Acquisition Division
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario
K1A 0Y7
613-998-9060

Dr. S. Haykin
Director
Communications Research Laboratory
McMaster University
1280 Main Street West
Hamilton, Ontario
L8S 4L7
416-525-9140, ext. 4291

Mr. E. Lewis (Chairman of WGI)
Marine Science & Surveys
Department of Fisheries and Oceans
867 Lakeshore Road
Box 5050
Burlington, Ontario
L7R 4A6
416-336-4828

Dr. C.A. Luther
Scientific Officer
Office of Naval Research, 425AR
800 North Quincy Street
Arlington, Virginia 22217
U.S.A.
202-696-4118

Captain Ian Marr
Manager, Ice Navigation Systems
Coast Guard Northern (DCGN/M)
Place de Ville, Tower A, 13th Floor
Ottawa, Ontario
K1A 0N7
613-998-6572

Mr. D. Mudry
Chief, Ice Climatology & Applications Division
Atmospheric Environment Service
365 Laurier Street West, 3rd Floor
Ottawa, Ontario
K1A 0H3
613-995-6730

Mr. C.S.L. Ommanney
Cold Regions Section
Surface Water Division
National Hydrology Research Centre
Environment Canada
11 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 2X8
306-975-5751

Mr. J. Ransom
Hibernia Project
Mobil Oil Canada Ltd.
Atlantic Place
215 Water Street, Box 62
St. John's, Newfoundland
A1C 6C9
709-722-3310

Mr. A. Sneyd
Canarctic Shipping Limited
350 Sparks Street, Suite 1005
Ottawa, Ontario
K1R 7S8
613-234-8414

Dr. J. Sykes
Associate Professor
Department of Civil Engineering
University of Waterloo
Waterloo, Ontario
N2L 3G1
519-885-1211, ext. 3776

Dr. J. Walsh
Faculty of Engineering and Applied Sciences
Memorial University of Newfoundland
St. John's, Newfoundland
A1B 3X5
709-737-8963

Mr. B. Wright
Co-ordinator
Ocean Engineering Frontier Development Group
Gulf Canada Resources Inc.
P.O. Box 130
Calgary, Alberta
T2P 2H7
403-223-4352

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

The Working Group on Image Analysis Systems and Artificial Intelligence (IASAI-WG) held three meetings in 1986/87. The first meeting was held in Edmonton, Alberta on May 4-5, 1986, in conjunction with the Tenth Canadian Symposium on Remote Sensing. The other two meetings were held in Ottawa on September 16-17, 1986, and January 22-23, 1987. The next meeting is tentatively scheduled to be held on June 25-26, 1987, in conjunction with the Eleventh Canadian Symposium on Remote Sensing in Waterloo, Ontario.

HIGHLIGHTS OF IASAI-WG

The meetings of the IASAI-WG were considerably enhanced in 1986/87 by the active participation of Mr. Peter MacKinnon, former President of the Canadian Artificial Intelligence Products Corporation, who has taken up an executive interchange appointment with the Strategic Technologies Branch of MOSST. With a view to bringing a stronger R&D focus in Canada to foster the creation of new economic wealth, MOSST is trying to assess technologies emerging on the international scene. One technological front is AI as it applies to advanced information systems and other areas. The task is to raise science and technology in general, and specific areas such as AI applications, to a high priority in the government's plans for the next few years.

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 IASAI-WG and plans were formulated for a wider distribution to interested users in Canada and elsewhere.

As a result of a specific recommendation from the IASAI-WG, 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.

RECOMMENDATIONS OF IASAI-WG TO CACRS

1) CCRS should 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.

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.

3) Crown-owned CCRS data and CCRS software should be licensed at no cost to Canadian universities, government agencies, and industry and sub-licensing outside Canada should 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.

4) CCRS should 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.

5) CCRS should 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.

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

MICRO-COMPUTING HIGHLIGHTS

In connection with the IASAI Working Group meetings, a group involved in promoting the use of micro-computer based image analysis systems in the remote sensing community met to present many technical advancements. Attention was given to the fact that micro-computer based image analysis systems are becoming more popular in many user institutions of remote sensing, as well in universities. Some small-scale institutions of remote sensing are using micro-computer based image analysis systems as stand-alone systems, while other users are using micro-computer based image analysis systems as workstations establishing computer

networks. Over the past year, the capability of micro-computer based systems has been enhanced due to the recent advancements in LSI technology, optical storage technology, and communication technology.

Optical technologies have facilitated in equipping micro-computers with the capability for large file storage for remotely sensed data. CCRS has attempted to create a sample CD-ROM which stores typical remote sensing data and distributed it to the sub-working group members for evaluation purposes.

While on a trip to Japan, Joji Iisaka collected up-to-date information on writable optical disks and distributed them to the members of the sub-working group. WORM (Write Once and Read Many) technologies are now being investigated at CCRS using a 5 1/4" drive.

With the recent LSI technology, one-board image processors for micro-computer based image analysis systems have also been developed. 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. Advancement of technologies for micro-computer based image analysis systems is changing so quickly that the activities of the sub-working group 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.

RECOMMENDATIONS ON MICRO-COMPUTING

1) CCRS should 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.

2) CCRS should assess technology for micro-computer based image analysis such as image/graphic boards and optical technology for micro-computers.

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

4) CCRS should be an active member of the international committees/groups on data format standardization such as GIS data and optical recording format.

5) CCRS should make CD-ROMs available to selected groups of 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.

MEMBERSHIP

Working Group

D.G. Goodenough, Chairperson
Canada Centre for Remote Sensing

P.M. Teillet, Secretary
Canada Centre for Remote Sensing

W. Davis
University of Alberta

M. Goldberg
University of Ottawa
S. Gourley
DIPIX Systems Limited

J. Iisaka
Canada Centre for Remote Sensing

H. Jones
Fisheries and Oceans

P. Kourtz
PNFI/Department of Agriculture

A. Levinsohn
Alan Levinsohn and Associates

J.S. MacDonald
MacDonald, Dettwiler & Associates Ltd.

P. MacKinnon
MOSST

R. Maher
Nova Scotia College of Geographic Sciences

E.G. Morrissey
AES/Environment Canada

G.W. Plunkett
Canada Centre for Remote Sensing

P. Sallaway
PAMAP

W.M. Strome
Perceptron Computing Inc.

J. Whiting
Saskatchewan Research Council

R.J. Woodham
University of British Columbia

REPORT OF THE SUB-WORKING GROUP ON IMAGE ANALYSIS DATA BASE FORMATS

BACKGROUND

The Image Analysis Data Base Formats (IADBF) Sub-Working Group 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. The IADBF held three meetings in 1986/87 in conjunction with the IASAI parent working group. The sub-working group has developed a capabilities matrix of over thirty database formats that are in use in Canada, and has reviewed in detail several of the major formats.

HIGHLIGHTS

1) The sub-working group has categorized and tabulated more than thirty database formats that are in use on image analysis and GIS systems in Canada. A matrix of capabilities includes categories such as vector support, raster support, topology support, and the systems where the format is used. Additional capability categories and databases used on personal computers are to be added.

2) The sub-working group has been treated to in-depth presentations by industrial, academic and governmental members on the following major formats:

Format	Description
Aries	- used on DIPIX ARIES systems.
CCRS UNIDSK	- used on the CCRS LDIAS, SMOKE, AIR-2 systems.
GBT	- Generalized Balanced Ternary format.
ISO-8211	- International Standards Organization format.
LEGO	- vector/raster format proposal by PCI.
MERIDIAN	- used on MDA Meridian systems.
PAMAP/GIS	- used on PAMAP systems
PCI-UNIDSK	- used on PCI systems
QUAD TREES	- research format with specific applications

3) A presentation on the work of the Federal Advanced Storage Architectures Committee.
4) A review and general consensus of advocating the object definitions as proposed by the U.S. National Committee for Digital Cartographic Data Standards.

RECOMMENDATIONS TO CACRS

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

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.

3) CCRS should make test datasets available and should support pilot experiments on the exchange of information between agencies.

4) CCRS should investigate the use of communications networks for data interchange and communications amongst IASAI members.

MEMBERS

J.D. Burchill
MacDonald, Dettwiler & Associates

H. Edel
Department of Fisheries and Oceans

S. Gourley
DIPIX Systems Ltd.

G. Karam
Carleton University

D. Leckie
PNFI/Dept. of Environment

G. Plunkett (Chairperson)
Canada Centre for Remote Sensing

P. Sallaway
PANAP Graphics Ltd.

M. Strome
Perception Computing Inc.

5.8 REPORT OF THE WORKING GROUP ON OCEANS

Introduction

The full CACRS Oceans Working Group met in May 1986 to formulate new terms of reference upon completion of the major report "Ocean Satellite Data Opportunities for Canada: A Long-Term View". At this meeting G. Holland stepped down as Chairman and N. Freeman was elected to take his place, with R. Worsfold agreeing to act as secretary. During the year a number of work activities were carried out by correspondence and by small groups of members. These include, inter alia:

1) the development of national ocean data requirements for the ERS-1 satellite mission;

2) the coordination of the Canadian response to the ERS-1 Announcement of Opportunity;

3) the survey of remote sensing education in oceanography at Canadian universities.

Terms of Reference

The purpose of the Oceans Working Group is to provide scientific and technical advice and assistance concerning matters related to remote sensing in oceanographic and relevant applications. Reports will be made through the WG chairperson to the Canadian Advisory Committee on Remote Sensing (CACRS) and the Canada Centre for Remote Sensing (CCRS).

The Oceans Working will provide such advice and assistance by:

a) identifying and specifying national needs for remotely sensed data;

b) maintaining an up-to-date awareness of recent developments;

c) initiating new research or operational projects where this seems appropriate in the national interest; and,

d) assessing the benefits of remote sensing in relation to cost.

In 1986-87, the Working Group will also:

1. Monitor the implementation of the recommendations of the Ocean Satellite Data Opportunities Report; in particular, the establishment of infrastructures for the handling of domestic and foreign ocean satellite data and a reassessment of remote sensing research training and education for the marine science community.

2. Prepare recommendations to CACRS concerning the immediate and long term requirements for Canadian input to national and international ocean remote sensing satellite systems* (eg. RADARSAT, ERS-1(J), NROSS, ERS-1(J), DMSP, etc.).

3. Make recommendations to CACRS and other organizations on the orderly development of techniques and applications in Canada of remote sensing of the oceans.

The Working Group will, where appropriate, foster and promote the use of remote sensing by:

1. Encouraging relevant instruction at universities, colleges and other educational institutions; and,

2. Initiating special training courses, seminars and conferences.

At the end of each calendar year, the Working Group will compile an annual report which will review activities during the past year, list current Canadian projects related to oceanography, assess recent progress, recommend appropriate action and contain other relevant information.

Co-ordinated ERS-Announcement of Opportunity Responses

1. The Life Cycle and Morphology of Wind-Generated Ocean Waves: Their Generation, Propagation and Dissipations

The overall objective of this research program is to determine whether data available from ERS-1 can lead to improvements in both scientific understanding and operational

prediction of ocean wave growth, development, and dissipation and, over the long term, to advances in global wave climatology. Specific objectives are:

1) to obtain insight into the performance of the scatterometer to yield useful estimates of the horizontal surface wind stress, 2) to use data from ERS-1 to discriminate among various wave models and classes of wave models, 3) to determine whether ERS-1 SAR can provide useful estimates of the directional wave spectra, 4) to accumulate a multiyear global data base of directional wave climate, and 5) to test the operational utility of ERS-1 wind fields in marine weather analyses and in short-term wind and wave forecasts.

The program is divided into two phases: 1) a wave validation or commissioning phase, to occur over a one month period during the third month after launch (unless the launch occurs between February and August, precluding meaningful validation until the following fall), and 2) a science/applications phase, commencing with the validation, and continuing throughout the active life of ERS-1, but with emphasis on annual periods between November and April.

Data requirements are confined to the Gatineau coverage region of the northwest Atlantic Ocean bounded by 35N to 55N and 40W to 80W; the primary validation site, chosen for its extreme wave climate and accessibility, is located on the eastern edge of the Grand Banks. A concentrated collection of AMI SAR image mode data is desirable throughout the entire region of interest for a 30 day period, commencing 60 days after launch. During this intensive validation period, our plan requires about 15 minutes of high priority SAR passes and 12 minutes of lower priority SAR passes every three days.

In the subsequent science/applications phase, our plan calls for two uninterrupted four week data sets in the same region during the northern winter (November through April). One of the sets consists of AMI SAR image data only; the other consists of AMI wind/wave data only, with associated SAR image samples located on 2.5^{o} latitude centers.

Using these uninterrupted data sets, we will: 1) extract estimates of the surface wind field, significant wave height, and directional wave spectra; 2) synthesize control wind fields, both with and without the benefit of the ERS-1 data, for those time periods centered on the passage of the most significant wave event; 3) exercise first, second, and third generation wave models with both "conventional" and "ERS-1 enhanced" wind fields; and 4) test the utility and operational use of ERS-1 wind and wave mode Fast Delivery Products in Canadian regional weather centers.

Our plan allows for one comprehensive ERS-1/NROSS/SIR-C experiment during the anticipated triple conjunction, currently expected to occur in 1991 or 1992.

2. Ocean Surface Mesoscale Feature Mapping

The proposed experiment would involve:

1. Investigating the usefulness of the SAR and altimeter for locating and tracking mesoscale ocean surface features, and applying these sensors to study the regional dynamics.

2. Studying the mechanisms for SAR imaging of such features.

3. Studying the seasonal variability in the imaged patterns and in the mechanisms linking water properties to SAR reflectance.

4. Studying water temperature effects (via atmospheric stability and varying water properties) on microwave measurements.

In addition we will study the large scale dynamics of the semi-enclosed, shallow waters of Hudson Bay during these same time periods, using altimeter and scatterometer data. The main aim here is to derive a technique for evaluating the coupling between the water and solid earth that can be applied globally.

The study will be centred on 2 major regions, one on the east coast of North America and one on the west coast, with a further study to be conducted in Hudson Bay. The east coast area is contained in 45W to 75W and 35N to 55N. This includes the Gulf Stream from Cape Hatteras to the area of its conjunction with the Labrador Current, and the coastal waters of the Gulf of St. Lawrence. The west coast area is contained in 120W to 145W and 45N to 60N, and includes the coastal waters round Vancouver and the Queen Charlotte Islands, as well as adjoining offshore water.

In both these areas AMI (SAR image) and altimeter data is required during the first year of ERS-1 operation, in two week periods in the months of February, May, August and November. Supporting data will be provided by research cruises planned for the vessels of the Bedford Institute of Oceanography and the Institute of Ocean Sciences, by air-dropped instruments from a US P3 aircraft, by instrumented drifting buoys, and from data available from other satellite and surface sources.

The proposed study will provide a sufficiently large number of examples of the detection of eddies and fronts, with supporting in situ, aircraft and/or other satellite observations, to show the value and limitations of using SAR imagery to map near surface water dynamics in both coastal and ocean conditions. The sample set will show the variation with season in the different areas and will provide validated examples of surface feature maps made under different weather (especially wind speed) conditions.

Also, the effects of surface temperature on the scatterometer will be evaluated, and the value of the altimeter data in showing the positions and movements of fronts and eddies, and in studying the dynamics of an enclosed shallow sea will be demonstrated.

Study of Satellite Oceanography in Canadian Universities

The oceans working group of the Canadian Advisory Committee on Remote Sensing recently completed a study of Ocean Satellite Data Opportunities for Canada. In addition to addressing the Canadian requirements for ocean data and the potential satellite measurements available over the next decade, the report also studied the infrastructure necessary to make optimum use of this new, high volume data source. Further, it addressed the question of providing trained personnel to work in ocean remote sensing and determined that the level of effort in Canadian universities in this field was already deficient. As a follow up to the report, the Oceans Working Group during their meeting held in Edmonton on May 5, 1986, has empowered M.I. El-Sabh from the Université du Québec a Rimouski to set up a working group sub-committee to formulate terms of reference related to the development of a report on the status of research training and education in the field of Satellite Oceanography at Canadian Universities. This sub-group is to assess the current situation and make recommendations.

Since oceanographic research and teaching at Canadian Universities are mainly concentrated in the West Coast (U. of British Columbia) and in the East Coast (McGill U., UQAR, Dalhousie U., Memorial U.), it was decided to form the ad-hoc committee from the following members:

1. M.I. El-Sabh, UQAR
2. Paris Vachon, U.B.C.

The present report summarizes their findings regarding the application of remote sensing in research and teaching in our oceanographic departments in Canadian universities. No effort was made to include application of remote sensing to the study of ice and icebergs, since this field is already covered by another working group of CACRS.

At the commencement of this work the president of the CACRS Education Working Group, Dr. F.J. Bonn (Sherbrooke U.) was contacted. The Education Working Group is now in the processes of publishing a directory of Remote Sensing courses and training programs in Canadian universities. The directory provides an overview of the remote sensing education programs in Canada, and no effort has been made to include the situation in oceanographic departments.

Recommendations

1) The Oceans Working Group recommends 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 A.O.

2) 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.

5.9 REPORT OF THE WORKING GROUP ON WATER RESOURCES

The Water Resources Working Group identified two main themes last year as a focus for their activity. One task focussed on hydrologic modelling and the use of remote sensing; the second was concerned with the determination of snow cover properties using remote sensing, particularly passive microwave data. A separate task is to prepare an updated slide set, complete with text, on the application of remote sensing to Canadian water resources. Activities were carried out by correspondence and through meetings of sub-groups of members.

Hydrological Modelling

Hydrological models are used for the analysis, synthesis, interpolation and forecasting of hydrological parameters. Such models have many forms, ranging from the simple to the complex. One potential way to improve hydrological forecasts is to utilize remotely sensed data (aerial and satellite-based) in operations forecasting models. However, as recommended at the most recent Technical Workshop on Streamflow Forecasting, research and development of models (or alteration of existing models) are required to adapt models to handle remotely sensed parameters. Water Resources Branch (Environment Canada) taking the initiative, commissioned a study of methodologies of streamflow forecasting incorporating remotely sensed data. Two reports have been received from the contractor, A.J. Robinson & Associates, Inc. (Appendix I). Phase I was a literature review to identify operational remote sensing techniques (satellite, airborne, weather radar, DCPs) for estimating water resource parameters and to identify models pertinent to flow forecasting in a hydroelectric context. The report indicates that the following parameters could be estimated using remote sensing: snowline, snow areal extent, snow water equivalent, snow surface temperature, snow and land albedo, land cover/use, precipitation, surface slope, channel dimension and overland flow length, drainage area, wave and seiches, lake and river stages, ice concentration and movement, and radiation. An initial list of 60 hydrological models was narrowed to 28 in the review. For Phase II, the SSARR model was selected for integration with data obtained by remotely sensed methods. The techniques to be interfaced were: snow cover extent using density slicing and digital techniques; snowpack water equivalent combining airborne gamma-ray flight surveys with snow course data using the Correlation Area Method; and, land cover using a pseudo-digital technique. The study area was a sub-basin in the Upper Tobique Basin, a tributary of the Saint John River.

Some of the recommendations/conclusions of particular interest to CACRS include:

a) Snowpack water equivalent is the most important parameter during spring snowmelt and its accurate calculation is essential for good forecasting results.

b) Existing GIS software packages should be investigated for their potential use in spectral data analyses and density slicing for albedo, snow cover extent and snowpack water equivalent determinations.

c) The SSARR model is not recommended for further research on integrating remotely sensed data with hydrological models.

d) Either the CEQUEAU or HSP-F models should be studied and tested; the test basin should be discretized for a range of grid sizes.

e) The Correlation Area Method (combination of point, line and areal data) is the recommended snow cover analysis technique for basins where orographic effects can be neglected or where the data acquisition network has a high density.

Despite the above conclusion with regard to the SSARR model, many agencies use it for operational forecasting. In Alberta it is used extensively to model snowmelt runoff from the mountain region of the Province. A demonstration study by the Alberta River Forecast Centre and the Alberta Remote Sensing Centre during 1985 and 1986 assessed the utility of computer processed NOAA imagery for snow cover mapping and streamflow simulation using the SSARR model. The percent snow covered area versus percent snow water equivalent relationship used in the snowmelt routine of the model is defined by forcing the model to use NOAA snow cover area estimates. The specification of snow cover depletion curves to SSARR, with snow water equivalent as a third parameter, allows for a better simulation result than that

achieved by use of an average (single) snow cover depletion curve. The study will continue in 1987, but lack of resources will probably hinder its operational implementation.

Another study along these lines has recently been initiated. The Saskatchewan Research Council has a joint study with Atmospheric Environment Service (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; a report will be available in 1987.

A common need in many of these studies is the integration of remotely sensed and conventional "ground" data. The correlation-area method is one approach to the problem. Objective analysis schemes may be another. For the past two years the 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. A version of the GLAS-1 method, the RAINSAT procedure and a simple climatological technique were evaluated by comparing the satellite - derived rain estimates with weather radar and gauge observations over a 440,000 square kilometre area in eastern Canada. Results for a month long trial have been examined and show that the simple climatological technique is at least as good as the other two for the longer duration estimates. A desire to compare the remote sensing and gauge estimates of precipitation on an areal rather than point basis led to the investigation of the applicability of various objective analysis schemes for interpolating precipitation data to a regular grid. The ability of a statistical optimization technique and several empirical interpolation schemes (Barnes, Cressman, Shepard) to interpolate actual precipitation data and to reproduce known synthetic precipitation fields has been evaluated. Qualitative and quantitative intercomparisons of the techniques are in progress.

The above studies, in which several members of the Working Group are involved, indicate that there will be a trend toward a new generation of hydrologic models which will take full advantage of the nature of remotely-sensed data. Accordingly, members identified the following objectives for the sub-group's activity:

a) to identify user agencies in Canada which can benefit from hydrologic modelling;

b) to identify potential inputs to hydrologic models which may be obtained using remote sensing techniques;

c) to identify and encourage the development and use of hydrologic models which can incorporate remotely-sensed inputs;

d) to advise and assist users in the use of such models and in the acquisition of the remotely-sensed inputs;

e) to assess and assist in assessing the increased accuracy and economic return of such models over conventional models; and

f) to advise and assist in developing software and hardware - including sensors and satellites - for the collection and processing of remotely-sensed data required for hydrologic modelling.

At a meeting in June the sub-group identified two tasks for the short-term which are aimed at educating, advising, encouraging, and assisting both the remote sensing technologies to the modelling of hydrologic processes. These tasks involve the preparation of:

a) a brief discussion paper or brochure which summarizes the state-of-the-art in this field and discusses related issues, and

b) a brief strategy paper which, based in part on the discussion paper, makes recommendations on research, development, and technology transfer.

The sub-group considers funding to be the major obstacle to progress in this field. It is hoped that these publications will provide a basis for increased funding and activity in this field in the near future.

Snowcover Properties

As noted above, snowpack water equivalent is the most important parameter during spring snowmelt; its accurate calculation is essential for good forecasting

results. Since the Water Resources W.G. was initiated in the early 1970's, snow cover has been one of its central themes of investigation. The delineation of areal extent of snow is now an operational tool; NOAA AVHRR or GOES data are the logical data sources, rather than Landsat. Now as the tools for remote sensing of snow water equivalent/snow depth become available, the working group is providing liaison for the co-ordination and information exchange on current research and development on the determination of snow cover properties using microwave data, particularly passive.

Hydrometeorology and Marine Division of the Atmospheric Environment Service has been the lead Canadian federal agency studying the use of passive microwave data for the determination of snow cover properties - water equivalent, depth, extent, wet/dry. PhD Associates is the lead private sector company. Steady progress has been made in the development and testing of algorithms for determining snow cover properties from passive microwave satellite data. The study area has been the Canadian Prairies. Algorithms for determining snow water equivalent using 37 GHz and 18 GHz NIMBUS-7 passive microwave (SMMR) data have been tested for selected periods over southern Manitoba and Saskatchewan with good results (Appendix I). SMMR brightness temperatures, and hence snow water equivalent estimates are for 30 km x 30 km areas. The all-weather capability of these sensors makes the technique extremely attractive for snow cover monitoring.

A major inter-agency (AES is lead agency) international program for the validation of algorithms for snow depth/snow water equivalent determination using DMSP SSM/I data will be conducted during the winter of 87/88. A mini-field program will be conducted during February 1987 to finalize procedures and flight lines before the main program in 1987/88. The trial will collect ground data on selected calibration lines and airborne gamma surveys will be used to measure snow water equivalent over new and existing flight lines in Manitoba and Saskatchewan.

A sub-group of the Water Resources W.G. has served as a forum for co-ordinating the validation experiment up to now. There are more than 10 federal, provincial, university and private sector agencies participating in the experiment, including NASA and the US National Weather Service. The experiment also offers the opportunity to collect ground and airborne active microwave data for intercomparison and calibration with other snow data. At the last CACRS meeting it was recommended that CCRS arrange with the University of Saskatchewan to include an assessment of the ground microwave system for determining snow cover properties during the 1986/87 winter in co-operation with the microwave validation experiment. This did not occur. A lack of funding and the inability of the sensors to operate under winter conditions appear to be the major deterrents in using the system at this time.

The potential of active microwave SAR data for snow cover determination is recognized. A joint proposal on "Application of ERS-1 Active Microwave Instrumentation Data to Remote Sensing of Snow" has been submitted to the European Space Agency in the framework of the ERS-1 programme. The proposal would involve ten scientists representing eight institutes in four countries. AES and CCRS (Radarsat Office) scientists participated in the proposal. The Prairie target area used in the DMSP SSM/I validation experiment is a potential study area for the ERS-1 study. In preparation for such an experiment a task group should be formed to focus on the use of SAR for snow cover determination. A preliminary airborne mission, with priority for mobilization on short notice in order to measure appropriate snow cover conditions, should be conducted, probably in Southern Ontario for ease of logistics. The task group could assist in planning and execution of the mission. CCRS support for such an airborne mission would be crucial to the success of such an experiment.

Other Developments

The slide set of remote sensing applications in water resources is still in progress. Completion is expected in 1987. Short descriptions of the applications will accompany the slides. The set will be provided to CCRS for appropriate distribution.

At CCRS, the chromaticity analysis is being transferred to a micro-computer image analysis system. TM and SPOT data are to be used in this package. The question of how to extract the chromaticity transform of data for quantitative extraction of suspended sediment and chlorophyll

from TM is being addressed. This is a more complex problem than just using MSS.

In Saskatchewan, the Saskatchewan Technology Enhancement Program (STEP) has included water resources projects. The following STEP projects have been completed: 1) The Deer Habitat Project by SPRR, 2) the Moose Habitat Project by SRC and 3) the Burns and Cutover Project by SPRR. Benefit cost ratios and levels of accuracy in the classes assessed and geo-referencing were also developed for these projects.

There is considerable interest in the formation of Information Centres. In the United States, the National Weather Service is reviewing the status and planning the future of the current Satellite Snow Cover Mapping Program, which generates real-time areal extent of snow cover maps for about 200 basins in the U.S.A. using GOES data. They are considering its consolidation with their operational Airborne Snow Survey Program. Other federal users would be asked to contribute to the cost of establishing a viable remote sensing hydrology program. The one-time procurement costs for a dedicated satellite hydrology image processing system are $356,000 (U.S.) and annual operation and maintenance are estimated at $212,000 (U.S.). They have prepared a position paper on establishing a federal interagency remote sensing hydrology program. If such centres were ever to be considered in Canada, the experience of the National Weather Service, Office of Hydrology should be referenced. It is not yet known if such an interagency program will develop; funding is still a problem. The working group will keep up-to-date on this program.

Up to now, the Working Group has had no feedback from CCRS on the usefulness of the Survey of Canadian Private Sector Companies in the Field of Remote Sensing Applications for Water Resources. The Working Group felt that this was a very useful document, but the lack of feedback from CCRS makes one wonder whether it was worth the effort. Yet, how else would we find out about and liaise with consultants and small companies with expertise in remote sensing applications to water resources?

Recommendations

1. The Working Group recommends 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 co-operation, through the hydrological co-ordinator, and support of the airborne mission is requested.

2) The Working Group on Water Resources should continue its role as a forum for co-ordinating and contributing to remote sensing developments in water resources in Canada. The working group would continue to provide:

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

APPENDIX I

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APPENDIX II

List of Group Members and Addresses

Dr. B.E. Goodison (Chairman)
Hydrometeorology Division
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario
M3H 5T4

Mr. T. Alfoldi
Canada Centre for Remote Sensing
(Merrivale Road, 4th Floor)
2464 Sheffield Road
Ottawa, Ontario
K1A 0Y7

Dr. Jean-Pierre Fortin
Institut national de la recherche
scientifique - eau
Université du Québec
2700, rue Einstein
Ste-Foy, Québec
G1P 3W8

Mr. D. Graham
Alberta Department of Environment
Water Resources Division
Oxbridge Place
9820-106 Street
Edmonton, Alberta
T5K 2J6

Mr. D. Harvey
Water Resources Branch
Inland Waters Directorate
Place Vincent Massey
Ottawa, Ontario
K1A 0E7

Dr. E. Langham
Radarsat Project Office
Suite 200
110 O'Connor Street
Ottawa, Ontario

Mr. G. McCullough
Department of Fisheries and Oceans
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

Mr. R.J. Myslik
Water Resources Branch
Department of Environment
75 Farquahar Street
Guelph, Ontario
N1H 3N4

Mr. L. Peters
Water Resources Branch
Department of Environment
P.O. Box 6000
Fredericton, N.B.
E3B 1H4

Mr. I. Ross
Ontario Centre for Remote Sensing
Ontario Ministry of Natural Resources
880 Bay Street, 3rd Floor
Toronto, Ontario
M5S 1Z8

Mrs. Irene Rubinstein
PhD Associates
107 Fordwich Crescent
Rexdale, Ontario
M9W 2T6

Professor S. Solomon
Department of Civil Engineering
University of Waterloo
Waterloo, Ontario
N2L 3G1

Mr. D.G. Schaefer
Atmospheric Environment Service
266 Graham Avenue
10th Floor, Room 1000
Winnipeg, Manitoba
R3C 3V4

Mr. A. Warkentin
Manitoba Water Resources Branch
1577 Dublin Avenue
Winnipeg, Manitoba
R3E 3J5

Ms. E. Wheaton
Environment Sector
Saskatchewan Research Council
15 Innovation Blvd.
Saskatoon, Saskatchewan
S7N 2X8

5.10 RAPPORT DU GROUPE DE TRAVAIL SUR LE PROGRAMME D'ÉVALUATION PRÉLIMINAIRE DE SPOT (PEPS)

LE PROGRAMME D'ÉVALUATION PRÉLIMINAIRE DE SPOT

Les caractéristique uniques du système SPOT et l'intérêt considérable qu'il a suscité dans le monde de la télédétection ont conduit le Centre national d'études spatiales (CNES) et SPOT IMAGE à organiser un programme d'évaluation des images SPOT dont le but premier est de mieux connaître l'utilité de ces images dans les différents domaines d'application de la télédétection. De plus, PEPS se propose de mettre en évidence les propriétés distinctives de SPOT ainsi que la qualité des images. Par conséquent, en mars 1984, la communauté de la télédétection du monde entier était invitée à soumettre des propositions de projets de recherche. A la suite de cette offre, SPOT IMAGE reçut trois cent quinze propositions de quarante huit pays; de ce nombre, cent trente deux furent choisies par le CNES et SPOT IMAGE assistés par un Comité scientifique international.

La sélection fut faite en fonction de plusieurs critères dont en particulier:

- intérêt scientifique et intrinsèque de la proposition,
- mise en lumière des caractéristiques particulières du système SPOT,
- évaluation des performances de ce système d'observation de la Terre en comparaison à d'autres,
- expertise des chercheurs,
- qualité technique des propositions,
- diversité des applications.

Une fois les projets choisis, on leur donna la priorité pour l'aquisition des données afin que les chercheurs puissent commencer rapidement leurs travaux. Par ailleurs, SPOT IMAGE s'engagea à fournir gracieusement quatre scènes par projet retenu. Finalement, afin d'assurer une diffusion aussi large que possible des résultats, on a prévu un symposium international environ dix-huit mois après le lancement du satellite, donc vers la fin de 1987.

LE PEPS AU CANADA

Parmi les cent trente deux projets retenus, on retrouve huit projets canadiens et un projet franco-canadien dont on trouvera une brève description dans le tableau ci-dessous. SPOT ayant été lancé à la fin de février 1986, les premières scènes furent acquises dès le début du printemps. Les chercheurs canadiens qui avaient demandé des scènes de printemps (mai-juin) les ont obtenues directement de SPOT-IMAGE, ces scènes ayant été enregistrées à bord du satellite, traitées à Toulouse et envoyées directement. Par la suite, grâce à une entente entre SPOT-IMAGE et le Centre canadien de télédétection (C.C.T.), ce dernier fut en mesure, à partir de la mi-juillet 1986, de programmer, d'enregistrer, de traiter et de diffuser les données SPOT du territoire canadien. Reçues par les stations de Gatineau et de Prince Albert, celles-ci furent traitées par le système MOSAIC à Vancouver jusqu'au milieu de décembre 1986 avant qu'il ne soit déménagé à Prince Albert où il se trouve en opération actuellement.

Malheureusement, le C.C.T. n'a pas réussi à mettre au point un système de production des épreuves-minutes dès le début des opérations ce qui a retardé de façon considérable la production des images SPOT, ce système étant indispensable pour visualiser rapidement les scènes afin d'estimer la couverture nuageuse. Malgré ce contretemps, plusieurs scènes commandées pour les projets PEPS ont été livrées avant la fin de 1986. Les études en sont néanmoins sérieusement retardées.

Finalement, à la suite d'une réunion préliminaire à Edmonton pendant le 10ème Symposium canadien sur la télédétection, les chercheurs PEPS ont demandé au C.C.T. de former un groupe de travail ad hoc dans le cadre du Conseil consultatif canadien de télédétection. Le C.C.T. a approuvé cette demande afin de faciliter la diffusion et l'échange d'information entre les chercheurs. La première réunion du groupe se tiendra à Ottawa le 21 avril.

PROGRAMME D'ÉVALUATION PRÉLIMINAIRE DE SPOT (PEPS)
PROJETS CANADIENS

Chercheur-Organisme: **Chantal Seuthé, C.Q.C.T., Énergie et Ressources, Québec**

Chercheurs assoc.:	D. Bruger, J. Beaubien, J-P Letourneau, P. Buteau
Description:	Évaluer l'apport des images SPOT pour la cartographie au 1:125 000 de la forêt ainsi que pour l'inventaire des tourbières au Québec.
Site de l'étude:	1. Volet forestier: Chibougamau, Matagami (Québec) 2. Inventaire des tourbières: Basse Côte nord (Québec).
Situation-données:	Une scène disponible sur quatre.

Chercheur-Organisme: **David A. Wilson, Bureau régional de l'Atlantique, Environnement Canada.**

Chercheurs assoc.: P. Rump, J. Arbour, N. Lefler, R. Simpson, J. Seel, M-L McCourt, C. Speight, M. Poirier, A. Paton, D. Smith.

Description: Évaluer l'apport des données stéréoscopiques de SPOT pour le programme de suivi de l'utilisation des terres du Canada en milieu rural. Il s'agit de déterminer les classes identifiables à partir des données SPOT, d'évaluer les avantages de ces données par rapport aux photographies aériennes et d'établir des classifications de l'utilisation des terres.

Site de l'étude: Région de Truro (Nouvelle-Écosse).

Situation-données: Une scène disponible sur quatre.

Chercheur-Organisme: **M.M. Allam, Levés et cartographie, Énergie, Mines et Ressources, Canada.**

Chercheurs assoc.: J. Gauthier, A.C.D. Terroux, J.H. Brown, C.K. Chaly, V. Kratky.

Description: Étudier les possibilités des images SPOT pour l'établissement et la révision des cartes topographiques au 1:250 000 et au 1:50 000.

Site de l'étude: Ottawa (Ontario); Kanasaskis (Alberta).

Situation-données: Aucune scène disponible.

Chercheur-Organisme: **Philip J. Howarth, Département de Géographie, Université de Waterloo.**

Chercheurs assoc.: L.R.G. Martin.

Description: Évaluer le potentiel de SPOT pour suivre l'expansion du milieu urbain dans les zones rurales; développer une nouvelle approche et la comparer aux méthodes actuelles.

Site de l'étude: Toronto (Ontario).

Situation-données: Complet; deux scènes disponibles sur deux.

Chercheur-Organisme: **Herbert Ripley, Aerial Mapping and Photography Limited**

Chercheurs assoc.: R. Stacey, J. Mawdsley, A. Speight, A. Lyndo, B. Dawe.

Description: Évaluer l'utilité des données SPOT pour l'inventaire des terres humides.

Site de l'étude: Amherst (Nouvelle-Écosse).

Situation-données: Aucune scène disponible.

Chercheur-Organisme: **Josef Cihlar, Centre canadien de télédétection, Énergie, Mines et Ressources, Canada.**

Chercheurs assoc.: M. Bernier, F. Ahern.

Description: Établir le potentiel des données pour l'établissement de cartes d'occupation du sol en zone agricole dans les basses-terres du Saint-Laurent.
Évaluer l'ampleur des dommages causés aux pins par les insectes.

Site de l'étude: 1. Volet agricole: Notre-Dame du Bon Conseil (Québec)
2. Volet forestier: Région de Rupert (Colombie Britannique).

Situation-données: Deux scènes disponible sur quatre.

Chercheur-Organisme: **Réjean Simard, Digim (1983) Inc.**

Chercheurs assoc.: T. Toutin, A. Leclerc, S. Raja Haja, J. Gibson, M.C. Mouchot, R. Boudreau, V.R. Slaney, J. Harris, K. McConnel, J. Ruppert, D. Seeman.

Description: Évaluer le potentiel des données SPOT pour les applications suivantes:
(a) modèle numérique de terrain et cartographie topographique;
(b) cartographie géologique;
(c) correction gravimétrique.

Site de l'étude: Kanakaskis (Alberta)

Situation-données: Aucune scène disponible.

Chercheur-Organisme: **Thomas Belsher, Centre IFREMER, Brest, France**

Chercheurs assoc.: J.M. Dubois, M. Viollier, L. Loubersac, G. Belbeoch.
Description: Inventaire, cartographie et évaluation des stocks de végétation marine.
Site de l'étude:
1. Baie des Chaleurs (Québec)
2. Atlantique du Nord (Bretagne)
3. Pacifique, les îles Tahiti et Moorea
4. Méditerranée, Rade d'Hyers.

Situation-données: Complet; une scène disponible sur une.

Chercheur-Organisme: **Ferdinand Bonn, C.A.R.T.E.L. Université de Sherbrooke.**

Chercheurs assoc.: G. Rochon, J-P Fortin, A. Royer, D. Morin, H. Gwyn, R. Brochu, J. Jobin, M. Therrien, A. Pesant.

Decription: Les principaux objectifs sont:
(a) génération de modèles numériques de terrain à partir de SPOT;
(b) comparaison des classes d'utilisation du sol en milieu urbain périurbain et agricole avec celles obtenues par le Thematic Mapper et les données SPOT simulées;
(c) évaluation de l'apport de SPOT dans la détermination des caractéristiques physiques d'un bassin versant dont les propriétés hydrologiques et météorologiques sont mesurées depuis 20 ans;
(d) évaluation de la teneur de l'atmosphère en aérosols et essai de diverses méthodes de correction atmosphérique;
(e) comparaison des renseignements fournis par SPOT avec ceux fournis par les capteurs radar comme Seasat et une simulation de Radarsat;
(f) étude des effets bidirectionnels liés à la visée oblique de SPOT.

Site de l'étude: Sherbrooke et le Bassin de la rivière Eaton (Québec).
Situation-données: Deux scènes disponibles sur trois.

6.1 REPORT OF THE INTERPROVINCIAL/ TERRITORIAL ADVISORY SUBCOMMITTEE OF CACRS (IPTASC)

TERMS OF REFERENCE

Objectives

1. To ensure that remote sensing technology, data resources, and developments in methodologies of application are made available to resource managers and scientific investigators in all Provinces and Territories of Canada.

2. To ensure that the needs of regional users of remote sensing are reflected in the national program.

   NOTE: "user" is an individual or agency actively engaged in a remote sensing role or having a jurisdiction related to present or potential remote sensing activities.

Functions

1. To facilitate an exchange of information originating in international, federal and provincial/territorial remote sensing programs, among the provincial/territorial remote sensing representatives.

2. To facilitate the mutual assistance of provinces and territories regarding the technical and organizational problems of their respective remote sensing programs.

3. To encourage the efficient cooperation between federal and provincial/territorial efforts to better serve regional remote sensing practitioners and potential users.

4. To facilitate the process of providing the federal remote sensing program with information as to use made regionally of remote sensing resources and the benefits derived from such use.

5. To make recommendations regarding proposals for current and future changes in or additions to the federal remote sensing program.

6. To prepare and present a report, that includes recommendations, to each CACRS meeting without prejudice to each provincial or territorial report to CACRS.

7. To review the above Terms of Reference annually.

Membership

IPTASC is a body of representatives appointed to CACRS on the recommendation of the provinces and territories.

Each member shall be entitled to one vote on each issue. For voting purposes a quorum shall be of four attending members. Up to, but not later than, four weeks after distribution of the minutes of a meeting attended by only four members, non-attending members may object to the Chairperson on an issue with which they do not agree. If agreement between the Chairperson and objecting members is not reached, the issue shall be resolved by a mail-in-vote of all members.

Each representative may invite someone to any IPTASC meeting in his/her stead. The alternate has the right to speak to and vote on any issue. In addition, the representative may invite someone to accompany him/her to any IPTASC meeting as an observer. The observer may speak to any issue, but does not have the right to vote. The selection of alternate and observer is, in all respects, at the discretion of the representative.

1986-1987 Meetings

IPTASC members met in Ottawa on April 1, 1986 prior to the Canadian Advisory Committee on Remote Sensing Annual Meeting held at Arnprior April 1 to 4th, 1986. The following recommendations were developed at this meeting and during the annual meeting:

1. Preamble: The convince potential users of the value of satellite data, government organizations must make high-quality imagery readily available to the public. The reason is simply that it is much easier to market a product if the customer can view the real thing. The microfiche which are presently available do not provide an adequate basis for judging image quality. Furthermore, although one can theoretically order imagery from any part of the world, in many cases long delivery times make it not worth the effort. The present system may be acceptable to users who order imagery constantly, but it is unsatisfactory to those who do so only occasionally.

   The national and provincial airphoto distribution centres have recognized the need for easy access to airphoto coverage. It is now possible, therefore, to go into the centres, view the airphoto you are interested in, buy a copy if you wish, and

walk away with it. Surely, with a little organization, the same arrangement could be made for satellite imagery.

Since many users use aerial photographs in conjunction with satellite data and most provinces already have outlets for air-photos, the CCRS data distribution centre should contract provincial remote sensing centres and airphoto distribution outlets to act as its agents. This arrangement would be similar to that of any wholesale supplier with its retail outlets. If at first the provincial centres are not willing to purchase imagery, CCRS might consider supplying cloud-free 10" x 10" positive transparencies on consignment.

In order to ensure that all the centres have the most up-to-date imagery available, they should place standing orders for cloud-free imagery.

Whenever the idea of provincial distribution of LANDSAT data has been raised in the past, it has been overcome by objections to the cost of the imagery. The most successful technology transfer operation in the history of CCRS, however, took place when employees on a winter-works program were supplied with copious quantities of imagery to display to potential customers. The program would be well worth the investment which the federal and provincial authorities would make.

Recommendation:

IPTASC thus recommends that CCRS set up an ad-hoc working group of appropriate federal and provincial representatives at the operations level to devise a business plan for disseminating data.

2. IPTASC thus recommends that the Chairperson of CACRS form an ad-hoc committee to facilitate the introduction of SPOT imagery into the Canadian remote sensing user community, by performing the following functions:

   - obtaining information on the recording of SPOT imagery, the characteristics of the data, the pricing policy which will apply for Canadian users, and any restrictions which the SPOT-IMAGE Corporation specifies regarding the use or distribution of the data by purchasers;

   - investigating the need for new software development initiatives at CCRS to meet the demand of SPOT data analysis;

   - co-ordinating Canadian research efforts on SPOT data in order to avoid duplication.

   It is recommended that the task force be composed of at least one representative from CCRS, at least two representatives from IPTASC, and at least two Chairpersons of disciplinary working groups, or individuals nominated by them, for a total membership of not more than ten. It is further recommended that the task force be established for a one-year period, that it prepare a progress report to the Chairperson of CACRS by 1 October 1986 and a final report for the 1987 CACRS meeting, and that a decision be made at that time regarding the continuation of the group.

3. IPTASC recommends that decisions regarding the "pointing policy" for SPOT be referred to the respective provincial remote sensing committee or centre for priorization and updating as required.

4. The CCRS airborne program is recognized by the provinces as the single airborne facility in Canada with the capability to support original research and development in sensor development, and to accomplish airborne missions for complex scientific investigations.

   In view of the proposed major cutbacks to the airborne program, IPTASC recommends that the "benefit" of the operation be judged by the evaluation of the long-term impact on the remote sensing research and commercial communities. Therefore, CCRS should hire a consultant for an unbiased evaluation of the airborne program. The resultant report should then be submitted to the appropriate levels for the reassessment of budget allocation.

   (Responses to these recommendations are included in Section 10.)

There was a meeting of IPTASC held on October 20-21, 1986 in Ottawa. The subcommittee 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 Interagency Committee on Remote Sensing (IACRS). 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 Forestry 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 CACRS 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.

Members of IPTASC

Mr. W.G. Best (Chairperson)
(now Past Chairperson)
Chief, Map Distribution and Remote Sensing
Surveys and Mapping Branch
Department of Natural Resources
Winnipeg, Manitoba
R3H 0W4

Mr. F. Hegyi
Director, Planning and Inventory Branch
Ministry of Forests
Province of British Columbia
1319 Government Street
Victoria, British Columbia
V8W 3E7

Mr. I.E. Ford
Technical Services Division
Department of Development
5th Floor, Atlantic Place
St. John's, Newfoundland
A1C 5T7

Mr. C. Bricker
Administrator, Alberta Remote Sensing Center
9820 - 106th Street, 11th Floor
Edmonton, Alberta
T5K 2J6

Mr. J.M. Whiting (now Chairperson)
Senior Research Scientist
Saskatchewan Research Council
15 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 2X8

Mr. V. Zsilinszky
Associate Director
Ontario Centre for Remote Sensing
Ministry of Natural Resources
880 Bay Street, 3rd Floor
Toronto, Ontario
M5S 1Z8

Mme D. Pilon
Coordinateur provincial en télédétection
Ministère de l'Énergie et des Ressources
1995, boulevard Charest ouest
Ste-Foy, Québec
G1N 4H9

Mr. L. Peters
Water Resources Branch
Environment New Brunswick
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1

Mr. J.F. Wightman
Nova Scotia Land Survey Institute
P.O. Box 10
Lawrencetown, Nova Scotia
B0S 1M0

Dr. D. Gillis
Engineering Faculty
University of Prince Edward Island
Charlottetown, Prince Edward Island
C1A 4P3

Mr. G. Nassiopoulos
Department of Renewable Resources
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6

Mr. S. Matthews
Habitat Management
Department of Renewable Resources
Government of the Northwest Territories
Yellowknife, Northwest Territories
X1A 2L9

6.2 REPORT OF THE MARITIME REMOTE SENSING COMMITTEE (MRSC)

The MRSC met 5 times during 1986 and over the year there were a number of changes in personnel. Carl Demings, first Coordinator of the MRSC, retired and Ed MacAulay, first chairman of the MRSC, resigned from the Committee during the year. Ken Snow filled the vacancy left by Ed and Brent Rowley was appointed MRSC Coordinator replacing Carl.

Early in the year a questionnaire was circulated to everyone in Atlantic Canada on the MRSC mailing list. Its purpose was to gather information on the current state of remote sensing in the region. The results will be used in the compilation of a regional remote sensing directory to be maintained on computer database at the MRSC office. 55 responses were received, each representing a regional government department, educational institution, or company involved in remote sensing to some degree. Completion of the computerized directory is planned for the near future as time and resources permit.

An MRSC Education Subcommittee was formed and an initial meeting was held in April, 1986. John Wightman is Chairman of the group with members representing all regional educational institutions having an interest in remote sensing. The rationale for establishing the subcommittee was to enhance cooperation among the regional education sector involved in remote sensing, to make more effective use of facilities in the region, and to coordinate efforts in applying for research funding. The group held one meeting and one teleconference during the year.

Following an Education Subcommittee initiative, a formal agreement has been signed between the College of Geographic Sciences (COGS) in Nova Scotia and Memorial University of Newfoundland (MUN) giving advanced standing to remote sensing graduates of COGS wishing to pursue the newly established Master's degree in remote sensing and digital image analysis at MUN.

The Education Subcommittee has also formulated and submitted a proposal for the establishment of a RADARSAT Applications Research and Development Center in the Maritimes to go ahead if and when the RADARSAT Program is approved by Federal Cabinet.

Following persistant requests from the MRSC for "quick-look" capability for satellite imagery in the region, the Canada Centre for Remote Sensing began production of LANDSAT TM microfiche covering Atlantic Canada. A subscription was ordered and the microfiche is currently being archived at the Maritime Center for Remote Sensing in Amherst. Access to the archive is free to the public and a modest advertising campaign in the form of a mailout was conducted to make the user community aware of the new service. Use of the archive has been heavier than anticipated. SPOT microfiche is also planned to be included in the archive as soon as it becomes available.

The MRSC office, maintained by the Committee Coordinator, was relocated to Halifax in November, 1986.

Discussions are currently underway between the MRSC and CCRS to finalize plans for the implementation of a number of new remote sensing demonstration projects to take place in the region. The new projects will focus on the use of the latest available imagery in resource management applications. One set of projects will utilize data from the SPOT-1 satellite. Other projects will be carried out using airborne radar data simulating data from Canada's RADARSAT scheduled for launch in the early 1990's. SPOT projects will be of an operational nature and should continue following completion of the demonstration project, if successful. The radar projects will be carried out with more emphasis on research into the use of this new data source in a manner similar to projects carried out under the Maritime Technology Enhancement Program.

Publication of the "Maritime Remote Sensing Newsletter" resumed in 1986 with 2 issues produced. The first issue was circulated to approximately 200 readers. Since then, the MRSC mailing list has grown to about 350 names in 6 countries. The second issue was mailed out in May, 1987, and for the first time, contains advertising from regional remote sensing companies.

6.3 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 analysed 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 NRCC and U of A); 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, U of A; the Center's display was staffed at many Provincial events.

The Center's ARIES system was in operation 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 multi-date 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. Other joint projects assessed satellite and airborne sensors for future use in vegetation and similar inventories. Other activities included seminars and training in digital analysis at ARSC.

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. The assembly of an operational large-scale photo (LSP) camera system was completed and delivered to Indian & Northern Affairs, Yukon Territories. A LSP regeneration assessment project was initiated under the Canada/Saskatchewan Forest Resource Development Agreement in cooperation with Weyerhaeuser and DPRR in Prince Albert.

Comments

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

6.4 REPORT OF THE PROVINCE OF BRITISH COLUMBIA

Airborne Remote Sensing

Ministry of Environment and Parks

The acquisition of all provincial aerial photography was carried out under contract through the British Columbia Ministry of Environment and Parks. A total of 79 844 line kilometres was obtained at various scales. This total includes 31 820 line kilometres of 1:60 000 black and white photography acquired for the Terrain Resource Information Management Program of digital 1:20 000 planimetric, cadastral and topographic mapping.

Ministry of Forests and Lands

The B.C. 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 B.C. 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. The study areas were flown at three altitudes to acquire data at 7 m, 3.5 m and 1.7 m spatial resolutions. Preliminary results of the MPB study indicate that MEIS data clearly shows red attacked trees. However, further analysis of the data is required to determine if green attacked trees can be consistently identified. Analysis of the juvenile stands data indicated that with the highest resolution data (1.7 m) six year old plantations, areas of sparse, adequate and dense conifer growth, and areas having brush and herbaceous competition are identifiable.

During the 1986 fire season, the B.C. 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 and it scanned eleven spectral bands from 0.42 to 13.5 micrometers and had an instantaneous field of view of 1.25 milliradians and a total field of view of 38°. A total of three fires were scanned and mapped and 16 missions were flown for fire detection. As member agencies of the Canadian Interagency Forest Fire Centre, the aircraft and scanner were also used by Alberta, Saskatchewan, Northwest Territories and Yukon Territories during the 1986 fire season.

From the 1986 infrared scanning with the Daedalus 1268 and the 1985 scanning with a Daedalus 1260, the B.C. 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 through improved detection and quick initial attack of lightning caused fires.

Institute of Ocean Sciences

The Fluorescence Line Imager (FLI) imaging spectrometer has now started to demonstrate its capability for mapping water surface chlorophyll distributions using the fluorescence signal at 685nm, and further observations are planned for this April in B.C. coastal waters. Observations over land have shown the value of its high spectral resolution, flexible spectral properties and high sensitivity for observations over land.

In May 1986, an agreement was signed with Moniteq Ltd. of Toronto by which they would operate the FLI on a commercial basis in return for company funded technical improvements. During the summer of 1986 they arranged to take the FLI to Europe to study the deterioration of the Black Forests. A number of other targets were also flown, including one over water for which the data has been analysed at IOS.

Planned operation for 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, and various sites in the U.K. as part of a joint operation with Hunting Surveys.

A workshop was held in Ottawa to present results of the FLI programmme 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 by MBB of Germany.

Pacific Forestry Centre

In cooperation with Dr. W.J. Bloomberg and Dr. R. Alfaro, a study has been initiated to investigate the application of remote sensing to pest damage and appraisal. This study includes the use of satellite and aerial photographic data for the detection,

survey and damage appraisal of root disease and for the determination of growth loss and mortality due to western spruce budworm defoliation. A draft report has been completed entitled 'Root disease survey with large-scale colour infrared aerial photography'. Mapping of root disease centres and determination of volume loss were accomplished and delivered to the supervisor of the Greater Victoria Watershed Forests for decision making in assigning cutting blocks. 70 mm large-scale, colour aerial photography was also obtained for root disease test sites in the interior of B.C.

The study of using remote sensing techniques for forest weed control is continuing. Landsat 5 TM digital data and 70 mm large-scale, colour aerial photography were acquired for the Bush River test site. Analysis of the data has been partially completed.

Dr. Y.J. Lee has been designated as the scientific authority for an unsolicited proposal awarded by DSS to Timberline of Vancouver entitled 'Modification to B.C.'s 70 mm camera boom system for silvicultural survey application'. Consultation of the technical aspects of the modification has been carried out with the B.C. Forest Service.

Spaceborne Remote Sensing

Institute of Ocean Sciences

The results of Canadian work in satellite ocean colour remote sensing was presented at an ESA workshop in November. Results from the airborne FLI instrument and plans for a satellite version were discussed. Other ESA member countries, notably France and Germany, have similar plans but so far no comparable prototype.

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 has 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 supports a variety of physical and biological studies by 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 movements 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.

The image processor continues to be heavily used. An upgrade to provide more than one interactive image terminal is planned, but funds are not yet available.

IOS continues active involvement in multi-national research programmes that make use of satellite remote sensing. J. Gower is a member of the Satellite Observing System Working Group for the World Climate Research Programme and is vice chairman of Commission A of Cospar which held an ocean colour workshop in Toulouse, France in July 1986.

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 US Geosat.

Pacific Forestry Centre

In cooperation with the B.C. Forest Service, Inventory Branch, a study has been initiated to study microcomputer data base systems for updating forest resource inventories using satellite digital data. Studies are also continuing on the use of satellite data for detection and damage appraisal of root disease and western spruce budworm defoliation and for forest weed control.

PAMAP Graphics Ltd.

PAMAP Graphics continues to work on the interface between image data and geographic information systems. We have been active on the CACRS Image Analysis Systems and Artificial Intelligence Working Group and the Image Data Base Format Sub-Working Group.

Their activities have mainly centred around the Forestry application. In September, PAMAP personnel accompanied Frank Hegyi of the Ministry of Forests and Lands, Inventory Branch, to the UFRO meeting of Foresters, where two joint papers were presented. From this activity, it is obvious that Canada is a leader in the application of satellite imagery to the Forestry application.

PAMAP personnel have visited several developing countries to assist in the resolution of their resource management problem, including Nepal and Thailand on CIDA missions and Korea, Thailand, Malaysia and Indonesia on a trade mission. Remotely sensed data plays an important part in many of these countries. However, it still is not being exploited as fully as possible.

PAMAP, with the B.C. Ministry of Forests and Lands, has continued to streamline the process of updating maps with satellite imagery. Within these activities, we have developed techniques that lead the way to automatic processing by removing noise and slivers with assistance of the information stored in a GIS. We continue to work on utilizing artificial intelligence techniques in determining the meaning of noted changes.

PAMAP, in cooperation with Dr. David Goodenough of CCRS, is beginning a research project, partially funded by NRC, 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.

Ministry of Environment and Parks

An assessment of the mapping capability of Landsat TM data for mixed wetlands and forest is near completion. The upper Cariboo River Wildlife Management Area was classified for ground cover types that correspond to important moose habitats. Preliminary results indicate that the resulting map accuracy compares favourably with existing mapping from fieldwork and interpretation of 1:20 000 aerial photos. The image analysis for this work was undertaken at B.C. Research. This project is being carried out in conjunction with Wildlife Branch personnel.

Cooperation with the Geological Branch of the Ministry of Energy, Mines and Petroleum Resources continues. Initial results of identification of clay alteration zones from Landsat TM data suggest that there is utility in using this data for specific geologic mapping tasks. Additional TM imagery has been ordered by the Geological Branch for reconnaissance purposes over areas of upcoming geological field work.

In conjunction with the Wildlife Branch, a pilot project has been initiated to assess the effectiveness of Landsat TM data for mapping coastal grizzly bear habitat. The first phase aims to revise existing maps for change caused by logging disturbance. The second phase will test the habitat mapping accuracy obtained by utilizing both imagery and digital topographic data.

Work continues on the development of algorithms to transform a classified image to a cartographically acceptable product. Software packages have been produced that will simplify a classified image based on similarity between classes, length of common boundary and minimum polygon sizes for individual classes. These packages process large image files efficiently, increase mapping accuracy and maintain the positional integrity of class boundaries. Work is proceeding on related filter products that will also consider polygon shape.

Ministry of Forest and Lands

The B.C. 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.

TM paper prints (1:50 000 and 1:125 000 scale) and transparencies (1:250 000 and 1:500 000 scale) are used for updating forest depletions in the Regions and Districts. These products are also being used by the inventory, silviculture, protection, planning, recreation and engineering sections for monitoring and planning purposes.

As a Beta Test Site for CCRS's LDIAS system, the Inventory Branch received an upgrade of the LDIAS software in 1986. Also, in conjunction with CCRS, full integration of the image analysis system with the Intergraph GIS has been completed and the Branch is now operationally updating disturbances using TM digital data.

The Inventory Branch has also integrated its image analysis system with PAMAP

Graphics Ltd's microcomputer-based GIS. This enables the download of TM imagery to floppies. Therefore, downloaded map design files and the corresponding downloaded TM images can be sent to the regional and district offices where the new disturbances can be digitized. The updated forest cover maps can then be returned to the Branch for uploading to the inventory data base. The Branch is also developing a PC-based "expert" system for disturbance updating using the PAMAP GIS system which will assist the regions and districts in the detection, confirmation and mapping of depletions from TM imagery.

The Inventory Branch also investigated the use of TM digital data for detection of mountain pine beetle red attacked trees in the Cariboo Forest Region. However, with the spatial resolution of TM data, red attack could not be consistently identified.

MacDonald Dettwiler and Associates Ltd.

In the past year, MacDonald Dettwiler and Associates Ltd. has done much in the area of research and development and has obtained a large number of significant contracts in the field of remote sensing.

Growth and international success in the commerical remote sensing ground station field includes:

- Delivery of the MOSAICS system to CCRS for geocoded processing of Landsat MSS, TM and SPOT MLA, PLA data.
- Prime contractor for the ESA ERS-1 ground segment.
- Contract to provide SPOT and TM upgrade to Thailand ground station.
- Two contracts to provide SPOT and TM processing to the India ground station.
- Delivery of SPOT/TM ground station components to General Electric for the Saudi Arabian ground station (included GICS and MERIDIAN).
- Contract to design the Customer User Service for Earthnet (ESA)
- Contract to provide the Generalized Synthetic Aperature Radar (GSAR) Processor to DFVLR, Telespazio, ESRIN, and Defense Research Centre Salisbury, Australia.

In 1986, the new MERIDIAN family of image processing and mapping systems was launched 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.

MacDonald Dettwiler is now preparing a meteorological system for delivery to Peru. Also, our real-time airborne synthetic aperture radar system (IRS) continues to improve its position in the market place through the delivery of an X-band SAR to CCRS, and the FIRE 240 series of digital film recorders remain in high demand.

In the area of research and development, MacDonald Dettwiler has made significant success in DTM generation from SPOT, in pass processing for Landsat/SPOT, in SAR geocoding, in automated feature detection and extraction, in interpretation of SAR, and in artificial intelligence use for mapping and forecasting.

MacDonald Dettwiler has expanded its operations in Europe and Asia by opening a permanent European Engineering and Marketing Office in the U.K. and a Marketing Office in Kuala Lumpar, Malaysia. Plans are also underway for an Australian engineering office.

B.C. Research

A report entitled 'Assessment of Landsat Thematic Mapper Data for Mapping and Monitoring Wetlands and Neighbouring Land Cover/Land Use' was completed. Copies are available from the Lands Directorate of Environment Canada.

The BCR image processing system has been extensively used by mineral exploration companies. Much of this activity was concerned with off-shore studies in arid and semi-arid environments. Structural and geo-botanical exploration studies have also been undertaken in the Canadian interior. All remote sensing work performed on the BCR system in 1986 employed Thematic Mapper data.

The system has been up-graded to V3.X of PCI software, and by custom software developed by industry clients for their specific needs. The addition of a dedicated 512 megabyte disk drive now allows for processing of full Landsat TM scenes. Further up-grades planned for

summer 1987 include additional memory for the VAX 780, integration of GIS software possibly on a second work-station, and acquisition of a large format colour electorostatic plotter.

(Submitted on behalf of the B.C. Remote Sensing Committee by Frank Hegyi, Director, Inventory Branch, Ministry of Forests and Lands).

6.5 REPORT OF THE PROVINCE OF MANITOBA

Airborne Remote Sensing

The Interdepartmental Committee on Aerial Photography (ICAP) coordinated aerial photography requirements for provincial government departments and agencies. The number of line kilometers flown during 1986 was 13,525.

The purpose for which the photography was flown is as follows:

a) federal government mapping programs 4036 line km.;

b) general use reconnaissance photography 70mm 0 line km.;

c) forest inventory programs 4972 line km.;

d) provincial government mapping programs 3451 line km.;

e) hydro electric development programs 1066 line km.

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.

Applications

The Manitoba Departments' of Environment and Health are monitoring the bacteriological quality of various beaches located within the south basin of Lake Winnipeg. There are differences in quality between beaches on the west side versus the east side of the Lake. The Manitoba Remote Sensing Centre provided enhanced LANDSAT MSS data that contrasted the differences in the physical quality of the waters of the south basin. The circulation patterns that existed within the Lake were examined to determined if the source of contamination could be located. Further analysis will also take place to determine whether changes in circulation patterns can be predicted, for example from regional wind influences and what effect this may have on bacterial populations encountered on various beaches.

The Department of Energy and Mines, Mineral Investigation Section, has a mandate to provide information on the abundance and areal extent of potential commercial peatlands. Much of the peat extraction activity occurs in southeastern Manitoba, however, there is growing interest in the Interlake region of the province. The Manitoba Remote Sensing Centre was asked to generate thematic maps of the peatlands in the area of interest. LANDSAT Thematic Mapper data is being used as the primary data source. Colour coded thematic maps will be plotted at a scale of 1:125,000 using an Applicon ink-jet plotter.

Fuel type mapping using LANDSAT data was expanded into the Porcupine and Duck Mountain regions of the province by the Manitoba Remote Sensing Centre. This was done at the request of Fire Management, Regional Services Branch, Department of Natural Resources. LANDSAT digital data was used to generate 1:125,000 color thematic maps which were plotted using an Applicon ink-jet plotter. The maps will be used by Fire Management personnel in district offices and in the field to plan fire strategy.

Jackpine budworm (Choristoneura pinus pinus) is a major pest in Manitoba. Aerial surveys are currently used to map the extent of budworm infestations. The Forest Protection Section of the Forestry Branch, Department of Natural Resources requested the Manitoba Remote Sensing Centre to find out if LANDSAT data could be used to detect severe budworm infestations. Enhancements were generated to determine if the extent of defoliation could be assessed. Further work is still being done.

A project was conducted for the Manitoba Department of Agriculture to aid them in the location and eradication of pocket gophers. Alfalfa is a favorite habitat for gophers who cause considerable damage to the crop and field surfaces. LANDSAT MSS data was used to locate alfalfa fields in S.E. Manitoba in order that the Department of Agriculture could check the seriousness of the problem by location and plan control measures.

A cooperative project between the Manitoba Remote Sensing Centre, Statistics Canada, and the Manitoba Department of Agriculture was conducted to compute crop areas in all of agricultural Manitoba. Areas were calculated for canola, cereals and summer fallow. LANDSAT computer tapes were classified using National Farm Survey data for both supervised Training and calculation of the linear regressions by crop district.

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.

A land cover mapping project was conducted for Manitoba Department of Agriculture to assess drainage problems associated with a large drainage basin in S.E. Manitoba. LANDSAT MSS data was classified and presented on 4 map sheets covering the area.

A land cover mapping project was conducted for Manitoba Department of Agriculture to assess both drainage problems and potential new agricultural land that could be put into production in the Interlake region of Manitoba. MSS data was classified and combined with CLI maps, soil maps, and topo maps for a multi-discipline investigation approach.

Mapping was conducted on the entire east side of Lake Winnipeg between the U.S. border and Gillam in order to aid in the locating of a new power transmission line. A total of 29 map sheets at a scale of 1:125,000 were classified from six LANDSAT computer tapes. These maps will be combined with soil maps, topo maps, aerial photos, etc. to assess the least expensive route.

A spring LANDSAT image was classified east of Norway House in order to locate shallow water in lakes which may be suitable for the seeding of wild rice and development of that industry in the region. Two maps at a scale of 1:50,000 were produced. These maps will be used in the field to considerably cut down on the time involved in locating suitable lakes and checking their biological parameters for rice production.

The Manitoba Remote Sensing Centre produced over 1500 applicon color plots during 1986. Many large contract orders were placed with the Centre.

Change in patterns of crops and fallow ratios were inventoried for a large area north of Winnipeg. Two years of data (1984 and 1985) were compared by Manitoba Department of Agriculture to evaluate trends and farming practices in this region. LANDSAT MSS data from late summer images was classified and mapped at a 1:50,000 scale.

User Liaison

The Manitoba Remote Sensing Cente continued to provide technical information and a data ordering service for remote sensing products. Demonstrations on equipment use and remote sensing applications were given weekly. A consulting service was also offered on applications work in addition to carrying out project work if requested. During 1986 there were 1380 clients that used the services and facilities offered at the centre.

To keep the user community informed two editions of the newsletter Remote Sensing in Manitoba were published. One was issued in April and the other in December.

Training

There were two introductory courses on remote sensing, of four days duration, offered by the Remote Sensing Centre. Registration was limited to fifteen to allow for individual exposure on the image analysis system. Each course had more applicants than could be accommodated. These courses in addition to advanced training for image analysts are under consideration for the future.

One staff member at the centre acted as advisor to four students working on Master's Degree programs at the Natural Resources Institute, University of Manitoba.

Conclusion and Forecast

In the early 70's, the Manitoba Remote Sensing Committee was established to investigate the formation of a permanent, annually funded facility to coordinate and monitor remote sensing technology in Manitoba. The work of the committee was realized in 1974 with establishment of the Manitoba Remote Sensing Centre (MRSC). Over the next few years it became evident that great benefits could be derived from remote sensing technology for operational purposes. Through assistance from the Canada Centre for Remote Sensing with the Technology Enhancement Program, MRSC is now an operations oriented centre. In Manitoba remote sensing is a proven credible technology that is here to stay with a bright future.

6.6 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 N.B. 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.

Recommendations

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.

2) It is recommended that access to SPOT data of New Brunswick be improved.

6.7 REPORT OF THE PROVINCE OF NEWFOUNDLAND AND LABRADOR

After a relatively slow period in remote sensing activities through 1985, the pace accelerated considerably in 1986. Several factors are responsible for this renewed interest. The signing of a Memorandum of Understanding between the Canada Centre for Remote Sensing and the Department of Development and Tourism to undertake a Technology Enhancement Program (T.E.P.) stimulated most of the activity.

TECHNOLOGY ENHANCEMENT PROGRAM

Although a formal Memorandum of Understanding between CCRS and the Department of Development and Tourism was not signed until June, the Technology Enhancement Program (T.E.P.) got underway early in 1986 with the installation of an ARIES III image analysis system at NORDCO Limited. The main focus of the TEP has been the six demonstration projects selected to illustrate a range of remote sensing applications to resource managers (Table 1). All of the projects have now started and the initial results are, for the most part, quite promising. Once the projects have been completed and evaluated, the participating agencies will be able to determine what role, if any, remote sensing should have in their ongoing operations.

The TEP has generated considerable interest in remote sensing within the Province, in addition to the demonstration projects. 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 as well as further discipline-oriented 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/88.

MEMORIAL UNIVERSITY OF NEWFOUNDLAND

In addition to the TEP related activities Memorial University of Newfoundland has increased its activity in Remote Sensing over the past year. The following is a summary of programs offered by the Faculty of Engineering and Applied Science and the Department of Geography at M.U.N.

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.

TITLE	LOCATION	AGENCY
1. Bedrock Geological Mapping	Saglek/Hebron area Northern Labrador	Dept. of Mines and Energy Mineral Development Division
2. Surficial Geological Mapping	Strange Lake area Northern Labrador	Dept. of Mines and Energy Mineral Development Division
3. Watershed Analysis	Upper Humber River Western Newfoundland	Dept. of Environment Water Resources Division
4. Land Use Mapping	Southwestern Newfoundland	Dept. of Forest Resources & Lands Land Management Division
5. Moose Habitat Analysis	Northwest Gander River Central Newfoundland	Dept. of Culture, Recreation & Youth Wildlife Division
6. Cutover Mapping	Badger-Grand Falls area Central Newfoundland	Dept. of Forest, Resources & Lands Forest Management Division

TABLE 1 - NEWFOUNDLAND TEP DEMONSTRATION PROJECTS

6.8 REPORT OF THE NORTHWEST TERRITORIES

Department of Renewable Resources

In 1986, the Department of Renewable Resources, Government of the Northwest Territories continued to develop new applications for airborne and spaceborne remotely sensed data. Although an image analysis system is not presently maintained in the Northwest Territories, researchers have made extensive use of the facilities at the Alberta Centre for Remote Sensing (ACRS) and received technical assistance from the Canada Centre for Remote Sensing (CCRS).

Airborne Remote Sensing Applications

In the last few years, the Department of Renewable Resources has used low level aerial photography to census barren-ground caribou on the calving grounds and post-calving aggregations. Black and white aerial photographs of the calving grounds are taken using Wilde RC8 or RC10 aerial survey cameras with 60% overlap for viewing in stereo (1:4,000 - 1:6,000 scale). To census post-calving aggregations, oblique air 35 mm aerial photographs are taken. Although aerial photography has proven successful for calving ground surveys, this technique has not been satisfactory for censusing post-calving aggregations; it is extremely difficult to locate suitably sized aggregations to photograph. This problem has recently been overcome with the use of radio telemetry. By radio-collaring a proportion of the herd, it is much easier to find and photograph the herd and therefore provide a more precise estimate of the population. In 1986, the Department of Renewable Resources radio-collared 40 barren-ground caribou from the Bluenose herd to assist field biologists in their efforts to determine the location of caribou and obtain a population estimate based on the post-calving photo-census. Over the next three years, wildlife biologists will obtain population estimates for this herd using this technique.

Spaceborne Remote Sensing Applications

During the past year, staff from the Department of Renewable Resources were involved in several remote sensing projects using LANDSAT imagery. The following information provides a brief overview of the Department's remote sensing program:

1) A four year study to classify and inventory habitat in the Mackenzie Bison Sanctuary was completed in 1986. Digital image analysis techniques were used to classify an area of 5830 km^2, west of Great Slave Lake. Vegetation data was obtained from LANDSAT computer tapes, which were acquired through the CCRS receiving station at Prince Albert, Saskatchewan. The imagery was recorded by the LANDSAT II multispectral scanner (MSS). The data was analyzed with the ARIES II image analysis system maintained at ARSC. Black and white aerial photographs (1:60,000 scale) provided a reference data set for plant communities. Vegetation communities were then classified into eight habitat types, plus water-covered areas. A classification accuracy of 81% was achieved, with 2.9% of the pixels unclassified. This work will be published in 1987.

2) A pilot study was completed to determine the feasibility of using LANDSAT imagery to predict habitat use by grizzly bears on Richards Island, N.W.T. The investigators made visual interpretations of LANDSAT MSS transparencies to classify land cover types. This information was used to determine if a correlation existed between cover types and areas known to be used by grizzly bears. Movements of radio-collared bears were monitored at three-week intervals to provide information about habitat use. Preliminary results indicate that LANDSAT imagery is useful in making predictions about habitat use by grizzly bears. Additional studies will be completed.

3) The use of remote sensing to identify potential falcon breeding habitat in the N.W.T. is being examined with LANDSAT MSS data and black and white air photographs (1:60,000 - 1:70,000 scale). Research has been conducted on known peregrine falcon and gyrfalcon nesting areas in the Mackenzie Valley and on the mainland Arctic tundra near Bathurst Inlet. Visual analysis of colour composite prints (1:250,000 scale), unsupervised classification, and digital image enhancements have been utilized. Preliminary results suggest that limited possibilities exist for using LANDSAT data to identify potential falcon breeding habitat in the N.W.T., and that additional techniques should be examined. Research on this project will continue in 1987.

4) As part of a two year resource inventory of Auyuittuq National Park Reserve on Baffin Island, habitat specialists have been using black and white aerial photographs and LANDSAT MSS imagery to classify biophysical map units. The map units were primarily based on geological features and were identified from 1:60,000 black and white aerial photographs. Five hundred and seventy-two

(572) different ecosections were delineated and mapped at a scale of 1:250,000. Areas supporting vegetation were determined by visual interpretation of LANDSAT MSS images. The information from the ecosection mapping is being synthesized to provide a classification of the land present in Auyuittuq and the distribution and abundance of plant communities and wildlife habitat.

New Initiatives

Discussions are presently underway with CCRS for a Technology Enhancement Program (TEP) in the Northwest Territories beginning in 1987. Once the TEP is in place, a variety of demonstration projects will be initiated.

User Liaison

The Northwest Territories has maintained user liaison through its association with ACRS and CCRS. The Department of Renewable Resources continued to provide liaison through attendance at meetings of IPTASC and CACRS.

Conclusion

During 1986, significant progress was made in the development of remote sensing applications in the N.W.T. With the TEP in Yellowknife beginning in 1987, the Northwest Territories is anticipating an increased level of activity in remote sensing by government and industry. The presence of an image analysis system in the N.W.T. will greatly enhance our ability to pursue new initiatives. Anyone wishing more information can contact Steve Matthews in Yellowknife [(403) 873-7775].

6.9 REPORT OF THE PROVINCE OF NOVA SCOTIA

This report was compiled from replies received from the major users of remotely sensed data in Nova Scotia as well as member reports given at regular meetings of the Nova Scotia Remote Sensing Committee. This committee meets on a regular basis five times a year. The committee has a broadly based membership from private industry, educational institutions, provincial government agencies and federal government agencies. The committee provides a forum for the exchange of ideas and information on developments in remote sensing. Discussions at committee meetings have provided the basis for inter-agency cooperation and joint ventures on research and industrial applications of remote sensing technology. The following report will highlight activities of agencies as reported to the committee.

Inland Waters/Lands Directorate

A first SPOT scene for the Truro, N. S. area was received in October of 1986, as part of the PEPS initial evaluation of SPOT imagery. The SPOT project, in cooperation with M.R.M.S., Nova Scotia Department of Municipal Affairs and A.C.A.S.I., is entitled "An evaluation of the Applicability of SPOT Stereoscopic Imagery to the Canada Land Use Monitoring Program". As the result of a limited amount of digital image processing to date, the spatial resolution is considered to be of a better quality than anticipated.

August of 1986 saw the end of one and the beginning of another cooperative research project with investigators at the College of Geographic Sciences. These projects are part of Environment Canada's ongoing evaluation of remote sensing techniques relating to land use monitoring and land and water conservation in the Atlantic region. In the study entitled "Targeting Areas at Risk to Soil Erosion in P.E.I." G. Bourns used Landsat TM imagery in the Montague River basin. Presently, D. Wall is determining the usefulness of TM imagery in establishing soil loss parameters related to vegetative cover and land management practices. It is intended that this research will contribute to the establishment of a land and water conservation demonstration area in the Wilmot watershed of P.E.I.

Linkages between remotely sensed data and geographic information systems form a part of the above projects.

Remote sensing products are used within the Water Planning and Management Branch, to deal with water related programs. Under a Federal/Provincial Flood Forecasting Sub Agreement, satellite imagery is used operationally to determine the area of snow cover in the Saint John River Basin. As well, support is provided for gamma surveys of that basin to calibrate the total water content for the Saint John.

Standard panchromatic aerial photography is routinely acquired through air survey companies in support of the Flood Risk Mapping Program. The focus in 1986 included the Newfoundland centres of Stephenville Crossing, Black Duck, Deer Lake and the Waterford River. The 0.5m to 1 m contour intervals require 1:5000 and 1:10000 photo scales.

Panchromatic air photography was also utilized in a hydrogeology study in the Annapolis Valley as part of the National Hydrologic Research Institute's investigation into pesticides in groundwater.

Although not imaging remote sensing, satellite applications are expanding within IW/LD. The Water Resources Branch is now using the GOES satellite for the transmission of water level data from 28 remote stations in Atlantic Canada.

As part of the St. Croix integrated data interpretation, several Landsat TM positive transparencies have been ordered from CCRS. Through the use of a Procom 2 these are to provide an overview of the land use in this international watershed.

Other examples of IW/L Directorate's (Atlantic) involvement in remote sensing include: membership on the Maritime and Nova Scotia RS Committees, presentation of a paper at the Tenth Canadian Symposium on Remote Sensing (Edmonton in May) and attendance at the PEPS Technical Meeting and SPOT 1 First In-Flight Results Conference (Toulouse in December).

Maritime Resource Management Service

During 1986, MRMS has undertaken a number of initiatives aimed at increasing the level of remote sensing activity within the company and throughout the Atlantic region.

Funding was committed to allow several remote sensing research and development projects to be carried out using both airborne

and satellite data including conventional aerial photography, MEIS II, Thematic Mapper, and SPOT imagery.

MRMS staff attended and presented papers at remote sensing conferences and symposiums in Canada and the United States with additional funding provided to allow staff to attend courses in digital image analysis and data interpretation in Canada and France.

Our DIPIX Aries II image analysis system was substantially upgraded in computing power, memory, and software during 1986 and new equipment was purchased to enhance our photo interpretation capabilities.

In late 1986, all remote sensing activities within the company 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.

Nova Scotia Department of Lands and Forests

This Department is continuing to monitor forest clear cuts using the DIPIX Image Analysis System at Amherst. They have tested the usefulness of the PROCOM II and have found it quite successful in preparing of detailed forest management activity information from an image of 1:1000000000 scale on to maps at 1:10000. While LANDSAT MSS has not been reliable in monitoring clear cuts, in agricultural 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.

Atlantic Canada Aerial Surveys Limited

This firm has been very active in acquiring all types of aerial photography for specialized projects throughout the region. In particular standard mapping photography has been acquired for the Land Registration and Information Service as well as the government of New Brunswick and Nova Scotia.

Department of Municipal Affairs

This agency is participating in a land-use project with Lands Directorate and MRMS using SPOT data.

Bedford Institute of Oceanography

BIO is to develop a brochure on applications of digital image processing in oceanography. There are extra copies available of the Proposal on Ocean Studies.
- Canada Atlantic Storm Program provides wind shear, land to sea, information with video coverage over water.
- Tests of SAR to image occur waves ice-reflectivity and other parameters are planned.
- J.P.L aircraft to be used on multiship large wave experiment for all of next March on the Grand Banks.
- ERSA is open to proposals, in which Canada may be involved. These include:
  a) imagery ocean waves by SAR and wave forecasting
  b) mapping ocean features using SAR to cut through cloud to delineate such features as the Labrador Current. One kilometer resolution is adequate. Proposed active micro wave sensor operates either a radar or scatterometer mode.
- BIO now has one year (a pass per day) of AVHRR imagery as a quicklook image tape.
- As far as the BIO image analysis system the University of Miami software is being used more and more for mapping. Easi-Pace is also available.

MacLaren Plansearch

This firm has been concentrating on in situ sensing. Weather forecasting data generated by satellite sensors is used in a daily operational mode. Usually 12 scenes a day are employed. MacLaren specializes in environmental research gathering of information. The company is always looking for a new means, such as that offered by remote sensing, for acquiring environmental data.

BP Canada Selco

BP has an inhouse image analysis system in Britain. Their company is using I^2S image analysis system to investigate a large tract of land in Newfoundland. BP is also involved in a geobotany project in Cape Breton.

Department of Agriculture and Marketing

The Soils and Crops Branch, uses air photography for soil surveys. Detailed surveys of individual farms are documented on 1:5000 base maps. This level of detail likely to be maintained although a new system of land use mapping in Ontario based on farming systems and grain operation, is to be watched, as part of the Department's aim to keep up with technology in soil degradation and land use monitoring.

Technical University of Nova Scotia

Considerable interest was generated in the Remote Sensing Community in November when representatives from SPAR and MDA made a presentation on possible location of Radarsat infrastructure in Nova Scotia. These firms have been attracted to the province through the technical excellence and support offered by TUNS. Possible facilities which could be located in the province might include data reception facility and telemmetry tracking and control facility and data processing facility. Negotiations are ongoing between these firms, the University and government departments.

Radar Short Courses

Tom Alföldi presented a short course on the technical aspects of radar data acquisition to the Nova Scotia Committee members. This was most informative and provided the necessary information for planning radar demonstration and pilot projects.

College of Geographic Sciences

Formerly known as the Nova Scotia Land Survey Institute this agency 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 accross 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. COGS has a representative on the Board of Directors.

The Canadian Remote Sensing Training Institute

CRSTI is being set up to coordinate remote sensing training in Canada, particularly for foreign students. This institute will not have a specific location but is strictly a coordinating and information exchange body whose membership is comprised of agencies and governments already active in the field of remote sensing training. Initial finances have come from the Canadian International Development Agency (CIDA).

COGS is also very active in providing training through short courses for international students. A very successful example of this was a 7-week course on GIS and Remote Sensing run for FAO for two soil scientists from India.

The College will be making a major push in 1987 to attract additional international students through the publication and distribution of a colour brochure.

Recommendations

1. 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.

2. CCRS is requested to 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.

Members of NSRS Committee

Ken Snow - Chairman 902-895-1591
Department of Lands and Forests

Neale Lefler - Vice Chairman 902-667-7231
Maritime Resource Management Service

Dave Wilson - Secretary 902-426-4196
Lands Directorate/Environment Canada

John Wightman - IPTASC/CACRS Rep. 902-584-2226
College of Geographic Sciences

Fred Guptill 902-421-3200
MacLaren Plansearch

Gary Woods 902-453-6020
BP Canada - Selco Division

Brent Rowley 902-424-4963
Maritime Remote Sensing Committee/MRMS

Alok Wadhawan 902-424-7769
Department of Transportation

Andrew Paton 902-424-7550
Department of Municipal Affairs

Anne Forbes 902-895-1623
Agriculture Canada

Andrew Montgomery 902-895-1571
Department of Agriculture & Marketing

Jim Seel 902-662-3902
Atlantic Canada Airborne Sensing Limited

Clive Mason 902-426-3857
Bedford Institute of Oceanography

Denis Gingras 902-426-1699
Inland Waters Directorate

6.10 REPORT OF THE PROVINCE OF ONTARIO

The information in this report is derived from 24 replies to a questionnaire received from the following sources:

Ontario Government:	5
Universities:	10
Private Companies:	15

APPLICATIONS OF AIRBORNE REMOTE SENSING

The Ontario Ministry of the Environment provided funding for Moniteq Ltd. to conduct a project with the FLI sensor over sites showing forest decline in West Germany, Switzerland and Austria. Approximately 26 tapes of data were acquired for the project. Regional staff of the Ministry recorded aerial photography in-house of emission point sources.

The Photogrammetry and Remote Sensing Section of the Ministry of Transportation and Communications had over 4,000 line-km. of both black and white and colour infrared aerial photography flown by private industry, at scales of 1:2,400 to 1:25,000. Oblique airborne video imagery was also recorded over 85 km. of flight lines. The image acquisition served remote sensing studies, mapping and mosaic compilation.

The Ontario Centre for Remote Sensing in the Ministry of Natural Resources continued development of the colour infrared negative aerial photographic technique. Work was conducted on the development of software for reading, analyzing and storing film calibration data to be used in designing quality control methods. Three trials were conducted in which the colour infrared negative product was demonstrated to have important advantages over the positive film for purposes of mosaicing. Work continued on the development of a demonstration laboratory to process into negatives continuous rolls of colour infrared film in large and small-frame formats.

OCRS participation in geobotanical investigations continued. The projects involved the correlation of ground spectral measurements, laboratory spectral readings and mineral content analysis of leaf ash, with airborne data from the MEIS II and FLI scanners.

The Faculty of Forestry of the University of Toronto generated airborne multispectral video test imagery over a tree nursery to determine system image resolution and the detectability of tree species. An aerial survey was also carried out over a forest area near Kapuskasing in Northern Ontario to determine site moisture conditions on the basis of tree species, and to differentiate areas of aspen and balsam poplar.

The Department of Geography of Trent University used a series of aerial photo graphs for the large-scale monitoring of rural land-use change in Southern Ontario by manual analysis.

The Resource Management Division of Sir Sandford Fleming College used several hundred provincial black and white airphotos in training.

The Department of Earth Science of the University of Waterloo applied MEIS II and LANDSAT MSS data to surficial geological and geomorphological mapping and aggregate exploration. Approximately ten CCT's of data were used.

The Department of Geography of the University of Waterloo reported the following airborne remote sensing projects:

- A comparison of coniferous forest classification accuracy between airborne MSS and MEIS II data over the Petawawa National Forestry Institute (study in collaboration with the Petawawa National Forestry Institute; supported by NSERC).
- Geobotanical study of the Natal Lake area in Northern Ontario (study in collaboration with Ontario Centre for Remote Sensing; supported by NSERC).
- Land cover/land use mapping in the Markham area of Southern Ontario using MEIS data of various resolutions, as background for a SPOT study (study supported by SPOT Image and NSERC).
- Modelling the radiation fluxes for the Perch Lake watershed using MEIS imagery (study supported by Atomic Energy of Canada Ltd.).
- Use of airborne MEIS in the exploration for buried gravel aggregates (study supported by the Ontario Geological Survey).

Graduate students in the Department of Geography of the University of Windsor used airborne data obtained from the Great Lakes Environmental Laboratory to study ice and wave conditions on Lake Erie.

F.G. Bercha (Ontario) Ltd. reported the following airborne sensing activities:

- Analysis of 80 ship returns in extended-swath optical imagery acquired by ERIM X and L-band airborne (CV-580) radar.
- Two-dimensional Fourier analysis of X and L-band (CV-580) wave imagery; sub-scenes were selected from images processed by CCRS on the C-Sharp processor.
- Monitoring of a total area of 100 sq. km. of clearcuts and regeneration on Vancouver Island from digital CV-580 SAR imagery from CCRS.
- Analysis of structural geology of central Nova Scotia on approximately 200 black and airphotos from NAPL.
- Lithological mapping of Eastern Nova Scotia on CCT's of airborne gamma ray and magnetic data from the Geological Survey of Canada.
- Wetland mapping in central Ontario on approximately 50 black and white airphotos and optically-processed X and L-band optically processed SAR-580 data.
- Assessment of potential of STAR-1 data to monitor crops.
- Assessment of narrow-mode C-IRIS data from trial flights.
- All ancillary image acquisition activi ties for agricultural program at Federal Government RADARSAT Office.

Dendron Resource Surveys Ltd. acquired large-scale 70mm aerial photography and conducted airborne laser profiling.

Remote sensing imagery used by Gartner Lee Ltd. consisted of conventional black and white, colour and infrared aerial photography at various scales, but mainly in the 9" format. These photos came from several provincial airphoto libraries (in British Columbia, Ontario, Quebec and New Brunswick), as well as from NAPL. A few private airphoto missions were sub-contracted for industrial clients. Over 100 projects were conducted, mostly in Ontario, each requiring anywhere from 5 to 100 airphotos.

Gregory Geoscience Ltd. used 1,780 35mm oblique transparencies for feature verification, 15 9" black and white photos at 1:50,000-scale for forest mapping, 31 9" black and white photos at 1:30,000-scale for highway mapping, and colour photos at scales of 1:50,000 and 1:25,000 for the revision of a 1:10,000-scale metro data base.

Horler Information Inc. used CCRS MEIS II and airborne MSS imagery in geological exploration applications and for the development of geobotanical remote sensing technology. Six CCT's were analyzed. The company developed image processing software for the analysis of vegetation stress in MEIS II imagery.

McElhanney Mapping Services reported conducting analogue, digital and orthophoto photogrammetric mapping from black and white and normal colour aerial photography taken with cartographic aerial cameras. The photography was obtained from the provincial and federal libraries, and new coverage was recorded by Ontario contractors. Approximately 2,000 stereo overlaps were processed in total. Approximately 1,000 frames of new photography were acquired.

Moniteq Ltd. acquired FLI data for projects in forest damage assessment, water quality assessment, and geobotanical studies for the detection of hydrocarbons and minerals. The company acquired both FLI and MEIS data for projects in water depth estimation and airborne image registration.

Morton and Partners Ltd. carried out airphoto interpretation for three Ontario projects in granular resources mapping using standard provincial black and white coverage. The company also interpreted provincial coverage for gold placer identification in British Columbia. Colour airphotos from the U.S. Geological Survey were used for gold placer identification in Nevada and Colorado. Contracted aerial photography was used for a site contour mapping project in northwestern Ontario.

PCI Inc. is heavily involved with a new firm, Rem/Sense Mapping Technologies, for the development of a system for processing airborne scanner imagery and introducing the technology into mapping and resource management. PCI is providing software for this project. A number of tests were conducted using stereo MEIS data.

Photomap Air Surveys Ltd. reports using approximately 2,000 airphotos per year ranging in scale from 1:50,000 to 1:4,000, acquired by subcontractors.

A.J. Robinson and Associates Inc. used gamma ray surveys from the New Brunswick River Forecast Center for snowpack water equivalent analysis. The data covered ten 20-km flight lines, and had been acquired over two years.

APPLICATIONS OF SPACEBORNE REMOTE SENSING

The Special Projects Section of the Soil and Water Management Branch, Ministry of Agriculture and Food, acquired two MSS and two TM images, for use by OCRS in research on crop rotation mapping. MSS data of a portion of Oxford County was used to provide crop data for a computer-generated land use map based on the OMAF Agricultural Land Use Systems concept.

The Ontario Centre for Remote Sensing participated in a program initiated by North Central Region of the Ministry of Natural Resources to develop a GIS for forest fire control. The OCRS contribution consisted of LANDSAT-derived maps and equivalent digital data, showing forest classes as defined by their readiness to burn. The maps were tested in field use during the summer of 1986, and were found both accurate and valuable. OCRS also started a program to test the use of LANDSAT TM data for the assessment of forest regeneration success.

OCRS staff completed a demonstration project in regional land cover mapping by watershed for Ontario Hydro. This project included the digitization of topographic contours representing different flooding scenarios resulting from dam construction, and the automatic calculation through the digital !image analysis process of the areas by theme which would be flooded. OCRS acted as subcontractor to an Ontario company (Hunter and Associates) in fulfilling this contract.

OCRS continued to participate in SIR-B geological experiments over the Canadian Shield. An OCRS staff member chaired and contributed actively to the Geoscience Working Group of CACRS.

The Ontario Centre continued to work with the Ontario Geological Survey and the Ministry of Agriculture and Food to test the integration of LANDSAT data analysis into computerized information systems for, respectively, mineral exploration and crop inventory. Experiments continued on the use of TM data for change detection in forestry and agriculture.

The Resource Management Division of Sir Sandford Fleming College used 9" LANDSAT prints illustrating various applications, as well as slides and films prepared by such institutions as CCRS, OCRS and Purdue University.

The Survey~ Science Department of Erindale College, University of Toronto, conducted preliminary work on the analysis of satellite imagery for assessing tectonic activity, and mineral and other resources in the East African Rift System.

The Department of Geography of the University of Waterloo reports that the following spaceborne remote sensing projects were in progress in 1986:

- Climatic and hydrologic monitoring using satellite imagery of the Saskatchewan River basin (supported by the Royal Canadian Geographical Society).
- Resource mapping of the Sokoto-Rima Basin, northwestern Nigeria. (project supported by International Development Research Centre).
- An evaluation of SPOT imagery for detecting residential expansion on the rural-urban fringe of Toronto (PEPS project, supported by NSERC).
- Image analysis of sea ice and ocean radar data (supported by NSERC under the Strategic Grant program).
- Remote sensing research and training with digital image processing in China (supported by International Development Research Centre).
- Use of LANDSAT TM data in glacier mapping and inventory (supported by NSERC).

- Mapping the radiation balance in an area of high relief using LANDSAT TM and DEM data (supported by NSERC and WATDEC).

- Optimal unsupervised classification techniques for change detection in the urban-rural fringe (funded by NSERC).

- Change detection of agricultural resources along the Hamilton-Waterloo axis (funded by NSERC and a Commonwealth Scholarship).

- Investigation of the role of sea ice and meltwater along the seasonal sea ice zone on synoptic development in the polar basin (funded by NSERC).

- Evaluation of raster to vector and vector to raster conversion algorithms for Geographic Information Systems (supported by NSERC).

The Department of Civil Engineering of the University of Waterloo used Meteosat and NOAA meteorological satellites to map vegetation in an area of the Sahel as input to a hydrological model for runoff estimation in small river basins of the area. Photo enlargements (1:250,000-scale) of LANDSAT imagery were used to estimate snow cover in the upper Indus River basin. Approximately 150 GOES images were used in carrying out research on the characteristics of hurricanes.

F.G. Bercha (Ontario) Ltd. reported the following activities in spaceborne remote sensing in 1986:

- Visual interpretation of SEASAT images of lakes and oceans, for use in audio-visual presentations.

- Optical interpretation of 10 subscenes (40 km wide) of SIR-A imagery from JPL for tropical rainforest depletion monitoring.

- Optical interpretation of SEASAT SAR data and digital analysis of LANDSAT MSS and TM data for 100 sq.-km. study area on Vancouver Island, to monitor clearcuts and regeneration.

- Use of two LANDSAT MSS CCT's and two prints, two TM CCT's and two prints, and one CCT and print of SEASAT data, for geologic structure analysis of central Nova Scotia.

- Use of approximately ten SIR-B prints and 25 LANDSAT MSS prints for structural, lithological and surficial analysis of specific areas of China and Iran.

- Use of four CCT's and image prints of SEASAT-SAR data for wetland mapping of central Ontario.

- Use of LANDSAT MSS (six 1:250,000-scale prints), TM (ten prints), SEASAT-SAR (six prints) and SIR-B (three prints) for regional structural mapping of the Grenville Province of Ontario.

- Assessment of NOAA AVHRR normalized vegetation indices data for usefulness in global crop monitoring.

- Simulation of RADARSAT data with SAR-580 to assess classification potential: C-VV image of Melfort, Saskatchewan was tested to assess ability of filtering and increased number of looks to reduce speckle.

- Use of SIR-B and SAR-580 data for ground-feature classification accuracy assessment.

Dendron Resource Surveys Ltd. used three LANDSAT TM scenes together with large-scale photography for a forest inventory in the Northwest Territories.

Gregory Geoscience Ltd. used 284 MSS and 23 TM images for map revision and change detection, additional TM images to input forest clearcut information into a digital FRI data base, and SPOT-1 data to define new streets at 1:5,000-scale as a base for the airphoto revision of a 1:10,000-scale metro data base.

Horler Information Inc. used six LANDSAT TM CCT's for geological exploration and geobotanical research.

Moniteq Ltd. used one LANDSAT TM scene for atmospheric corrections.

PCI Inc. employed spaceborne remote sensing in geology, acid lake studies, and large-scale geometric correction and mosaicing including military data base development.

Ph.D. Associates Inc. used passive microwave data with a resolution of 30 sq. km. from the Scanning Multichannel

Microwave Radiometer (SMMR) on board the NIMBUS-7 satellite to monitor the type, extent and concentration of sea ice, the speed of winds and the rate of rain over open ocean, and snow-water equivalent and soil moisture over land.

A.J. Robinson and Associates Inc. conducted land use analyses on two LANDSAT TM images in photographic prints and transparencies, and performed snow-cover mapping with six digital NOAA-7 scenes.

Teledetection International used six LANDSAT TM images and four SEASAT radar images for the geological interpretation of the Lake Abitibi area of Quebec.

NEW TECHNOLOGY

The Special Projects Section of the Soil and Water Management Branch, Ministry of Agriculture and Food, continued to work toward an agricultural land use information system incorporating crop data from the digital analysis of LANDSAT MSS data according to the OMAF agricultural land use system classifications.

The Ministry of the Environment funded the testing of FLI for forest stress evaluation in Europe.

The Photogrammetry and Remote Sensing Section of the Ministry of Transportation and Communications reports that the application of aerial video imaging is under evaluation.

The Ontario Centre for Remote Sensing continued developing the colour infrared negative aerial photographic method, and continued to work toward integration of LANDSAT data analysis with resource-management GIS data bases.

The Resource Management Division of Sir Sandford Fleming College reports an increase in the school's facilities for the application of GIS technology.

The Faculty of Forestry of the University of Toronto reports that further improvements were made on the university's four-camera video sensor.

The Earth Science Department of the University of Waterloo developed techniques for selecting optimum band-ratio triplets, and for identifying the best bands for discriminating pre-selected ground features.

The Department of Geography of the University of Windsor acquired the SPECDAT Image Processing System, including the video image system, host computers and software).

F.G. Bercha (Ontario) Ltd. reported the following activities in technology development:

- Development of a VAX/VMS-based, batch-oriented algorithm for two-dimensional Fourier analysis of ocean wave imagery.
- Development of techniques for registering, integrating and analyzing different types of data (LANDSAT TM and MSS, radar, geophysical and geochemical).
- Development of methods for enhancing radar, LANDSAT and geophysical imagery for geologic applications.

Dendron Resource Surveys Ltd. implemented a GIS system and integrated LANDSAT interpretation with other data using GIS technology. The company also continued airborne laser research with reference to biomass estimation and scanning lasers.

For its PROCOM-2 instrument, Gregory Geoscience Ltd. developed a roll film carrier, a digitizing unit and a stereo-change detection module which permits the projection of two images at the same time onto a map base.

Horler Information Inc. purchased a Dipix ARIES II system running the full suite of the V-stream version of 3.2 software. The company developed software, techniques and expertise for vegetation stress analysis.

Moniteq Ltd. continued to develop applications of airborne FLI. The company developed software for the following purposes:

- airborne image registration;
- atmospheric corrections;
- processing 8-band spatial and spectral FLI data (interactive software).

PCI Inc. reports software development for new algorithms to convert raster theme data

to vector data and to store the data in a spatial data base management system.

Ph.D. Associates Inc. developed techniques for deriving estimates of wind speeds and rain rates over the open ocean, and estimates of snow-water equivalent and soil moisture over land, from Nimbus-7 SMMR data.

A.J. Robinson and Associates Inc. developed computerized zoom transfer scope techniques using a full-natural-colour video-digitizing technique on a micro-computer.

TRAINING

Representatives of the Ministry of the Environment participated in the ground-truthing of sites in West Germany for the PLI test program in Europe.

The Photogrammetry and Remote Sensing Section of the Ministry of Transportation and Communications reports internal training of Ministry staff, and assistance to universities and colleges.

The Ontario Centre for Remote Sensing conducted two photo interpretation courses (geared respectively to Boreal and Great Lakes-St. Lawrence forest conditions), three intensive survey courses in remote sensing application, and a basic and an advanced course for supplementary aerial photography operators. OCRS also collaborated with the University of Waterloo to offer a certificate short course in remote sensing. In cooperation with McLaren Engineers Inc., OCRS trained scientists from Thailand in digital satellite image analysis for forestry, land use and agriculture. The Centre also assisted Barringer Research Ltd. in the training of Thai scientists. A member of the OCRS staff participated in a mission of the Ministry of Industry, Trade and Technology to establish the remote sensing requirements of Jiangsu Province in the People's Republic of China. OCRS hosted scientists from several European countries, from Malaysia, Thailand and Australia.

The Resource Management Division of Sir Sandford Fleming College reports the following courses related to remote sensing:

- photogrammetry and photo interpretation courses in two-year Forestry Technician program;
- photo interpretation (SAP) and remote sensing courses in three-year Forestry Technologist program;
- basic course in aerial photography and additional courses in remote sensing and GIS technology in the Fish and Wildlife and Parks and Forest Recreation Programs;
- intensive photo interpretation course for geology in the Geology program;
- courses in photography, photogrammetry and mapping and remote sensing in the Cartography programs.

The Faculty of Forestry of the University of Toronto taught the following remote sensing courses:

- Remote sensing and image interpretation (an engineering course);
- Forestry applications of remote sensing (fourth-year forestry elective course);
- Remote sensing (second-year introductory course).

The Survey Science Department of Erindale College, University of Toronto, offered a half-credit course entitled "Remote sensing: its interpretation and application" and developed a course in image processing for 1987.

The Department of Geography of Trent University offered a second-year under graduate course entitled "Methods of geographic analysis", in which several exercises used single-band and colour-composite LANDSAT images, as well as colour-infrared airphotos.

The University of Waterloo reports the following courses related to remote sensing:

Given by the Department of Geography:

- Undergraduate courses: Introductory airphoto analysis and remote sensing (150 students); airphoto interpretation (45 students); environmental remote sensing (40 students); advanced airphoto interpretation (5 students); advanced remote sensing (15 students).

. Graduate courses:
Remote sensing (5 students); geographic information systems (5 students).

Given by Systems Design Engineering:

. Undergraduate courses:
Introduction to pattern recognition (35 students); image processing (20 students).

. Graduate courses:
Pattern recognition (12 students); nonlinear and adaptive image processing (10 students).

Graduate students:

. 14 Master's candidates;

. 12 Ph.D. candidates.

Dr. Hubert George of the Earth Science Department of the University of Waterloo reports B.Sc. thesis supervision and giving invited lectures.

In cooperation with OCRS, Waterloo's Department of Geography conducted a one-week Certificate Course in Remote Sensing.

The Civil Engineering Department of the University of Waterloo offered a graduate course in advanced hydrology, which was one-third devoted to the use of satellite data in hydrology.

The Department of Geography of the University of Western Ontario gave a second and third year course on airphoto interpretation and remote sensing to approximately 60 students.

The Department of Geography of the University of Windsor offered a fourth-year undergraduate course in remote sensing. Graduate students used remote sensing techniques and images in Master of Arts dissertations.

F.G. Bercha (Ontario) Ltd. reported that staff of that company were guest lecturers at Carleton University in remote sensing in general, in applications of radar sensing, and in a survey of applications for agriculture, ice and oceans. One staff member acted as an advisor to students completing honours dissertations in geography at Carleton University.

Dendron Resource Surveys Ltd. reported offering training in applications of large-scale photography and GIS. The company was involved in a major remote sensing project in Peru with training and technology-transfer implications.

Gregory Geoscience Ltd. trained one student from France for four weeks and one trainee from Thailand for ten days, and gave several half-day seminars.

Horler Information Inc. provided consulting services in the areas of remote sensing technology, image analysis systems, geographic information systems, international development, and the generation of data bases.

PCI Inc. conducted user and programmer courses to users of that company's EASI/PACE image analysis software packages in France and Sweden. Plans were made for a three-month remote sensing course to be given in India in 1987. PCI also states that the company offers introductory remote sensing courses tailored to the customer's specific requirements.

Teledetection International taught a third-year course entitled "Introduction to remote sensing application" for the Department of Geography at York University.

REMOTE SENSING ADVISORY COMMITTEES

The OCRS Industrial Advisory Committee submitted a report to the Deputy Minister of Natural Resources calling for full guaranteed funding of the OCRS budget, to remove all need for competition with industry. The Committee stated that the OCRS program was recognized as offering significant benefit to the development of Ontario's remote sensing industry.

The Interministerial Remote Sensing Advisory Committee met in December, 1985 and February, 1987. No meetings were held in 1986.

VIEWPOINTS ON THE STATUS OF REMOTE SENSING

Mr. G. Jackson, Program Manager of the Special Projects Section in the Soil and Water Management Branch of the Ministry of Agriculture and Food, states that remote sensing is coming of age, and that recent technical advances illustrate that it can be used to identify and quantify crops with an increasing measure of confidence.

Mr. D. McLaughlin of the Phytotoxicology Section in the Air Resources Branch of the Ministry of the Environment comments that more emphasis should be placed on terrestrial applications, particularly forest resource inventory, vegetation stress mapping, and other regional studies.

Professor J. Vlcek of the Faculty of Forestry, University of Toronto, comments that there is not enough "hard fact" data on the cost-benefit of remote sensing applications.

Professor A. Brunger of the Department of Geography at Trent University states that remote sensing is expensive and under-utilized, and that it needs to become decentralized and "user-friendly".

Professor S.I. Solomon of the Civil Engineering Department, University of Waterloo, calls for a Canadian Space Agency to coordinate and fund both hardware and software development activities.

Dr. H. George of the Earth Science Department, University of Waterloo, comments that student interest in remote sensing is dampened by a depressed job market for personnel with remote sensing skills. He also observes that, except for a very few universities in Ontario, image processing facilities at educational institutions are poor or non-existent, with the result that research activity and academic mobility are limited.

A.S. Bhogal, physical oceanographer with F.G. Bercha (Ontario) Ltd., comments that, while the allocation of funds for the Radar Data Development Plan is a very encouraging development, it would not undermine the federal government's commitment to a space-based remote sensing system.

J. Drieman, geographer with F.G. Bercha (Ontario) Ltd., comments that many geologists are still not convinced or even aware of the potential advantages of remote sensing.

C. Hutton of F.G. Bercha (Ontario) Ltd. calls for joint federal-provincial studies to assess the applicability of RADARSAT to monitor crops in Ontario. She comments that the small fields and unique crops (i.e., cash crops and greenhouses in Essex County) need further study.

Dr. T.V. Ward, Vice President of Marketing for Moniteq Ltd., comments that there should be increased emphasis on communicating the benefits of remote sensing to the operational community.

R.A. Stanton-Gray, applications scientist with PCI Inc., states that PCI foresees remote sensing having a major impact on the methods used for mapping in Ontario when multispectral scanner data is available at spatial resolutions ranging from 0.3 m to 6 m.

Dr. L.W. Morley, President of Teledetection International, comments that remote sensing is just beginning to be properly and fully used.

RECOMMENDATIONS

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.

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.

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.

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6.11 RAPPORT DU QUÉBEC

Ce rapport d'activité du Québec regroupe les bilans préparés par le Centre québécois de coordination de la télédétection (C.Q.C.T.), cinq (5) universités ou centres de recherche, deux (2) firmes privées et l'Association québécoise de télédétection.

SITUATION GÉNÉRALE

En 1986-87 le Québec s'intéresse encore beaucoup aux données Landsat et plusieurs projets de développement et d'application sont réalisés à partir de données MSS et TM. Par ailleurs, le Québec manifeste un vif intérêt pour les données SPOT et prépare résolument l'avenir par la recherche sur le potentiel des images RADAR.

Par ailleurs, 1986 et 87 marquent définitivement le développement et l'utilisation des micro-ordinateurs pour le traitement numérique d'images.

Ces années sont également pour le Québec sous le signe de la collaboration internationale et du transfert de technologie.

RÉALISATIONS ET NOUVELLES INITIATIVES EN 1986

Centre québécois de coordination de la télédétection (C.Q.C.T.), ministère de l'Énergie et des Ressources

- Situation générale

L'activité télédétection au gouvernement du Québec a continué à se développer. De plus en plus de services et ministères s'intéressent au potentiel de la télédétection et certains d'entre eux envisagent d'utiliser cet outil dans des opérations courantes d'inventaire et de gestion du territoire.

- Projets du domaine des applications

En 1986, le C.Q.C.T. a été impliqué dans plusieurs projets de développement et projets pilotes dont certains ont un haut potentiel opérationnel. Pour chacun sont indiqués l'organisme gouvernemental client et les collaborateurs, s'il y a lieu.

. utilisation de l'imagerie TM accentuée pour la planification des travaux de reboisement de territoires perturbés (Direction de la sylviculture, MER);

. utilisation de l'imagerie TM comme support à la synthèse géologique, régions de rivière George et de lac Paillerault (Service de la géologie, MER);

. utilisation des images Landsat-MSS pour l'inventaire des tourbières, région de Tête-à-la-Baleine (Service de la géologie, MER);

. identification des cultures à l'aide des images TM (phase 1): classification à l'échelle d'une municipalité (Service des études environnementales, MAPAQ; C.C.T.);

. identification des cultures (phase 2): cartographie de l'utilisation du sol agricole sur le territoire d'une M.R.C. par classification des données TM (Service des études environnementales, MAPAQ; C.C.T.);

. cartographie des friches à partir d'images TM accentuées (Service des études environnementales, MAPAQ; les firmes Dryade et Octographe);

. détermination de zones de l'habitat potentiel du caribou (Service des plans d'aménagement forestier, MER);

. évaluation du potentiel de l'imagerie TM dans l'inventaire phytosociologique des espaces nordiques: exemple d'application au Cap Smith (C.F.L., Université Laval).

- Programme SPOT

Le C.Q.C.T. est fortement impliqué dans le programme SPOT. Dès réception d'une première image, les études prévues dans le cadre du programme PEPS ont été amorcées. Le volet à avoir été touché pour l'instant est celui de la mise à jour des cartes forestières à l'échelle 1:20 000. Les résultats obtenus ont été présentés au Colloque international de mi-parcours du PEPS à Toulouse en novembre 1986 (Service de l'inventaire forestier, Service de la géologie, MER; C.F.L.).

Par ailleurs, en collaboration avec le C.N.E.S. (France) et le Centre canadien de télédétection, le C.Q.C.T. a, tel que prévu, fait démarrer le Programme d'Utilisation des Images SPOT au Québec (PUIS au Québec).

Ce programme qui a été accueilli avec enthousiasme par les différents intervenants de la télédétection au Québec est réalisé dans le cadre de la Coopération scientifique et technique franco-québécoise en télédétection. Le programme PUIS vise à favoriser

l'utilisation opérationnelle de la télédétection pour des opérations précises d'inventaire et de gestion du territoire.

Les projets qui seront réalisés dans le cadre de ce programme sont les suivants:

. Utilisation d'images SPOT en exploration géologique, région de Joutel, nord-ouest québécois.
Responsable: DIGIM INC., Rochon Guy.
Organisme gouvernemental impliqué: Service de la géochimie et de la géophysique, ministère de l'Énergie et des Ressources.

. Évolution du potentiel de l'imagerie SPOT pour la cartographie des espaces forestiers de la forêt domaniale de St-Félicien.
Responsable: U.Q.A.C., Lemieux, G. (en collaboration avec l'Université de Sherbrooke).
Organisme gouvernemental impliqué: région administrative, secteur "Forêts", Saguenay-Lac St-Jean, ministère de l'Énergie et des Ressources.

. Cartographie des friches et planimétrie des parcelles agricoles.
Responsable: OCTOGRAPHE INC., Audet, H.
Organisme gouvernemental impliqué: Service des études environnementales, Régie de l'assurance agricole, ministère de l'Agriculture, des Pêcheries et de l'Alimentation.

. Détermination de la couleur des lacs à l'aide de l'imagerie SPOT en vue de la préparation de campagnes d'échantillonnage des lacs.
Responsable: INRS-eau, Fortin, J.-P.
Organisme gouvernemental impliqué: Direction des relevés aquatiques, ministère de l'Environnement.

Mentionnons toutefois, que toutes les activités prévues dans le cadre du programme SPOT au Québec se déroulent actuellement au ralenti dû à des difficultés d'approvisionnement en données.

- Développement

Le C.Q.C.T. et le Centre de foresterie des Laurentides (C.F.L.) copartenaires du système conjoint d'analyse d'images du Québec (SCANIQ) ont maintenant à leur disposition un système Aries III de la compagnie DIPIX.

Au cours de 1986, le développement d'un logiciel permettant d'optimiser l'utilisation de la palette de couleurs de Taylor a été amorcé et sera rendu opérationnel en supplément du logiciel de base Aries III.

- Diffusion de produits

. Produits standards du C.C.T.

Suite à plusieurs démonstrations et rencontres au C.Q.C.T., de nombreux organismes et groupes publics et privés ont manifesté le souhait de se procurer des images satellites standards qui sont produites par le C.C.T.

Jusqu'à présent, le C.Q.C.T. a offert ses services pour le choix des images, la préparation de la commande et la préparation de quelques commentaires en fonction des besoins de la clientèle et a contribué à la diffusion de ces produits du C.C.T.

. Copies de données de satellites sur rubans magnétiques.

Le C.Q.C.T. gère une importante collection d'images de satellites du Québec sur rubans magnétiques.

Afin de faciliter l'accès à cette collection à différents intervenants qui souhaiteraient rapidement se procurer des données, le C.Q.C.T. en collaboration avec le Centre d'information géographique et foncière (C.I.G.F.) a entrepris de vendre sur demande des copies d'images Landsat MSS et TM sur rubans magnétiques qui sont en collection.

Centre d'applications et de recherches en télédétection (CARTEL)

- Recherche et formation

Au cours de 86, le CARTEL a procédé à l'engagement de trois nouveaux attachés de recherche, dont deux à l'Université de Sherbrooke et un à l'Université Laval. Alfonso Condal, Hardy B. Granberg et Norman T. O'Neill ont été engagés dans le cadre du programme d'Actions Structurantes du M.E.S.S.T. De plus, une analyste en informatique et un ingénieur se sont joints à l'équipe à Sherbrooke, tandis qu'un technicien était engagé à Laval.

. Hardy B. Granberg, M.Sc., Ph.D. (McGill) est spécialiste des régions nordiques (nord du Québec, du Canada et de la Scandinavie), et ses activités de recherche se rapportent à l'étude du couvert nival en relation avec l'hydrologie et la climatologie du pergélisol (bilan radiatif).

. Norman T. O'Neill, M.Sc. Ph.D. (York) est spécialisé en physique de la télédétection et du rayonnement.

. Alfonso Condal, M.Sc., PH.D. (British Columbia) est attaché de recherche au Département des sciences géodésiques et télédétection de l'Université Laval. Il est spécialisé en physique atmosphérique et il a travaillé principalement avec des données thermiques (NOAA).

. Sophie Rochon, B.Sc. (McGill), est analyste en informatique et elle est responsable du système de traitement d'images.

. Patrick Cliche, B.Sc.A. (Sherbrooke), est ingénieur et il est responsable de la station de spectroradiométrie.

. Michel Fillion, B.Sc. (Laval), est responsable du système de traitement d'images à l'Université Laval.

- Implications internationales

. République Dominicaine

Suite à un protocole d'entente entre le CARTEL et le CEUR (Centre d'études urbaines et régionales) de l'Université Catolica Madre y Maestra de Santiago en République Dominicaine (sous l'égide du CRDI), un projet conjoint a été entrepris sur la télédétection de l'utilisation du sol en République Dominicaine.

. Thaïlande

Dans le cadre du protocole d'entente DIGIM (Lavalin)/CARTEL, le Centre a reçu du 1er au 21 novembre un groupe de thaïlandais (12 personnes) pour un stage de formation en télédétection.

. Maroc

Au cours de l'automne, le Centre accueillait pour un stage de formation de plus longue durée, M.A. Merzouk du Département des sciences du sol de l'Institut Agronomique Hassan II du Maroc. En fin de stage, il a participé à la préparation d'un projet conjoint dont l'objectif est l'évaluation de l'apport de la télédétection à la base des données pédologiques et à la cartographie des sols au Maroc et l'établissement d'une méthodologie d'utilisation, le tout devant servir à mesurer les capacités agrologiques des sols.

Un aperçu détaillé des activités du CARTEL en 1986 est donné dans le rapport de l'Université de Sherbrooke.

. Université Laval

En supplément de ses différentes activités menées dans le cadre du CARTEL, le Département de géodésie et de télédétection de Laval a conduit plusieurs projets spécifiques:

. Préparation d'un montage vidéo sur le traitement et l'analyse numériques des images.

. Développement d'une méthode de segmentation des images de haute résolution.

. Développement d'une méthode d'analyse des images RADAR utilisant des filtrages et la segmentation. Le projet est réalisé en collaboration avec la firme DIGIM inc. et l'Agence spatiale européenne (ASE).

. Utilisation des images RADAR en agriculture; le projet est réalisé dans le cadre d'une thèse de doctorat.

. Développement d'une méthode d'analyse des textures pour l'étude de la forêt.

Un Ph.D. en télédétection a été décerné en 1986 et quatre autres étudiants devraient compléter des études graduées en 1987.

Université du Québec à Chicoutimi (UQAC)

- Enseignement

Le cours de "Télédétection et traitement numérique des images" est maintenant dispensé, en plus des étudiants de géographie, aux étudiants de biologie et de géologie. L'émulation y est plus grande et la pluridisplinarité est favorisée. Le cours utilise trois (3) systèmes informatiques soit le programme SANIL sur un Vax 11/780, les programmes APPLEPIPS et MICROPIPS sur Apple IIe et IBM-PC et le programme SPECDAT sur VIP de Spectral Data (IBM-PC-XT).

- Recherche

Les principaux projets de recherche en cours touchent la télédétection thermographique des espaces forestiers en régénération après feu, coupe ou reboisement, l'anémographie des microclimats agro-forestiers et la lutte au gel radiatif dans les bleuetières. De plus, des étudiants de 1er cycle font des mémoires

de fin d'études sur l'application des traitements numériques d'images, notamment: la thermographie comme outil en géologie structurale, en morphologie d'une tourbière et en climatologie urbaine.

Les études se concentrent sur la région de la Sagamie et utilisent des données Landsat, Deadalus et MEIS-II.

INRS-eau (Institut national de la recherche scientifique)

En 1986, l'INRS-Eau a continué ses travaux sur l'application de la télédétection pour l'étude des ressources en eau et des caractéristiques des bassins versants.

- Projets spécifiques

Parmi les projets menés, citons en particulier:

. le développement d'un modèle de prévisions hydrologiques basé sur la télédétection et exécuté sur micro-ordinateur;

. l'analyse de différents types de couverts dans l'infrarouge thermique;

. la cartographie des eaux du fleuve St-Laurent pour aider à l'étalonnage d'un modèle d'écoulement des eaux du fleuve, basé sur les éléments finis.

Ces travaux ont été réalisés grâce à des subventions et contrats totalisant près de 250 000 $ et provenant du Fonds FCAR, du Centre de recherche pour la défense de Valcartier, du CRSNG, d'Hydro-Québec et d'Environnement Canada.

- Développement sur micro-ordinateur

Les divers travaux ont été réalisés grâce à l'acquisition en mars 1986 d'un système ARIES III. Ce système est branché à un VAX-780 et dispose d'un affichage sur 32 bits et de l'APP (Aries pixel processor).

Par ailleurs, le modèle de prévision est développé sur un micro-ordinateur PC-AT avec carte graphique professionnelle permettant l'affichage simultanée de 256 couleurs sur 4096. Un algorithme de compression de couleurs développé par l'INRS-Eau permet d'obtenir des images d'excellente qualité. Un second logiciel permet de reproduire ces images en couleur sur papier à l'échelle désirée, grâce à une imprimante Color Jet Printer d'IBM. Ces logiciels seront commercialisés par la firme OCTOGRAPHE.

Centre de foresterie des Laurentides (C.F.L.)

Au C.F.L. du Service canadien des forêts à Québec, l'année 1986 a surtout été marquée par une recherche sur le potentiel de l'imagerie TM comme outil supplémentaire pour faciliter l'inventaire de la forêt.

- Développement méthodologique

. Exploitation des images TM

Des recherches antérieures sur les données MSS ont démontré que l'interprétation visuelle d'images accentuées par traitement numérique était la meilleure façon d'extraire l'information sur la forêt contenue dans ces images transmises par satellites. Conséquemment les études sur TM ont d'abord porté sur la recherche de méthodologies d'accentuation répondant aux besoins forestiers.

Sept régions d'étude ont permis de couvrir les principaux couverts forestiers du Québec dans la forêt boréale coniférienne et mixte. Après la production d'accentuations préliminaires, ces régions ont été inventoriées par survols en hélicoptère, par transects au sol ou au moyen de photographies aériennes. À l'aide de ces informations - terrain, différents types d'accentuations furent étudiés tout en tentant de répondre aux objectifs de chaque projet.

Après avoir essayé les accentuations communes comme des compositions colorées à partir de l'addition des différentes bandes spectrales, des étalages d'histogrammes, des rapports de bandes, etc., le C.F.L a approfondi la transformation en composantes principales (TCP) extraites de combinaisons variées des six bandes spectrales disponibles, dans le but de mettre au point une méthodologie aussi simplifiée que possible et donnant des résultats relativement constants quelle que soit la scène traitée.

Dans la méthodologie développée, les bandes spectrales 3 (rouge), 4 (proche infrarouge), 5 (infrarouge moyen) et à l'occasion 2 (vert) sont utilisées pour la TCP basée sur l'échantillonnage de trois types de couvert facilement identifiables (conifères, feuillus et dénudés), suivant des proportions choisies en fonction du ou des types de végétation à accentuer. En dernière étape, des étalages linéaires ou segmentés contribuent à produire des images les plus conformes possibles aux observations du terrain.

. Intérêt pour les images SPOT

En 1986, le C.F.L a aussi collaboré à des travaux sur des données multispectrales aéroportées, simulant celles de SPOT, pour une évaluation des dommages de la TBE. Peu d'énergie y fut consacrée à cause de la valeur mitigée des premiers résultats, des problèmes de radiométrie, et surtout à cause de la disponibilité prochaine des réelles données SPOT. Le C.F.L. participe au programme PEPS (Programme d'Évaluation Préliminaire de SPOT) en collaboration avec le Centre québécois de coordination de la télédétection (C.Q.C.T.).

- Transfert de technologie

Dans un but de transfert de technologie, cinq des sept projets ayant contribué à développer la méthodologie utilisant MSS et TM ont été réalisés avec des organismes gouvernementaux et privés qui ont accueilli très favorablement les résultats. En plus de la résolution accrue par rapport à MSS, ces organismes ont particulièrement apprécié les possibilités de discrimination de la régénération forestière et des niveaux de dommages causés par la tordeuse des bourgeons de l'épinette (TBE). Une compagnie utilise les documents produits pour planifier des coupes de récupération.

À la suite de ses travaux sur MSS et particulièrement sur TM, le C.F.L. est de plus en plus convaincu que la télédétection par satellites pourrait jouer un rôle important en aménagement du territoire forestier.

DIGIM

En 1986, la firme DIGIM a réalisé plusieurs projets de développement et de transfert de technologie et a intensifié ses activités de commercialisation.

- Développement et applications

. Digim a complété une étude très détaillée sur l'utilisation de données radar ROS pour des applications en agriculture et en foresterie. Cette étude faite pour le compte de l'Agence Spatiale Européenne a permis d'établir des attentes réalistes de l'utilisation du satellite européen ERS-1 pour les applications en agriculture. D'autres travaux ont été jugés nécessaires pour l'évaluation du potentiel d'application des données ERS-1 pour la foresterie.

. Poursuite des travaux de développement pour le compte d'EMR d'un système automatique pour la cartographie de base à l'aide d'images SPOT. Le système sera opérationnel en début 1987.

. Soutien au développement de logiciel au C.C.T. pour le traitement géométrique d'images SPOT.

. Des travaux d'analyse d'images TM et de données géographiques pour la prospection de dépôts calcaires en Nouvelle-Écosse ont débuté.

- Projet internationaux

. Un important projet de transfert de technologie dans les applications de la télédétection spatiale avec le gouvernement thaïlandais a débuté. Ce programme impliquant 9 départements ainsi que le Conseil National de Recherches de la Thaïlande inclus la formation de 23 stagiaires au Canada et la réalisation de 6 projets de démonstration en foresterie, agriculture, cartographie topographique, utilisation et cartographie des sols et ressources en eau. Ce projet financé par l'Agence canadienne de développement international (ACDI) se poursuivra jusqu'à la fin 1988.

. Un projet de production d'images de télédétection MSS et RBV améliorées pour l'exploration minière au Niger a été complété.

- Commercialisation

. Commercialisation d'images SPOT auprès d'utilisateurs canadiens pour des images acquises à l'extérieur du Canada. Cette commercialisation résulte d'un accord de distribution des données SPOT établi avec la société SPOT Image de Toulouse.

. Intensification des activités de commercialisation de cartes de base produites à l'aide d'images stéréoscopiques SPOT. Début à l'automne 1986 un projet pilote visant la cartographie topographique à l'échelle du 1:50 000 d'une zone montagneuse située en Malaisie. Ce projet financé par l'ACDI se poursuivra jusqu'à l'automne 1987.

. Digim a participé avec la firme Éconosult aux études relatives à l'évaluation économique du projet RADARSAT.

OCTOGRAPHE

La principale activité de la firme OCTOGRAPHE en 1986 a été le développement d'un système de traitement d'images basé sur micro-ordinateurs.

- Développement d'équipement et de logiciels

La firme Octographe travaille à la mise au point d'un système de traitement d'images sur micro qui sera commercialisé en deux (2) versions différentes sous le nom d'OCTIMAGE (système de base) et de GRAPHIMAGE (système plus élaboré).

Le projet est réalisé grâce à l'assistance financière du ministère de l'Expansion industrielle régionale et de la Société de développement industriel.

- Projets d'application

Grâce à l'acquisition d'un système Imavision, OCTOGRAPHE offre un service complet de traitement d'images.

Deux (2) projets d'application ont été annoncés en 1986 et se poursuivront en 1987: d'une part l'évaluation des images SPOT envers des problématiques agricoles (avec le ministère de l'Énergie et des Ressources, le ministère de l'Agriculture, des Pêcheries et de l'Alimentation et la Régie des Assurances agricoles du Québec); d'autre part, la cartograhie du changement affectant la forêt pendant une décennie sur le feuillet cartographique 31H (avec Environnement Canada).

Association québécoise de télédétection (A.Q.T.)

En mai 1986, l'Association a préparé une journée de télédétection dans le cadre du 54e Congrès de l'Association canadienne-française pour l'avancement des sciences. L'événement a eu lieu à l'Université de Montréal.

L'assemblée générale a eu lieu par la même occasion et un nouveau Conseil d'administration a été élu pour la période 1986-1988. Monsieur Keith P.B. Thomson a été nommé président.

Par ailleurs, l'A.Q.T. a donné son appui à une exposition itinérante sur la télédétection qui devrait débuter en 1987. Cet événement est sous la responsabilité de monsieur J.-M. Dubois de l'Université de Sherbrooke et a aussi reçu l'appui du Centre canadien de télédétection.

PROJETS ET ACTIVITÉS ANNONCÉS POUR 1987

Plusieurs projets et de nombreuses activités sont déjà planifiés pour 1987. Pour chacun des projets annoncés l'organisme responsable et le cas échéant, les collaborateurs sont indiqués entre parenthèses.

Les programmes PEPS et PUIS au Québec

Moyennant un approvisionnement en données et des conditions climatiques favorables à l'été 1987, cette année devrait vraiment être l'année de SPOT au Québec.

Tous les organismes participant à ce rapport sont impliqués dans l'un et/ou l'autre des programmes PEPS et PUIS au Québec.

Projets de développement et d'applications

En dehors des six projets québécois directement réalisés dans le cadre du programme PEPS et PUIS, plusieurs autres projets et activités de développement, de recherche et d'applications sont prévus.

. Élaboration de cartes d'occupation du territoire comme support à la carte écologique (C.Q.C.T. - ministère de l'Environnement).

. Développement de spatio-cartes types à l'échelle de M.R.C. (C.Q.C.T. - Service de l'aménagement des terres).

. Cartographie des ensembles structuraux dans la région de Schefferville: intérêt de la stéréoscopie SPOT (C.Q.C.T. - Service de la géologie, MER).

. Cartographie des dépôts meubles et des zones sensibles (C.Q.C.T. - ministère des Transports).

. Évaluation de la stéréoscopie SPOT pour la carte de base à l'échelle 1:20 000 (C.Q.C.T. - Service de la cartographie, MER).

. Utilisation des données NOAA en océanographie (Université Laval).

. Application des données RADAR en agriculture: région de Drummondville (Université Laval).

. Achèvement de la première version du modèle de prévision hydrologique basé sur la télédétection (INRS-eau).

. Mise au point de nouvelles techniques permettant par survol aéroporté de capter des données anémothermographiques des espaces agro-forestiers étudiés. Par modification d'un bimoteur de type Aztec, survol des espaces et photographie au flash des transducteurs de vitesse et d'écoulement de l'air au sol et au même moment acquisition de l'imagerie thermique. Les nouvelles méthodes ainsi développées permettront de cartographier les microclimats qui affectent la croissance des végétaux ou de localiser toutes autres modifications thermiques (U.Q.A.C.).

. Poursuite des travaux sur TM en classification automatisée de certains thèmes d'intérêt particulier pour les forestiers (C.F.L.).

. Développement de méthodologies sur micro-ordinateur pour des usagers potentiels impliqués en inventaire et en gestion forestière (C.F.L.).

. Développement d'outils informatiques puissants permettant la réduction du nombre de points d'appui nécessaires à la rectification d'images SPOT. Cette technique, appelée spatiotriangulation, limitera l'effort d'acquisition de données au sol et permettra une meilleure stratégie de production des cartes de base surtout en milieu isolé et difficilement accessible (Digim).

. Commercialisation des sytèmes de traitement d'images OCTIMAGE et GRAPHIMAGE (Octographe).

Collaboration internationale

Plusieurs projets de collaboration internationale sont prévus pour 1987.

. Dans le cadre de la coopération France-Québec en enseignement supérieur et recherche en matière de télédétection, le ministère de l'Enseignement supérieur, de la Science et de la Technologie du Québec sanctionnait en fin d'année un programme d'échange entre le CARTEL (Université de Sherbrooke) et le CRPE (Centre de recherches en Physique de l'Environnement) de l'Université de Paris VII. Par le biais d'ententes préalables, les laboratoires associés de l'INRA (Avignon) et du LERTS (Toulouse) ainsi que les organismes tels que DIGIM et Agriculture-Canada participent également à l'échange. Le protocole prévoit des échanges dans les domaines suivants: mise au point de méthodes d'analyse et d'interprétation quantitatives des images radar appliquées à l'étude de la végétation et de la géologie, les méthodes d'analyse d'images et l'intégration de données multisources, les applications agricoles de la télédétection et les méthodes de correction atmosphérique des images. Le programme, d'une durée de trois ans, comprend des stages et des missions.

. Digim effectuera le traitement et l'analyse de données LANDSAT MSS et TM à des fins de prospection hydrogéologique au Mali.

. L'Association québécoise de télédétection (A.Q.T.) parraine le 4e Colloque international sur les signatures spectrales qui aura lieu en janvier 1988 en France. Le président de l'A.Q.T., monsieur K.P.B. Thomson, est membre du comité d'organisation.

. En collaboration avec le CNES (France), le C.Q.C.T. a la responsabilité d'organiser un atelier sur les résultats dans le cadre du programme PUIS au Québec. Cet atelier qui pourrait avoir lieu au début de 1988 devrait réunir des intervenants français et québécois du domaine des applications.

Projets conjoints C.Q.C.T. - C.C.T.

Le C.Q.C.T. et le Centre canadien de télédétection envisagent de réaliser conjointement quelques projets pilotes dans le cadre du programme d'amélioration des techniques (PAT).

RECOMMANDATIONS

- Nous aimerions recommander au Centre canadien de télédétection de faire en sorte de pouvoir reporter à l'été 1987, et au même tarif, les survols commandés en 1986 et non réalisés par suite des mauvaises conditions climatiques. Le laboratoire de télédétection de l'UQAC a un important projet de climatologie urbaine et de thermographie forestière à compléter en 1987-88 à partir d'une commande de survols restée en suspens. (U.Q.A.C.)

- Un des principaux obstacles à l'utilisation plus courante de la télédétection par satellite réside dans la rareté des bonnes images pour un territoire et une date déterminés. Il serait souhaitable de reconsidérer l'installation d'un capteur multispectral à bord de Radarsat. Il contribuerait à rentabiliser ce futur satellite canadien. (C.F.L.)

- Le C.Q.C.T. se trouve dans la position de devoir déplorer à nouveau les délais d'attente imposés aux clients des données de satellites. Par ailleurs, le C.Q.C.T. demande au Centre canadien de télédétection de maintenir disponible toute la gamme de produits de satellites qui était offerte avant le 1er avril 1987 et ce tant que l'entente de privatisation ne sera pas réalisée.

6.12 REPORT OF THE PROVINCE OF SASKATCHEWAN

The information in the report is derived from thirty-six replies to a questionnaire sent out to a total of 289 questionnaire recipients. They were received from the following sources:

government agencies	- 48%
training institutions	- 12%
private entities	- 40%

Applications of Airborne Remote Sensing

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, Canada Centre for Remote Sensing, Ponteix Water Users Association and Saskatchewan Agriculture.

Canadian Wildlife Service studies include continued analysis of 1:24,000 colour infra-red imagery concerning the value of prairie habitat in support of the North American Waterfowl Management Plan. Data have been collected from approximately 24 quarter sections at each of 130+ locations across the Prairie Provinces. Plans call for this photography to be repeated in 1990. The co-operating agencies are Lands Directorate, U.S. Fish & Wildlife Service, and Sask. Parks & Renewable Resources with negotiations underway for Ducks Unlimited to join.

The Saskatchewan Water Corporation uses black and white aerial photography in support of its dam construction and related water supply projects on an on-going bases.

Agro-Tech Systems Inc. has a system under development which uses black and white infra-red aerial photography, together with selected soil sampling, to generate a map of fertilizer requirements of a field. The map will be used by the fertilizer applicator to vary the fertilizer application rate according to the actual requirement at each location in the field.

CCRS and Sask. Parks & Renewable Resources used airborne pushbroom scanner data (and TM data) to detect spruce budworm. Five metre MEIS-II data was successfully used. This data was more accurate than those produced by aerial sketch mapping. SPRR was used aerial IR for its regular forest inventory assessment although it was much curtailed due to weather this year.

The Saskatchewan Institute of Pedology used black and white aerial photography for soil survey work and infra-red photography as part of the Innovative Acres Program for salinity assessment.

Applications of Satellite Remote Sensing

The STEP Program

The Saskatchewan Technology Enhancement Program (STEP) was started in November, 1984 with the signing of a Memorandum of Understanding between CCRS and SRC. The equipment arrived in January, 1985. Since that time some 6000 hours have been logged on the system or 8.3 hours/day (every day of the week).

The STEP program has ten demonstration projects. These projects are: mitragory waterfowl, deer, moose and caribou habitat; bulk area estimates of crops; field boundary assessment; forest fuel mapping; burn and cut-over inventory; salinity in irrigated areas; and depression storage as a measure of flood potential. Four of these are now complete with draft reports being assessed: deer and moose habitat; burn and cut-over inventory; area estimation of canola, small grains and summerfallow. An additional four are in the writing stage: caribou habitat; forest fuel mapping; salinity in irrigated areas; and depression storage. Only waterfowl habitat and field boundary assessment remain to be completed. Copies of the reports maybe obtained in July, 1987 from Jeff Whiting, Sask. Research, Saskatoon, Canada S7N 2X8.

The results from the completed STEP projects are as follows: Deer Habitat Project (SPRR) - The Terrestrial Wildlife Habitat Inventory completed over eight years ago

is becoming outdated. The benefit cost of using digital methods is at least 4:1 with varying accuracy in the five classes assessed. The general accuracy was 82%; The Moose Habitat Project (SRC) - A habitat mapping program has never been attempted in Saskatchewan prior to this. The overall accuracy of the map is 82% however assessment was also made at one kilometre UTM grid inter-sections at randomly selected squares [16 km x 16 km] between forest inventory map and the digital remote sensing map. The grid accuracy varied between 60% and 98% depending upon the class [treed bog to water]; The Burns and Cut-over Inventory (SPRR) - Accuracy assessment was done using the Forest Inventory Map using geo-referencing evaluation methods (GEM). The 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. Further work is required, however, for the operational use in cut-over assessment. The cost/benefit ratio was assessed to be 5:1; and The Crop Area Estimation Project was reported in the last CACRS report.

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. In fact a third shift (midnight to 08:00) was initiated in October. Regular seminars, newsletters, tours and courses were offered throughout the year.

Other Satellite Programs:

The Saskatchewan Research Council has been active in the following areas: geology, agriculture and hydrology. A co-operative project was initiated with France [INREA] on image analysis applied to Integrated Investigation of Mineral Exploration Data. The purpose of this project is the integration data using raster images in Northern Saskatchewan. The data includes bedrock and surficial geology, structure, various geophysical data (ground and airborne), geochemical, topographical, and vegetation. New feature and theme maps were generated such as magnetic vertical gradient as a variant to economics or terrain. In another joint project with Sask. Mining and Development Corp. and Mollard & Assoc., structural assessment of the Swift Current petroleum area was made with TM data. Over 2,000 individual lineaments were defined inspite of over 2,000 m of Phanerozoic sedimentary strata overlying the pre-Cambrian basement. 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. SRC has also been co-operating with Nova Scotia Land Survey College concerning the detection of soil salinity in relation to groundwater discharge. SRC is interested in using the satellite technique to find other such areas in the Prairies.

The Saskatchewan remote sensing centre (at SRC) has been involved in a number of small projects in response to problems that have arisen during past projects: 1) **Improved digital burn mapping.** To counteract the problem of classification overflow of new burns into lake reflectances a repeat classification was used. Unsupervised classification of areas having both recent burns and lakes resulted in classification of the burn as well as part of the lake under the same signature file. This could be eliminated by adding signature files developed from lake training areas draw in area of confusion and then rerunning the classification using **both** the unsupervised signature file and the lake signature file developed in the interactive training task. The resulting classification had two separate classes; one for the lakes and the other for the burn; 2) **Enhancement of Thematic Mapper Data.** Principal Component Analysis and Band Ratio-ing were used to digitally enhance Landsat TM data for the separation of closely related (reflectance wise) terrestrial habitats. Native grasslands, crops, and trees and shrubs could be easily separated using standard enhancement techniques available on the Aries II DIPIX system. Visual separation of these habitats was investigated using various combinations of raw channels and enhancement products; 3) **Preliminary results of Biomass Assessment of Forage Crops** using TM and MSS data. Both Principal Component Analysis and Band Ratio-ing appear to be better than Contrast Stretching for the development of visual products which enhance the separation biomass levels. It appears that although a product can be developed for the Thematic Mapper which delineates a number of different levels of biomass

ranging from very low to very high more accurate delineation may result if the enhancements concentrate on either the low or high end of the biomass rather than a single product for the full range of biomass. Low levels of biomass can be emphasized using MSS data if standard band ratio products utilizing rations of band 7 and 4 and bands 5 and 4 are used in conjunction with raw or enhanced bands 7 and or 5; **4) Separation of closely related Habitats** using a two tier classification. Recent work using TM and MSS in the arctic encountered the problem of separating two cover types; one on a dry site and another on a wet site. Both supervised and unsupervised classification resulted in no or poor separation. The method investigated to resolve this problem was to first classify the area according to the moisture levels and then classify the area according to vegetation. The signature files resulting from both classifications were then run through the maximum likelihood classifier to separate the dry-confusing habitat from the wet-confusing cover type. TM data was used for this experiment and further work is underway by the University of Regina.

SRC has also used Digital Terrain Models (DTM) to evaluate the snow distribution in small Prairie watershed and hence use NOAA data to prediction flood runoff using the SSARR runoff model based upon snow cover data. A co-operative program was also initiated with the University of Saskatchewan and CCRS to evaluate the use of NOAA data in vegetation indices and precipitation distribution on crop yield.

Mollard & Associates has used satellite data for petroleum exploration and exploitation in Saskatchewan. In addition, remote sensing was used in the routing study of a transmission line between Uranium City and Wollaston Lake. Slope features were assessed using remote sensing to evaluate the effect of gas line construction on valley and hill sides.

Tamarack Resources has been very active in both airborne and satellite contracts in support of environmental impact assessment, wildlife and agricultural studies.

Sask. Parks and Renewable Resources undertook a study using Landsat transparencies to map native habitats which were greater than 80 acres in south-eastern Saskatchewan for the white-tailed deer habitat acquisition program.

Sask. Mining & Development Corp. (SMDC) has been involved in the following projects: research into the methods of regional geological structures in Northern Saskatchewan; Terrain classification studies were used to complement environmental impact assessments for mineral development projects; and research into methods of analysis of regional geophysical data (eg. airborne magnetic data) through image processing.

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.

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

New Initiatives

SED Systems is determined to continue and expand SED's commitment and is working on several fronts. Their vast ground station and communications experience is being applied to remote sensing. The space program experience is applicable to sensor and flight systems for remote sensing satellites. And their knowledge of data production techniques gained at PASS, is being used in close co-operation with SRC to define the requirements for a permanent remote sensing facility for Saskatchewan. To SED, that means a business opportunity. To users, it means our commitment to advancing remote sensing by developing operational methods in applying the technology to resource management.

Other News

The University of Saskatchewan was awarded a contract from CCRS to operate the CCRS ground microwave truck last year. This year was the first complete field season and some 300 tapes of data were collected. Two graduate students are working on this data and a third student has just started analyzing the antennae output. The data will be used to assess the airborne and satellite SAR data.

Training

A seminar series was initiated last year with the University of Saskatchewan

and this continued in to this year. A planned SPOT seminar was postponed due to lack of data. Another series will be started with the University of Regina which concentrates on remote sensing aspects of digital terrain models and GIS. Two courses at the University of Saskatchewan use the CCRS/SRC STEP equipment for their lab work.

Conclusion

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. The Sask. Research Council wishes to thank CCRS, Alberta Remote Sensing Centre and the Manitoba Remote Sensing Centre for their help and support. Without them, STEP would not have been successful.

6.13 REPORT OF THE YUKON TERRITORY

Projects currently underway or completed in 1985/86 involving remote sensing.

Yukon Forestry Service

Initiated project to attain 1:40,000 B/W IR of Yukon Territory south of 64°05' latitude. Currently have covered south-east and south-central Yukon. Completed 62° latitude to 64°05', and from Yukon-Alaska border east to 132° longitude next year.

Using LANDSAT to map fire distribution of 1986 fire season onto existing cover maps. An ongoing project into its 5th year.

Are investigating using LANDSAT (MSS) imagery to assign fire hazard ratings to forest types (system developed in Ontario). Are having some problems (not detailed enough). TM & SPOT considered to provide more detail than necessary.

Canadian Wildlife Service

This year they are using LANDSAT (MSS) to classify and map vegetation north of tree line (north end of Old Crow Flats and north). This summer they surveyed 400 vegetation plots (visual classification), concentrating on distribution of willow. Mapping scale not determined yet.

Ducks Unlimited & Wildlife Branch (YTG)

Propose using TM imagery to map and classify wetlands in Needle Rock area of Yukon, between Pelly and MacMillan Rivers along the Tintin Trench. Current status of project unknown.

Agriculture Canada

Mapping soil associations for entire Territory at 1:1,000,000 scale using LANDSAT imagery. Project is part of Canada wide effort being spearheaded by the Land Resource Research Centre (Ottawa). LANDSAT will be used where data is non-existent. Data will be polygon specific (every polygon has a unique number). Hard copy image analysis only.

Prospector's Association

Have established a facility for analysis of digital satellite data in conjunction with CCRS. George Mason is the contact person.

Wildlife Branch (YTG) and Department of Geography, Saskatchewan

Using MSS and TM data to prepare moose habitat maps. Dr. D. Gauthier is conducting the study at the University of Regina.

Remote Sensing Workshop: Whitehorse Lands, Parks & Resources

Sponsored by Renewable Resources and in conjunction with CCRS. Three day workshop on remote sensing applications with hands on demonstration on a Perceptron Image Analysis system. Many thanks to Doug Heyland, Tom Alfoldi and John Hornsby for their fine presentations and demonstration of the image analysis system.

7.1 REPORT OF THE ATMOSPHERIC ENVIRONMENT SERVICE, ENVIRONMENT CANADA

This report summarizes the activities in satellite meteorology of a number of AES components:

The Weather Services Directorate (WSD), The Atmospheric Research Directorate (ARD), The Central Services Directorate (CSD), and The Canadian Climate Centre (CCC), all located at 4905 Dufferin Street, Downsview, Ontario M3H 5T4

Summary of Highlights

Meteorological satellites continued to be an important data source for AES research and operations during 1987.

A new digital display system was developed for use with the satellite based communication system (METSIS). This communication system successfully passed its Phase I tests during 1986.

Major Research and Development in the Applications of Satellite Data

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. The soundings were made available to forecasters staffing a special short-range forecast desk and case studies were examined by an operational forecaster after the field phase. The forecasters concluded that the soundings lacked sufficient detail, especially in the low levels, to be useful to a regional forecast office (MacAfee, 1986).

Tests of a simultaneous retrieval scheme using empirical orthogonal functions of temperature and relative humidity computed from radiosonde data as a basis for the retrieved perturbations were presented at the Third International TOVS Study Conference (Steenbergen, Greaves, and Yip, 1986). The results (for clear conditions only) were encouraging and work is proceeding on inclusion of the effects of cloud in a similar manner to that reported by Huang and Smith at the TOVS Study Conference. It is planned to make retrievals available for encouraging and work is proceeding on inclusion of the effects of cloud in a similar manner to that reported by Huang and Smith at the TOVS Study Conference. It is planned to make retrievals available for testing in numerical models during the coming year.

The RAINSAT system continued to run quasi-operationally in the Toronto satellite receiving station (see previous report). Products were sent to the Maritimes Weather Centre during CASP as well as to the Quebec Weather Centre. Reports prepared by the operational staff indicated that the products were useful to them (Abraham, 1986). A statistical comparison of the probability-of-rain maps with weather radar data for the summer season indicated modest but significant skill in separating raining and non-raining clouds (King, 1986).

The Microwave Research Project is a program of research and development to ensure that the AES will be ready to make use of the microwave remote sensing data that will be available operationally at the end of the decade. The primary emphasis has been devoted to the use of Seasat Scatterometer wind data, Passive Microwave Radiometer liquid water, water vapour, and rain data for applications in regional short range forecasting. Studies indicate that these two data sets would significantly improve surface wind analysis and moisture analysis thereby resulting in improved wind and precipitation forecasting.

A response was prepared for the ERS-1 Announcement of Opportunities to utilize the Scatterometer data in near real-time in AES Weather Centres.

During 1986 the Ice Research and Development Division continued to develop algorithms to derive ice information (ice extent, ice edge, ice concentration and first year/old ice fraction), wind speed over open oceans, rain rate over oceans, and total atmospheric water vapour from passive microwave satellite data (NIMBUS-7 SMMR). A comprehensive plan to validate the Special Sensor Microwave Imagery (SSM/I) sensor to be launched on a DMSP satellite in 1987 was completed.

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.

Techniques Development and Applications of Satellite Data

The Satellite Data Laboratory operates a

limited archiving program to support AES research programs. Thirty-day rotating digital archives are maintained for both the VISSR and A/VHRR data.

A 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 Hydrometeorology Division has carried out to a project to compare the ability of existing satellite techniques to derive daily, weekly and monthly precipitation estimates under Canadian conditions using GOES data. A modified life history method, the RAINSAT procedure and simple climatological techniques were evaluated by comparing the satellite-derived rain estimates with radar and gauge observations over a 440,000 square kilometre area in Eastern Canada. During 1986, this project was expanded to include the integration of remotely sensed and conventional information through objective analysis as well as the examination of some of the network implications of adding remotely sensed data.

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 in 1984 and 1985 was carried out in 1986. Multi-spectral data from the NOAA satellite were analyzed using the division's supervised digital classification scheme.

Research on the development of regional algorithms for determining snow depth and water equivalent using passive microwave data continues. Airborne and satellite (NIMBUS-7) passive microwave (37 and 18 GHz) data were collected over the Southern Canadian Prairies. Regressions of airborne microwave brightness temperatures vs. airborne gamma snow water equivalent data averaged over 25 km lines have been performed and tested on coincident satellite data with good success. Results indicated the need to consider snowpack structure and whether the snowpack is dry or wet. Water equivalent can only be determined for dry snow. The onset of melt, or even surface wetness, can readily be detected if the snowpack is being monitored regularly. A follow-on multi-agency airborne/satellite experiment will be conducted during the 1986/87 winter as part of the validation plan for SSM/I on the next US Defence Meteorological Satellite (DMSP). The major validation experiment is planned for 1987/88.

Monitoring of the satellite-derived surface water temperatures for the Great Lakes and Bay of Fundy continued as in previous years. Analyses of surface water temperatures on the Scotian Shelf and Grand Banks were done as weather conditions permitted. Temperatures are corrected for atmospheric attenuation using radiative transfer calculations based on radiosonde data.

The Special Projects Office in Edmonton and the Yukon Weather Office are engaged in development activities and training in the application of satellite imagery to weather analysis and forecasting. The Special Projects Office development and applied research is directed towards Natural Hazards applications.

A methodology and computer program have been developed to diagnose hail size from HRPT data. Using cloud top temperatures from active thunderstorm updrafts which are extracted automatically a statistical technique has been developed to predict hail size reaching the ground. The technique was tested on an independent dataset this summer. Papers were presented at the AES/CMOS Workshop on Operational Meteorology and at the AMS Conference on Satellite Meteorology.

A project has been initiated to develop the capability to process TOVS data into synthetic soundings in Edmonton, using a statistical retrieval method. An operational system, fully automatic, is scheduled for completion in early 1987. It is planned to conduct experiments in using TOVS data for severe thunderstorm forecasting in Alberta in 1987.

Techniques have been developed to use NOAA BAND 3 imagery in detecting stratus, fog and other cloud forms. A paper was presented at the AES/CMOS Workshop on Operational Meteorology.

Satellite Applications in Operational Use in 1986

Data for operational use were received from geostationary satellites, GOES-6 and METEOSAT (Wefax), and from polar orbiting satellites of the NOAA and METEOR Series. The direct readout system consists of geostationary satellite VISSR readout stations

in Vancouver and Toronto and polar orbiting satellite HRPT readout stations in Edmonton and Toronto. These stations are linked to weather forecast centres by dedicated communications lines carrying satellite imagery in photo facsimile format. Circuit schedules for transmission of satellite imagery are coordinated through a consensus of users on each circuit. The Vancouver VISSR readout station has a direct communications link to the Meteorological Data Analysis System (METDAS) in the co- located weather forecast centre. The METDAS is used for computer satellite image analysis, including image enhancement, film-looping of images on a CRT colour monitor and overlaying satellite imagery with other meteorological fields. In addition to these readout and distribution centres, the AES operates APT readout stations at Whitehorse, Inuvik, Resolute, Frobisher Bay and Yellowknife, a shared HRPT readout station in Greenland and a METEOSAT WEFAX readout station at Gander.

The GOES Readout Stations at Toronto and Vancouver have been equipped with 'MAGIC' boxes to convert the new mode AAA stretch VISSR data format to Mode A.

The Pacific Weather Centre (PWC) has become an operational production centre for satellite products. Distribution to outside users is by a photofacsimile network terminated by Unifax printers. At the current time, the primary users are the regional weather offices.

PWC has developed a large number of satellite products that are of interest to other centres. Plans are in place to begin distributing the satellite products to other weather centres. The Pacific Weather Centre has a high speed digital data link with the Canadian Meteorological Centre (CMC). Over this line, CMC sends grid point data of the most recent analyses and prognoses to PWC. The same line will be used to send back satellite products.

At the same time PWC has been developing enhancements to its operational display station. It will now receive data transmitted through commercial grade telephone lines. Simultaneously, the software has been implemented within the satellite facility for the transmission of digital satellite data over as many as eight data lines (to local and remotely located display stations).

The PWC now has the benefit of a NESDIS GOES-Tap satellite data service. This has increased the data base since it allows for the reception of the Geostationary Meteorological Satellite (GMS) imagery. The PWC operational forecasters can now analyze atmospheric dynamics as far upstream as Eastern Asia. Work is underway to integrate the GMS imagery into the PWC satellite facility and distribute the data over the AES photofacsimile networks.

Work has commenced on the software for remapping image data to the polar stereographic projection and for normalization of the visual data. This capability will allow the further development of the Pacific Region precipitation algorithm.

The satellite facility has been intensively used for the operational study of rapid cyclogenesis over the Pacific, i.e., storms that are increasingly referred to as "bombs". It is hoped that this will provide the information necessary for the improved forecasting of developing storms.

The Canadian Ice Centre continues to receive and utilize NOAA AVHRR hard-copy imagery for daily ice analysis and forecasting. Data were received on UNIFAX-II photorecorders from the AES HRPT receiving stations at Toronto and Edmonton, and from Söndre Strömfjord, Greenland. LANDSAT-4 data were also received in a similar fashion from the CCRS facility at Prince Albert, Saskatchewan. Additionally, digital NOAA AVHRR data on CCT was shipped by courier from Edmonton weekly and processed on the DIPIX Aries-II for integration into the composite ice charts.

Research into digital image enhancement techniques for NOAA AVHRR data as well as airborne and satellite radar data continued on the Aries-II image processor. This work concentrated on automated image navigation techniques and in determining acceptable image resolution required for operational ice analysis. To facilitate this work, a high speed communication link was installed between the Satellite Data Laboratory and the Ice Centre to receive digital AVHRR imagery in near real-time.

Plans for Future Operational Systems

The existing 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's 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.

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

AES has 59 DCP assignments, including four in the ASAP program, in addition it has sensors on water survey platforms.

Most AES DCP's report hourly; however, 12 are 3 hourly, and the ASAP systems are 12 hourly. There are no random reporting sites. At present 53 DCP's are active, and 5 are expected to be activated during Spring/Summer of 1987.

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 received bulk data from the Canadian Meteorological Centre (CMC) and the Satellite Data Lab (SDL), and weather charts from Ontario Region and distributed it using 56 Kbps channels to receive only earth stations.

In the operational trial, photos and charts were displayed on existing mechanical recorders which were retrofitted to accept digital input. These devices will be replaced in Phase II by Multi Purpose Display Stations (MPDS). The MPDS is a microcomputer based unit capable of displaying charts, photos, overlays, zoom, etc., and will have a hard copy device associated. Prototypes were delivered, tested and evaluated in 1986.

In 1987/88 and 1988/89 (Phase II), another 60 receive-only sites will be installed as well as an uplink at CMC in Dorval. In early 1988/89, the Edmonton station will be upgraded to an uplink for transmitting HRPT data to Ice Central in Ottawa as well as transmitting satellite image data to Vancouver and Downsview.

Experimental Space Activities

Experimental space activities from aircraft, balloons and shuttle platform are conducted in the Experimental Studies Division.

Data obtained with the shuttle sunphotometer by Marc Garneau in the SPEAM I experiment are being further analyzed. An advanced SPEAM II experiment will be reflown with the second Canadian astronaut, Steve MacLean, on a flight currently scheduled for 1989. Engineering work for flying a Brewer ozone spectrophotometer for ozone sounding in the GAS (Get-Away-Special) container on the shuttle flight in 1989 is being conducted by Bristol Aerospace Ltd.

A STRATOPROBE balloon flight was launched in July from the Balloon Facility in Ainsworth, Nebraska. The purpose was to make "ground-truth" measurements for the SAGE II and SME satellite-borne experiments. A sunphotometer was flown on a light aircraft to verify the Langley calibration. The analysis of the STRATOPROBE data is in progress and is expected to yield altitude profiles of O_3, HNO_3, N_2O, NO, H_2O, CH and aerosols.

A climate observatory to monitor the radiation balance changes due to greenhouse gases has been set up at Asquith, Saskatchewan.

Nuclear winter studies on controlled burn fires are planned; these began with the Chapleau burn experiment in August, 1985. A large (1000 km long) fire plume cloud was also detected in GOES satellite imagery from the very large natural fire at Red Lake in May 1986.

A special ground-truthing program for the SBUV-2 instrument on NOAA-9 is being conducted at Edmonton. Large plastic balloons are used to measure ozone profiles up to 40 km on a weekly basis in coordination with satellite overpasses. Ozonesondes on regular balloons are also flown at Churchill, Resolute and Goose Bay once per week on a regular basis.

Ozone monitoring continues in the Canadian network. Umkehr measurements of ozone have been carried out with the Brewer spectrophotometer. Continuous data is being acquired by the triad calibration standard for ozone in Toronto. Ground-based NO and SO measurements are also conducted on a routine basis at Toronto. A new Brewer spectrophotometer has been installed at Churchill for the replacement of the obsolete Dobson total ozone instrument. In Toronto, a turbidity standard with four sunphotometers with four wavelengths are being operated. The standard calibration and inspection of data from Alert and Edson is maintained.

Contacts

SATELLITE SOUNDING QUALITATIVE ANALYSIS OF SATELLITE IMAGERY - J.D. Steenbergen, Aerospace Meteorology Division, Atmospheric Research Directorate

MICROWAVE RESEARCH - Dr. Steven Peteherych, Aerospace Meteorology Division, Atmospheric

Research Directorate

METSIS - M. Kallaur, Chief, Planning and Development Division, Central Services Directorate

SATELLITE DATA ARCHIVE - S. Lapczak, Chief, Data Management Division, Canadian Climate Centre

HYDROMETEOROLOGY - D.W. Colwell, Chief, Hydrometeorology Division, Canadian Climate Centre

SOLAR RADIATION APPLICATIONS - M.O. Berry, Chief, Applications and Impact Division, Canadian Climate Centre

ICE - Dr. R.O. Ramseier, Chief, Ice Research and Development, Central Services Directorate

PACIFIC WEATHER CENTRE - G. Wells, Officer in Charge, Pacific Weather Centre, Weather Services Directorate

WESTERN REGION - John Bullas, Special Project Officer, Arctic Weather Centre, Weather Services Directorate

EXPERIMENTAL SPACE ACTIVITIES - Dr. Wayne Evans, Chief, Experimental Studies Division, Atmospheric Research Directorate

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7.2 REPORT OF THE LANDS DIRECTORATE, ENVIRONMENT CANADA

Remote sensing tools remain a valued component of the Lands Directorate land evaluation and monitoring and ecological research programs. In the 1986-87 period the Directorate has expanded its facilities for non-digital remote sensing analysis and participated in several research studies addressing the capabilities of new sensor systems.

Land Use Monitoring

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. To assist in analysis, a PROCOM II system has been purchased and in use operationally for over one year. A revised rural land classification system and user manual have been developed and tested in the last year (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 continues to utilize aerial photography for a wide range of application studies including urban centred regions analysis, and has overseen a project to evaluate land use change from 1920-1950 and 1950-1980 in all six calibrated basin study areas supporting the federal-provincial Long Range Transport of Air Pollution (LRTAP-Acid Rain) program (Moyes 1987). An integrated land use study of the St. Croix basin in New Brunswick has also been initiated 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 (G. Bourns). A second project (by D. Wall) 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 (Germain 1986). 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 1000 LANDSAT MSS images with a detailed aerial photo validation methodology (Weatherall 1985).

Ecological Research

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 (Tomlins 1986). 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. Copies of this unplublished report are available from the Ecological Research and Integrated Programs Division of Lands Directorate on request.

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.

Related Activities

In 1986, the Lands Directorate became an integral component of the Inland Waters Directorate of Environment Canada. This has resulted in an ongoing integration of land and water research in the new Directorate now named Inland Waters/Lands.

The Lands Directorate assisted in the formation of the Canadian Society for Landscape Ecology and Management in November 1986 and is cosponsoring a national symposium on this emerging field of science in May 1987. It is also leading an initiative to raise the profile of wetlands conservation as a national

environmental issue. To this end, it is cosponsoring the Canadian Symposium on Wetlands Ecology and Conservation in August 1987.

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7.3 REPORT OF THE INSTITUTE OF OCEAN SCIENCES, FISHERIES AND OCEANS CANADA

Airborne Remote Sensing.

The FLI imaging spectrometer has now shown its capability for mapping water surface chlorophyll distributions using the fluorescence signal at 685nm, and further observations are planned for this April in B.C. coastal waters. 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.

In May 1986 an agreement was signed with Moniteq Ltd of Toronto by which they would operate the FLI on a commercial basis in return for company funded, technical improvements. During the summer of 1986 they arranged to take the FLI to Europe to study the deterioration of the Black Forest. A number of other targets were also flown, including one over water for which the data has been analysed at IOS.

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, and various sites in the U.K. as part of a joint operation with Hunting Surveys

Spaceborne Remote Sensing

The results of Canadian work in satellite ocean colour remote sensing was presented at an ESA workshop in November in France. Results from the airborne FLI instrument and plans for a satellite version were discussed. Other ESA member countries, notably France and Germany, have similar plans, but so far no comparable prototype.

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.

Data Analysis

The IOS image processor continues to be heavily used. An upgrade to provide more than 1 interactive image terminal is planned, but funds are not yet available.

International Programmes.

IOS continues active involvement in multi-national research programmes that make use of satellite remote sensing. J. Gower is a member of the Satellite Observing System Working Group for the World Climate Research Programme, and is vice chairman of Commission A of Cospar, which held an ocean colour workshop in Toulouse, France in July 1986.

Future Programmes

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 geostatioary satellites and wind, wave and altimetric data from the US Geosat.

7.4 REPORT OF THE PETAWAWA NATIONAL FORESTRY INSTITUTE, AGRICULTURE CANADA

Introduction

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. The advantages of flexibility in wavelength selection, use of narrow wavelength bands, ability to geometrically correct the data to cartographic coordinates, and capability to enhance and ultimately automatically interpret the data make the technology attractive for forestry applications. 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. Such developments are also key criteria for a system to be appropriate for cartographic and other mapping applications. PNFI in cooperation with CCRS have developed a proposal outlining the needed developments.

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.

Research Activities

Investigation of MEIS imagery for species discrimination in Alberta [a cooperative project with CFS Northern Forestry Centre (R. Hall), Alberta government (Resource Evaluation and Planning and Alberta Forest Service), and CCRS] has produced good enhancements for different species. Studies investigating radiometric correction methods and use of linear array imager data for insect damage assessment, stand height estimation with stereo data and regeneration surveys are in progress.

Analysis of field spectometer data of individual trees suffering from varying degrees of spruce budworm defoliation, along with analysis of the spectral characteristics of needles, bark and the visually red debris caused by budworm feeding, have identified spectral bands appropriate for discriminating levels of both current year and cumulative defoliation. Narrow, well placed bands are important for detecting current defoliation. The study was undertaken with CCRS and CFS-Maritimes and used the CCRS Spectrascan and Licor Spectrometers. MEIS filters will be manufactured and tests of capabilities for assessing damage conducted.

Fluorescence Line Imager data acquired September, 1985 have been processed. Preliminary analysis of the data and investigation of display techniques have been undertaken and presented at the Canada-Germany Workshop on Imaging Spectrometry (Dept. Fisheries and Oceans, Ottawa, Oct. 1986).

A 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 add some useful information on softwood species discrimination.

Other Activities

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. The Ontario Minstry of Natural Resources and Algonquin Forest Authority provided the data. 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 is being conducted. As a first step, Dendron Resource Surveys Ltd. was contracted to undertake a survey of provincial organizations. A survey of forest inventory map production procedures is also being conducted.

A project to produce Landsat MSS enhancements of a region of northeastern China

was initiated and completed. The enhancements are to provide forest fuel information. Mr. Cai of the China Ministry of Forestry visited the institute and with PNFI staff enhanced twelve Landsat MSS scenes. B. Todd visited China, field checked the enhancements, and presented the results (Todd, B., D. Cai and D. Leckie, Production of enhanced Landsat imagery for forest fire fuel mapping of northeastern, China, Proc. Beijing Int'l Symp. on Remote Sensing, Beijing, China, Nov. 1986)

The Fire Management Systems group, in cooperation with the Societe 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 airborne infrared forest fire detection instrument. It is intended to operate at altitudes of 2500m, have a 140 degree swath, sense in the 3 to 5 and 8 to 13 micron range, cost less than $50,000, and be easily mounted on conventional twin engine detection aircraft. It will not have imagery output but rather a simple display of the angle direction to the fire. It may be possible to link this output to Loran C navigation information to establish an approximate location of the fire. The target fires are in the 1/2 to 2 ha size class. 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. A study of forest canopy attenuation of target signals with scan angles will begin this summer in support of the instrument's design. Assuming suitable funding, construction of prototypes could begin during 1987.

The Fire Management Systems group is also continuing its work on developing expert systems for assisting in forest fire management and use of microcomputer systems for display of remote sensing data.

PNFI operates an image analysis system dedicated to remote sensing research. Significant upgrades to the software were developed and an interface between the Dipix ARIES image analysis system and ARC/INFO GIS has been developed.

Appendix I: Project Staff

Digital Remote Sensing

Dr. D.G. Leckie (Project Leader)
A. Dombrowski
F.A. Gougeon (educational leave, U of Waterloo)
S.M. Yatabe

Fire Management Systems

Dr. P.H. Kourtz (Project Leader)
B. Mroske
B. Roosen
B. Todd

7.5 REPORT OF THE SURVEYS AND MAPPING BRANCH, EMR

A. Operational Use of Satellite Data for the Revision of Topographic Maps

The Topographical Survey Division of the Surveys and Mapping Branch has been actively using LANDSAT imagery to revise 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 current method of revising 1:250 000 maps is to visually compare MSS and TM imagery to 1:50 000 maps of the same area on a PROCOM. The 1:50 000 maps are used instead of 1:250 000's for two reasons:

(a) the large scale makes it easier to plot the changes, and

(b) the 1:50 000 maps are generally more up-to-date than the corresponding 1:250 000 maps.

Where necessary, the revision information is verified in the field. Once recorded on the 1:50 000 maps, the changes are integrated into the standard cartographic process for 1:250 000 map revision.

The monitoring of 1:50 000 maps makes use of the same basic approach. The aim is to identify quickly areas of change in order to better plan the 1:50 000 revision program as well as the aerial photography needed for the revision. The method has been a very economical means of acquiring timely information about cultural changes in many parts of the country where LANDSAT MSS and TM images are suitable. It is expected that SPOT data will further extend the areas of the country where the method is applicable.

So far, this technique has been used for about one fifth of the 918 maps of the 1:250 000 series, and about one third of the 11 000 existing 1:50 000 maps are indicated in the table below:

1:250 000 Revision	contract	204
	in-house	9
1:50 000 Change Detection	contract	3765
	in-house	700
	-changes observed	2748
	-no changes	1017

In theory, savings realized through the application of the method to the revision of the 1:250 000 map series are considerable since it would cost approximately $65 000 to revise one 1:250 000 map with newly flown photographs ($50 000 for aerial photography and $15 000 for compiling the changes) while the average cost using satellite data has been $5000. However, in practice, because of the high cost, 1:250 000 maps were rarely updated with new photographs, but rather though a combination of expedients such as deriving changes from more up-to-date 1:50 000 maps of the same area or making use of information gathered from various sources. Yet, these methods were never very satisfactory: for instance, it is very unusual to find sixteen up-to-date 1:50 000 maps to revise the corresponding 1:250 000 map. The end result was a gradual deterioration of the 1:250 000 map series which could not be properly maintained with the resources available. It is therefore fair to say that the use of satellite data has made it possible to revive an important Canadian map series that was slowly becoming obsolete.

Similarly, the use of LANDSAT images to monitor changes on the 1:50 000 maps has not only resulted in significant savings in aerial photography but, and perhaps more importantly, has made it possible to better direct scarce revision resources and thus improve the overall currency of that map series.

B. Research and Development

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, described briefly below, have been undertaken towards that goal.

Joint Tests of SPOT Data with the Institut Géographique National of France

In 1985, the Surveys and Mapping Branch and the Institut Géographique National of France signed an agreement to promote scientific and technical exchanges. Within the framework of this agreement, both organizations decided to evaluate the potential of SPOT data for topographic mapping by carrying out joint experiments with the following objectives:

1. test the content of SPOT images in relation to 1:50 000 and 1:250 000 map specifications of each country in order to determine the percentage of map features that can be seen and correctly identified on SPOT images.

2. test the planimetric accuracy of stereoscopic SPOT images.

3. test the height accuracy of stereoscopic SPOT images.

4. test the planimetric and height accuracy of a strip of stereoscopic SPOT images with various combinations of ground control points.

Test areas, one in Canada and one in France, were selected and the required scenes ordered by each organization over their respective territory in the spring of 1986. Both the Surveys and Mapping Branch and the Institut Géographique National will carry out the tests with both sets of data using their own instruments and methods. It is planned to report the results or these experiments at a Colloquium especially organized for this in the spring of 1988 in Ottawa and at the next Congress of the International Society for Photogrammetry and Remote Sensing at Kyoto, Japan.

Unfortunately, because of delays in obtaining the SPOT data, we have not been able to start these investigations in 1986 as planned and, unless the data can be obtained early in 1987, it may not be possible to complete the experiments in time to report the results at the Kyoto meeting, and the planned Colloquium will have to be postponed.

PEPS Project

In 1984, in answer to a call for proposals from SPOT IMAGE, the Surveys and Mapping Branch proposed to 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. Although the objective of the Branch PEPS is similar to the previous research project with the IGN, the methods and the instruments that will be used will be different, thus providing a comparison between different approaches to using SPOT data. This project will be carried out in cooperation with the staff of the former Photogrammetric Research Section of the National Research Council.

As with the joint project with IGN, lack of data has seriously delayed this investigation.

Change Detection and Revision Mapping with Digital Satellite Imagery

Software has been developed through Dipix Systems Ltd to permit topographic map files in vector Standard Interchange Format (SIF) to be rasterized. Once in raster form, the map data can be updated by visual or computer assisted comparison with recent digital satellite imagery using raster image analysis software. The updated map data is then returned to the vector domain. This 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. To this end, CCRS has been provided with a number of digitized photographs of ground control points for use in positioning images. The equipment used for this experiment includes an Aries II image analysis system based on a VAX computer and an Aries III system based on a MicroVAX 2. Hardware includes an Eikonix scanner, Quick Colour Recorder (QCR) and an Aries Pixel Processor (APP). Plotters available include a Versatec 42 inch (107 cm) colour electrostatic plotter and a Calcomp 1043.

Mathematical Morphology applied to Line and Edge Detection in Digital Imagery

The aim of this project is to detect, as automatically as possible, linear features such as roads, shore lines, etc. Algorithms based on mathematical morphology have been developed to detect bright lines, dark lines, bright steps, and dark steps. The algorithms, which include morphologic dilation, erosion, and image difference, are being tested on TM and SPOT imagery using a VAX 11/751 and the results displayed on a DIPIX Aries.

7.6 REPORT OF STATISTICS CANADA

INTRODUCTION

The remote sensing activities at Statistics Canada in 1986 relied on LANDSAT multi-spectral scanner (MSS) data for established projects estimating cropland areas in Prince Edward Island, New Brunswick, Manitoba, Saskatchewan and Alberta.

The DIPIX ARIES III remote sensing image analysis system, was upgraded in 1986 with an ARIES Pixel Processor (APP), a tape drive and a dedicated Micro Vax II computer.

LANSAT POTATO PROJECT NEW BRUNSWICK AND PRINCE EDWARD ISLAND

The potato area project was carried out in New Brunswick in the counties of Carleton, Victoria and Madawaska. They accounted for the majority of production in that provice. In Prince Edward Island one LANDSAT tape (scene) was used to estimate the area under potatoes. The tape provided coverage of 85 percent of the Island and 90 percent of the potato crop growing region. An estimate of the potato area not covered by the satellite image was made and added to that from the LANDSAT scene to obtain the province total. In operation since 1980, the LANDSAT work is linked to the National Farm Survey, the source of ground data for projects in both New Brunswick and Prince Edward Island.

Some fifty-five ground segments were involved in New Brunswick and thirty-five in Prince Edward Island. The data from these segments, gathered in early July 1986, were used to "train" the DIPIX ARIES III computer to recognize potatoes in the study area. In New Brunswick, a LANDSAT MSS image dated August 5 was obtained, a classification generated, and its performance analysed and estimates produced by August 19. In Prince Edward Island cloud cover throughout most of the summer meant no clear image until September 1. The Prince Edward Island tape was ordered from EOSAT on September 15 and arrived at Statistics Canada September 19 for analysis. Although interpretation of the image required less than 5 days, the value of the 1986 project was limited to verifying the airphoto estimates, the basis for the numbers published September 9.

POTATO AERIAL PHOTO PROJECT PRINCE EDWARD ISLAND AND NEW BRUNSWICK

This project was first undertaken in 1985 in response to an unreliable record for availability of LANDSAT imagery. Clouds in recent years had limited the amount of remote sensing work that could be done therefore a back-up system was necessary.

A sample of land parcels were selected and photographed just before the row-closing stage in the potato crop. Imagery obtained for analysis consisted of 70 mm colour prints at a scale of 1:30,000.

Potato fields were identified through visual interpretation. The crop area in each field was then measured with an electronic planimeter. Estimate at the province level were then produced by expanding the field estimate using a stratified two-stage sample design.

Aided with magnifying instruments and interpretation keys, analysts were able to identify, with confidence most potato fields. It is likely that errors were of commission rather than omission. The results of the project served as major indicators in establishing the 1986 Prince Edward Island and New Brunswick potato area estimates.

The air photo work proved to be timely and accurate. In New Brunswick for example, the estimate was 49,700 acres compared to the LANDSAT estimate of 52,000 acres.

In Prince Edward Island the air photograph project resulted in an estimate of 67,600 acres. Because of cloud, a clear LANDSAT image was not available until

September 1 and the 66,500 acre estimate was not produced in time to be of assistance in establishing the 1986 potato area estimate.

As LANDSAT data is not always available when required our plans are to continue to support the LANDSAT program with the aerial photo project.

MANITOBA, SASKATCHEWAN AND ALBERTA CROP AND SUMMERFALLOW ESTIMATION PROJECT

Background

Area estimates were produced for canola, total cereal grains and summerfallow in Manitoba, Saskatchewan crop districts 7A, 7B, 8A, 8B and Alberta crop district 4A.

Methodology

The procedure involved the integration of LANDSAT MSS data with ground gathered calibration data. Following the classification of an image and its verification with the ground data a regression estimator was used to derive the total number of acres of canola, grains and summerfallow. The regression estimator used the relationship between the ground data and the LANDSAT satellite data to correct for classification errors of omission and commission. The use of the regression estimator provides a more precise estimate with a fixed sample size than can be achieved when estimates are made using the satellite data alone.

Acquisition of Ground Data

The ground gathered data was obtained by Statistics Canada enumerators from the National Farm Survey (NFS). Crop location and area information was collected in the field during late June using a random sample of NFS land segments. Segments are tracts of land one by three miles. The information was recorded on historic aerial photographs of the NFS segments in the study region.

Acquisition of LANDSAT Imagery

In Manitoba four LANDSAT MSS frames were used covering ten crop districts or approximately ninety percent of the province's total agricultural area.

Image dates ranged from July 14 to July 22 and cloud cover was an impediment to analysis in certain frames.

For Alberta crop district 4A, the Stettler-Wainwright area, only one LANDSAT frame was required. The date of the image was August 7, 1986.

Two LANDSAT frames were required for the work in Saskatchewan. Cloud was again a problem throughout the growing season but a clear image was obtained July 6 for crop district 7, the Kindersley-Rosetown-Biggar area and August 5 for district 8, the Melfort-Nepawin area.

SUMMARY

Statistics Canada has been using remote sensing technology for a number of years. The objective has been to develop operational data handling procedures through a series of pilot projects. Crop area estimates have been made for selected crops and regions by the integration of digital image analysis, computer assisted visual image analysis, ground observations and a regression estimator. Experience has made Statistics Canada cautious about overestimating the value of remote sensing technology in making reliable crop area estimates. However, the Agency intends to continue to develop the available technology to enhance current information on crop area, conditions and yield.

8.1 REPORT OF THE CANADIAN REMOTE SENSING SOCIETY

Introduction

The Canadian Remote Sensing Society (CRSS) functions to serve the interests of individuals and organizations interested in various aspects of remote sensing in Canada. With that goal in mind, and in cooperation with its parent society, the Canadian Aeronautics and Space Institute (CASI), it produces the Canadian Journal of Remote Sensing, co-sponsors the Canadian Remote Sensing Symposiums, and assist local groups with local activities.

The Canadian Journal of Remote Sensing

Currently, the Journal is published twice a year and averages five to eight articles per issue. Most authors are Canadian, but frequently it publishes papers from outside Canada. The technical quality of the published papers is excellent, augmented by the exhaustive review process. The major complaints are a) 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 - which the society cannot afford, 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 associated financial implications, and hopes to arrive at a decision prior to the next general meeting of the society scheduled to be held during the 11th Canadian Remote Sensing Symposium.

The Canadian Remote Sensing Symposiums

1) **The 10th Symposium**: Edmonton, Alta., 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 proceedings, after exhaustive review of all papers, the proceedings have been published and distributed.

Financially, the symposium was less than successful since it ran an approximate $6,000.00 shortfall. The shortfall was underwritten first by CRSS and then CASI.

2) **The 11th Symposium**: Waterloo, Ont. 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. The organizers are closely watching expenditures, in order to ensure that a financial shortfall does not occur. Similar to past Symposiums, all papers will be reviewed prior to publication of the symposium proceedings.

3) **The 12th Symposium**: Vancouver, B.C., 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. IGARS 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. Publishing proceedings prior to the Symposium has several major ramifications:

a) authors would be required to submit their manuscripts well in advance of the Symposium;
b) the exhaustive review process would have to be dropped;
c) the proceedings would cost less to publish, and
d) review committees and people involved would not be bogged down by an extra work overload.

Potential spinoff benefits would include:

a) more reviewer time would be available for Journal articles;
b) more authors would be inclined to submit their articles to the refereed journals;
c) symposium costs would be reduced, and
d) authors would receive a wider distribution for their work.

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 which included guiding the development of the Canada Centre for Remote Sensing, receiving the input and chairing for many years, the Canadian Advisory Committee on Remote Sensing, as well as many other achievements too numerous to list here. Our congratulations go out again to Dr. Morley.

Plans for the Future:
[These Items are Under Discussion Only]

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 for forthcoming symposiums, and perhaps have symposiums on an annual basis.

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

3. It is highly desirable to reduce the cost of the Symposiums.

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.

Recommendation

"It is recommended that all members of CACRS should be or become members of the Canadian Remote Sensing Society."

Appendix I: Canadian Remote Sensing Society Council Members

Dr. Peter A. Murtha, Chairman
Faculty of Forestry, UBC
Vancouver, B.C.

Mrs. Dianne Thompson, Vice-Chairman
Intera Technologies Ltd.
Calgary, Alta.

Dr. Ferdinand Bonn, Past Chairman
University of Sherbrooke
Sherbrooke, Que.

Mr. Jacques Guerette, Secretary-Treasurer
Gregory Geoscience
Ottawa, Ont.

Dr. Frank Ahern
CRSS Journal Editor-in-Chief
Canadian Centre for Remote Sensing
Ottawa, Ont.

Mr. A.J. Timmins
Executive Director CRSS
Ottawa, Ont.

Regional Representatives:
Dr. Geof Tomlins, British Columbia
Mr. Ken Campbell, Prairie Provinces
Dr. Phil Howarth, Ontario
Dr. Eugene Derenyi, New Brunswick
Dr. Dennis Bajzak, Newfoundland

8.2 REPORT OF THE ONTARIO ASSOCIATION OF REMOTE SENSING

The Ontario Association of Remote Sensing (OARS) was established in 1972 and is composed of members representing all sectors of the remote sensing community in Ontario. The objectives of the organization are:

1) To develop the understanding and use of remote sensing in Ontario;

2) To encourage the open exchange of information between Ontario users of remote sensing techniques;

3) By interacting with other associations and agencies, to develop the understanding and use of remote sensing in Canada and internationally.

PROGRAM

In order to meet these objectives the Association holds four program meetings annually. These meetings are organized to allow members to learn and to exchange ideas and information relating to a wide range of remote sensing topics. Guest speakers include representatives of regional and national interests.

NEWSLETTER

The Association also produces a newsletter on a quarterly basis. The newsletter is the main contact that the members outside of the Toronto region have with the Association. The newsletter contains articles on remote sensing developments and applications, member activities, new products, upcoming meetings and Association activities.

MEMBERSHIP

Membership in OARS is open to persons who have an interest in remote sensing. The 1986 membership numbered approximately 100 including both regular and student members. Membership fees are $20.00 for regular members and $5.00 for students. The executive and member council were elected at the Annual General Meeting February 19, 1986 and remain in office for a two year term. The officers of the executive are listed in Appendix 1.

ORBITING REMOTE SENSOR

A program has been established to encourage contact with members in remote parts of the province. Known as the Orbiting Remote Sensor program, members are available to travel to various locations to discuss their own field of interest in remote sensing. In the past, members have given several lectures to universities and colleges and have been well received. Again this year, Mr. Jim Thompson has been available to discuss aerial survey methods and applications.

ACTIVITIES

General meetings have been held as follows:

1) February 19, 1986 - Annual General Meeting. The meeting was held at the Oakham House dining room at Ryerson. Dinner was followed by a business meeting and the election of the new executive. The guest speaker, Mr. Art Collins of CCRS, scheduled to talk about the SPOT program, was unable to attend due to weather conditions in Ottawa.

2) April 14, 1986 - Presentations dealing with remote sensing of Sea Ice were made by Dr. R. Ramseier, Environment Canada, and Dr. John Sykes, University of Waterloo.

3) October 6, 1986 - Presentations were made by two of the members that have been involved in the Orbiting Remote Sensor program. Alan Gregory of Gregory Geoscience Ltd. discussed Geographic Information Systems (GIS) and the analogue/digital interface of remote sensing data. Jim Thompson also presented the members with some useful information regarding GIS and micro-computer applications.

4) December 16, 1986 - The subject of this program meeting focussed on the use of SPOT data. P. Howarth, D. Johnson, L. Martin and G. Holder, University of Waterloo, presented results of their work on "Spot and Other High Resolution Digital Data for Studying the Urban Rural Fringe". Terry Fisher, CCRS, discussed "SPOT - Canadian Reception and Ground Processing Capabilities at CCRS".

CONCLUSIONS

The Association is an active organization which serves members with a varied background in remote sensing. It provides an opportunity for learning and discussion within a group of individuals with similar interests. Within the context of the

National Remote Sensing Program, OARS can contribute towards the dissemination and exchange of information from a regional perspective and provide a "Grass Roots" connection with remote sensing users.

APPENDIX I

Executive: for the 1986/87 term of office:

President:	R. Pierce Ontario Hydro
Past President:	P. Howarth University of Waterloo
Vice-President:	A. Tyrie Erindale College University of Toronto
Secretary/Treasurer:	T. Erb Ministry of Transportation and Communications
Program Chairman:	E. LeDrew University of Waterloo
Newsletter Editor:	C. Wagner Ontario Hydro
Counsellors:	L. Tam Ministry of Transportation and Communications
	R. Caven Consultant
	G. Boyd Fisheries and Oceans Canada

9.1 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 main-frame 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 REPORT OF THE UNIVERSITY OF BRITISH COLUMBIA

B.C. REMOTE SENSING COUNCIL - INTERDISCIPLINARY PROGRAM IN REMOTE SENSING: 1986-1987

General

The Remote Sensing Council members coordinate graduate programs with a specialty in remote sensing which lead to either Master's or Ph.D. degrees in Computer Science, Electrical Engineering, Geography, Geophysics and Astronomy, Forestry, Oceanography or Soil Science. Faculty involved directly in remote sensing are listed in Appendix I.

Students enter the graduate program by admission as a Master's or Ph.D. candidate in one of the above departments. The discipline department and the students committee chairman are selected from the Department or Faculty which represents the student's primary field of interest. In consultation with this committee, usually consisting from 3 to 5 professors, specialized programs of study are developed for highly motivated and well qualified candidates in any aspect of remote sensing, or in any application of remote sensing technology, and can range from theoretical development of remote sensing technology (including image analysis and sensor development) to specialized applications of remote sensing (including vegetation, land use analysis, G.I.S., and meteorological and oceanographic studies). Graduate students and associated research topics involved in remote sensing are listed in Appendix II. Senior undergraduate and graduate level courses in various aspects of remote sensing are offered in the associated departments (Appendix III).

Research Facilities

In the UBC Interdisciplinary program in remote sensing, research facilities (Table 1) are located in several departments, including Computer Science, Electrical Engineering, Geophysics and Astronomy, Geography, Forestry, Oceanography and Soil Science:

1. *Laboratory for Computational Vision*
   [LCV](Dept. Computer Science)
   Dr. R.J. Woodham, Director

   The Laboratory for Computational Vision supports research in computational vision, artificial intelligence, remote sensing and other applications of digital image analysis. Groups in Computer Science, Forestry, Oceanography, Geography and Soil Science rely heavily on the Laboratory's digital image analysis system. Over the past six years, the Laboratory has evolved into a distributed computing environment based on the Unix operating system and an Ethernet local area network that is shared with other research groups in the Department of Computer Science.

   The laboratory provides hardware for raster image input, processing, analysis and output on video and a variety of film products. Since 1981, the main work-horse has been a DEC Vax 11/780 running Unix, 4.2BSD. Recently, 3 SUN 3/50 workstations, each also running a version of Unix 4.2BSD, have been added. The image display system is a Raster Technologies One/25 (512x512x24 bits of RGB image memory plus 512x512x2 bits of graphic overlay memory) connected to a SUN 2/120FS. The SUN 2 also hosts a Matrox/Hitachi CCD camera/frame grabber (512x512x8 bits). Other specialized peripherals include: an Optronics C-4500 colour film scanner/writer, a Lenco RGB to NTSC video encoder and an Image Resources Videoprint 5200 video hardcopy camera (with both 35 mm and SX-70 film systems).

   The Optronics C-4500 is a unique resource on campus. It is both a film scanner and a film writer. As a film scanner, it can scan colour or B&W film up to the dimension of a standard aerial photograph (23x23 cm) at a spatial resolution up to 12.5 micrometers per point, with 8 bits of dynamic range per colour per point. (A back of the envelope calculation reveals that a colour aerial photograph scanned at maximum resolution would produce over 1 Gigabyte of data!) Opaque photographic prints also can be scanned at a spatial resolution up to 100 micrometers per point. As a film writer, it exposes colour or B&W film (4x5, 8x10, 10x10) at a spatial resolution up to 25 micrometers per point, again with 8 bits of dynamic range per colour per point.

   Substantial Unix software has been developed for this hardware. A software library for raster image

manipulation, radiometric and geometric correction, registration, filtering, classification, enhancement and interpretation is supported using a standard image file representation. A standard graphics interface is also supported, extending the basic Unix plot film format. Our standard image file and graphics file software include interfaces to C and to Franzlisp and support for the Comtal computational vision research, [such as knowledge representation languages] which also have been developed and supported under Unix. A symbolics 3650 Lisp machine has been recently purchased. Through a research contract with International Artificial Intelligence (IAI) we have acquired the 24-bit high-resolution colour frame buffer option. A software loan agreement with Symbolics Canada has been signed for the Symbolics paint, geometry, rendering and dynamic animation systems. Integrating of the Lisp machine, and its software, into our existing facility is in process. [For further information about the L.C.V. contact Dr. R.J. Woodham.]

2. *Satellite Oceanographic Laboratory (SOL)*

Located in the Department of Oceanography, the Satellite Oceanographic Laboratory maintains a HRPT receiving station for NOAA polar orbiting satellites. The system is supported by a VAX-11/750 computer. Currently SOL is working toward a fully automated receiving station that requires operator intervention only to archive satellite passes stored on disk.

The image display is based on Raster Technologies display units - a second unit was recently installed to allow more people access to image processing.

The SOL is directed by Dr. W.J. Emery, but since last summer, he has been on a leave of absence at NOAA's National Center for Oceanographics and Atmospheric Studies in Denver, Colorado.

3. *Geophysics and Astronomy Laboratory*

Located in the Department of Geophysics and Astronomy, the Laboratory has developed an image analysis system to serve its special needs. The image analysis system consists of a VAX 11/750 computer, an FPS Array Processor and an 1^2S Image Display system. In the near future, more instrumentation will be available for graduate and undergraduate student use. The Department's remote sensing contact is Professor Gordon Walker.

4. *Geography Laboratory*

During the past year, the Geography Department has taken steps to include GIS in their teaching and research. New equipment is being obtained including a digitizer, WYSE-AT, colour graphics display and GIS software including ARC-INFO from ESRI and "Sonnet Cad" from OMNI Forest Services Inc.

Mr. Brian Klinkenberg, who expects to receive his Ph.D. in 1987 has been taken on Faculty and is in charge of the GIS development in Geography.

5. *Electrical Engineering Laboratory*

Dr. M.R. Ito is the contact for remote sensing in the E.E. Laboratory. Equipment available for use includes a VAX 11/750, Ramtech Display and HP9550 Graphics Display. "Several" design work and image display systems are on order, and the lab is being substantially upgraded to accommodate demands of new contract work. Current plans call for hiring 2 additional full time staff, one professional digital designer for system architecture & VLSI and another for pattern recognition research.

6. *Forestry Remote Sensing Laboratory (FIRMS)*

Dr. P.A. Murtha is in charge of the "Forest Information Resource Management Systems" (FIRMS) recently evolved from the Forestry Remote Sensing Laboratory. From the stand-alone advanced MERIDIAN/PC image analysis workstation, and from funds allocated under the CFS Human Resources Program and the "UBC Funds for Excellence" program, the remote sensing laboratory has been upgraded to FIRMS. The laboratory now has version 3.0 of the MDA-MERIDIAN image analysis software, TERRASOFT and other GIS software, as well as digitizing capability and 4 independent or

connected workstations. All workstations have the GIS software. Through the University network (UBCNET) operating system connection, the FIRMS Lab is connected to the VAX-11/780 in the Lab for Computational Vision or any of a number of computers connected by phone lines (i.e. RESORS). This connection provides the capability to transfer Satellite data, B.C. Ministry of Forests and Lands Intergraph file data, or other digital data to the PC's from the VAX or to send data or Digital Elevation Model (DEM) data from FIRMS back to the LCV. Satellite image data can also be entered via floppy discs to the hard discs in the PC's.

7. Soil Science

Remote sensing activities in Soil Science are conducted by Dr. Hans Schreier. Two micro-computer based GIS-PMAP facilities have been established. A research assistant (Ms. Jennifer Kuo) with a MSc in Computer Science has been hired to assist in a large GIS agricultural program.

Selected Research Summaries
[Topics 'selected' by submissions from researchers.]

A.K. Mackworth
"Knowledge Representation and Algorithms for Vision."

The long-term goal is to characterize the knowledge necessary for visual perception, to determine good computational representations for that knowledge and to describe efficient algorithms for using it to see. Our Mapsee systems can successfully interpret complex hand drawn sketch maps of geographical areas. It has been used to give advice to an automated aerial image interpreter demonstrating the quantitative benefits of using a good model of spatial organization that complements spectral knowledge. We have carried out experimental and theoretical studies of the time/space complexity of our algorithms showing that they are efficient. A new model of vision has been proposed and non-procedural representations can lead to a new theory of image-based systems for vision and graphics.

R.J. Woodham
"Photometric Methods for Image Analysis."

The objective is to develop a theory of image formation and to apply the theory to a variety of computational vision tasks. Image acquisition is treated as a measurement process. An image irradiance equation is formulated to determine image brightness as a function of surface orientation, for a fixed surface material, scene irradiance and viewing geometry. Shape from shading algorithms inherently embody assumptions about surface smoothness and curvature. Much of my recent work has helped to make these assumptions explicit. This provides a theoretical base for determining what can and cannot be computed directly from measurements of image brightness.

The fundamental difficulty is that an image does not uniquely determine the underlying scene. There are trade-offs in illumination, viewing geometry, surface material and shape that cannot be resolved in a single view. One way to augment the information in a single view is to use multiple images. Photometric stereo uses multiple images in a novel way. The idea is to obtain multiple images from the same viewing direction but under different conditions of illumination. The multiple brightness measurements recorded in successive views determine surface orientation locally, without smoothness or curvature assumptions. There is no motion of object or viewer. Therefore, the problem of matching corresponding points, as in binocular stereo, is avoided.

Another way to augment the information in a single view is with non-image data. Models of the underlying surface, in the form of a digital terrain model are used in remote sensing to constrain the interpretation of Landsat imagery. DTM's are used to decouple the effects of direct solar irradiance, diffuse sky irradiance and path radiance from ground cover. An 'albedo map' is produced which is defined to be an image showing only variations due to ground cover. That is, all variations due to topography, illumination, shadows and viewing direction are removed. The practical goal of this research is to extend the range of terrain and imaging conditions that can be handled by automatic image analysis systems.

P.A. Murtha
"FIRM Applications to Forest Management"

The MERIDIAN system is an IBM PC/AT-based advanced workstation with image analysis and map overlay capabilities. The system has been upgraded to FIRMS (Forest Information Resource Management Systems).

The long-term objective is to develop an integrated image analysis and geographic information system with on-line access to forest attribute data in the B.C. Ministry of Forests IGDS data base in Victoria. Such a system would permit modelling management decisions prior to implementation and assessment of the environmental effect of such decisions. For example it would be possible to select the most appropriate location of a pipeline through an area of sensitive soils with minimal environmental impact.

The short term objectives have been (a) to evaluate the system during operational use, determine software shortcomings, and implement software upgrades, and (b) to apply the system to remote sensing analysis problems ranging from mapping of the UBC Research Forest, to assessment of soils, to evaluation of bark beetle attack.

H.E. Schreier
"Evaluation of Remote Sensing Techniques to Quantify Soil Degradation"

Two studies were completed:

The first one involved the quantification of soil organic matter variability in an agricultural field in Abbotsford, B.C. using spectral reflection and air-photo density scanning techniques. The quantitative remote sensing information was then related to the soil fertility status. The results revealed that in order to make optimum use of fertilizers variable rates should be applied according to the soil pattern quantified by the remote sensing analysis. This project formed the M.Sc. thesis research of Mr. F. Zheng and was completed in February 1986.

The second project involved similar research in an agricultural field near Ashcroft, B.C., but in this case attention was given to soil with low organic matter content. Good relationships were obtained between spectral reflection and soil texture and the results were used to improve soil fertilizer management. This project was carried out in coooperation with the Potash and Phosphate Institute, and Dr. A. van Ryswyk, Agriculture Canada, Kamloops.

Other Research

Other Faculty Members and Research topics are given in Table 2. Current graduate students and theses topics are given in Appendix II.

Conclusion

There are seven departments and nine faculty members in the UBC Faculty of Graduate Studies involved in remote sensing. Their activities are communicated via the UBC remote sensing council. There are seven remote sensing:image analysis:-G.I.S. laboratories with several workstations per laboratory. Some of the laboratories are connected in a distribute network, or connected via the UBC MTS operating system. There are over 30 graduate students directly involved in research in remote sensing or applying remote sensing techniques.

Concerns

Our major concern rests with the uncertain project funding picture that has emerged at the federal level and the industrial emphasis for research grants.

Our other concerns are:

1) the extremely high cost (prohibitive) of acquiring new airborne digital data, and the current inappropriate timing of any proposed missions, and
2) the availability of appropriate sensors for remote sensing work in Geophysics and Astronomy has deteriorated and consequently affects research programs.

Finally, 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. Research grants cannot afford the current private industry fees for airborne data collection.

Remote sensing research seems to have increasing emphasis on "space station style" remote sensing. The individual university researcher is increasingly out of the picture. CACRS and CCRS should make every effort to support and encourage more funded remote sensing research at the Universities by the federal government.

Table 1. Major equipment and software available for remote sensing research at the University of British Columbia.

Lab	Major Equipment No.	Type	Major Software
1) LCV (Computer Sci)	1 -	DEC Vax 11/780	- Unix 4.2 BSD
	3 -	SUN 3/50 Workstations	- plus Unix software for image manipulation, radiometric and geometric correction, registration, filtering, classification, enhancement and interpretation
	1 -	Raster Tech. ONE/25 image display connected to SUN 2/120 FS	
	1 -	Matrox/Hitachi CCD camera/frame grabber	- Mapsee2
	1 -	Symbolics 3650 Lisp machine	- Symbolics paint
	1 -	Optronics Colormation C-4500 color film scanner/writer	
	1 -	Ethernet local area network	
2) SOL (Oceanography)	1 -	Vax 11/750	- software to track receive, display and analyze NOAA AVHRR data
	1 -	HRPT Receiving Station for NOAA Satellites	
	2 -	Raster Tech Display units	
3) Geophysics and Astronomy	1 -	Vax 11/750	- Software for image display and analysis
	1 -	FPS Array Processor	
	1 -	I^2S image Display	
4) Electrical Engineering	1 -	Vax 11/750 with Ramtech Displays and HP9550 graphics display (Second Design Work and Image Display systems on order)	- Software for image display and analysis. Emphasis on Radar
5) Geography	1 -	"A ST Premium" with Digitiger and Color Graphics Display	- ESRI - Arc-Info OMNI -Sonnet Cad.
6) FIRMS (Forestry)	1 -	IBM-AT, 60 Mbyte (mB) hard disk	- Meridian Ver 3.0
	1 -	ITT Extra 286, 20 mB " "	- Terrasoft GIS
	1 -	AST Premium 286.10, 40 mB " "	- dBase III+
	1 -	Compaq 386, 130 mB " "	- Lotus
	4 -	Image Displays	- DTM
	-	UBC Port for Networking to LCV	- Kermit, etc.
	4 -	Graphics Tablets	
	3 -	Printers including Tektronics 4696	
	1 -	HP Plotter (B-size)	
	-	Number 9 "Revolution" Graphics Board	
	-	Number 9 "Pro 32" Graphics Board	
7) Soil Science	1 -	IBM PC-AT	- GIS
	1 -	AST Premium 286 with 2 mB RAM	- PMAP
	1 -	Digitizer	
	1 -	Barringer, Mark 2 Field Spectroradiometer	

Table 2. Faculty Member, Department, and Current Research Topics.

Name	Department	Research Topics
Dr. Bill Emery	Oceanography	"Satellite Applications to Oceanography"
Mr. Bruce Haggerstone	Landscape Architecture	"Remote Sensing as applied to landscape analysis"
Dr. Mabu Ito	Electrical Engineering	"Pattern recognition of discrete objects"
Mr. Brian Klinkenberg	Geography	Ph.D. Thesis Topic (In Progress) "Fractals, Landscape Simulation Models"
Dr. Alan Mackworth	Computer Science	"Knowledge representation and algorithms for vision"
Dr. Peter Murtha	Forestry/Soil Science	"FIRMS applications to forest management" "Digital analysis of vegetation damage"
Dr. Hans Schreier	Soil Science	"Evaluation of remote sensing techniques to quantify soil degradation"
Dr. Gordon Walker	Geophysics & Astronomy	"Remote Sensing Sensor Development" Book recently published. [Walker, G. 1987. "Astronomical Observations and Optical Properties". Cambridge University Press.]
Dr. Bob Woodham	Forestry/Computer Sci.	"Photometric methods for image analysis"

Appendix I. Faculty associated with the UBC Remote Sensing Council.

Dr. W.J. Emery, B.Sc., Ph.D. (Hawaii) *Associate Professor*	*(Oceanography)*
Mr. B. Haggerstone, M.Sc. (Harvard) *Lecturer*	*(Landscape Architecture)*
Dr. M.R. Ito, M.Sc., Ph.D.(Brit.Col.), P. Eng. *Associate Professor*	*(Electrical Engineering)*
Mr. Brian Klinkenberg	*(Geography)*
Dr. A. Mackworth, B.A.Sc., A.M., D.Phil (Sussex) *Professor*	*(Computer Science)*
Dr. P. Murtha, B.Sc.F., M.Sc., Ph.D. (Cornell) *Professor*	*(Forestry/Soil Science)*
Dr. H. Schreier, B.A., M.Sc., Ph.D. (Brit.Col.) *Associate Professor*	*(Soil Science)*
Dr. G. Walker, B.Sc., Ph.D. (Cantab.), FRSC *Professor*	*(Geophysics & Astronomy)*
Dr. R.J. Woodham, B.A., M.Sc., Ph.D. (M.I.T.) *Associate Professor*	*(Forestry/Computer Science)*

Appendix II. *List of Graduate Students Enrolled in 1986/87 in the UBC Remote Sensing Program in the Various Departments, Anticipated Degree, Thesis Topic, Expected Completion Date.*

Department	Name	Topic	Degree	Completion Date
Computer Science (R.J. Woodham)	J.L. Brooks	Computational Vision	M.Sc.	May '88
(Al Mackworth)	T. Bult	Knowledge representation for Chinese character recognition	M.Sc.	Aug. '87
	A. Carter	Probabilistic Methods in Expert Systems	Ph.D.	
	M. Majka	3-D Representations for Computational Vision	Ph.D.	Spring '87
	R. Rensink	Perceptual Aspects of a Fractal Structure of Surfaces	M.Sc.	Spring '86
Electrical Engineering* (M. Ito)	Neil Cox		Ph.D.	
	Kai-Sang Ching		M.A.Sc.	
	Susan Pullman		M.A.Sc.	
	David Romalo		M.A.Sc.	
	Sanjay Singhal		M.A.Sc.	
	Irawan Soeharjono		M.A.Sc.	
	Ching Leong Wan		M.A.Sc.	
	Sammy Yick		M.A.Sc.	
Forestry (Peter Murtha)	Grant Bracher	Red Edge Analysis of Tree Status	Ph.D.	May '89
	Ann Gallie	Chromaticity Analysis and Water Quality Using Ground Data and Satellite Imagery	Ph.D.	Nov. '87
	Ulf Runesson	Early Detection of Bark Beetle	Ph.D.	Sept. '87
	Arun Bansal (India)	Assessment of Revegetation	M.Sc.	Summer '88
	Al Banner	Computer Based Image Analysis for Early Detection of Spruce Beetle Attacked Spruce	M.Sc.	Oct. '86
	John Donahue (USA)	Detection and Analysis of Landslide Events	M.Sc.	May '88
Forestry (Bob Woodham)	M. Gray	Radiometric correction of satellite imagery for topographic and atmospheric effects	M.Sc.	June '86

Appendix II (Cont'd)

Department	Name	Topic	Degree	Completion Date
Geography (Brian Klinkenberg)	Gong Peng (PR China)	GIS and Urban Analysis	Ph.D.	May '89
(Tim Oke)	Hans Schmid	Remote Sensing of Sensible Hot Flux	Ph.D.	May '88
Landscape Architecture (Bruce Haggerstone)	Luc Roberge	Unannounced	M.Sc.	Sept. '88
	Dave Kaegi	Non-Thesis	M.Sc.	Spring '88
Oceanography (Bill Emery)	Andrew Thomas	Correlation Between In Situ Measured Plankton Distributions and AVHRR Imagery	Ph.D.	May '87
	Mike Collins	Estimation of Sea-Ice Motion	M.Sc.	May '87
	Hae Yong Shin	Sea-Surface Temperature	Ph.D.	Aug. '86
	Carl Szczechowski	Feature Enhancement in AVHRR Imagery	M.Sc.	May '86
	Paris Vachon	Modelling Synthetic Aperture Radar	Ph.D.	'88
Plant Science (Brian Hall)	Tim Ross	Remote Sensing of Alkali Soils	M.Sc.	Fall '87
Soil Science (Hans Schreier)	Feng Zheng (P.R.China)	Using Spectral Reflection and Multi-dye Layer Pixel Values to Quantify Soil Patterns for Assessing Field Fertility Conditions	M.Sc.	May '86
	Steve Crudge	Quantifying Soil Erosion Using Remote Sensing	M.Sc.	May '87
	Steve Smith (NZ)	Modeling of Forage Production Using GIS and Remote Sensing	Ph.D.	April '88

( ) = Supervisor's name

**Since this is the first time Electrical Engineering has been reported in the CACRS Report, below is a listing of successful Master of Applied Science Degrees and theses topics for last year.*

September 1985 - August 1986
(M.A.Sc.)

Patricia KAVANAGH	*Doppler Centroid Ambiguity Estimation for Synthetic Aperture Radar*
Carl SAUNDERS	*A Microprocessor Based 3D Anthropometer*
Alfred SCHMIDT	*Secondary Range Compression for Improved Range/ Doppler Processing of SAR Data with Squint*
David TSENG	*Restoration of Random Motion Degraded Sonar Images*
Hans WASMEIER	*Development of Tests and Preprocessing Algorithms for Evaluation of Speech Recognition Units*
Darrell WONG	*A Hybrid Model of Vocal Fold Vibration with Application to some Pathological Cases.*

Appendix III. Undergraduate and Graduate courses offered by various Departments in Remote Sensing.

Astronomy 421	*- Astronomical and Astrophysical Measurements*
Astronomy 431	*- Astronomical Laboratory*
Civil Engineering 453	*- Elementary Photogrammetry*
Civil Engineering 456	*- Photogrammetric Surveying*
Civil Engineering 576	*- Civil Engineering Uses of Aerial Photographs*
Computer Science 414	*- Introduction to Computer Graphics*
Computer Science 435	*- (Forestry 435) - Computer-based Image analysis for Forest Inventory Systems*
Computer Science 505	*- Image Understanding I: Image Analysis*
Computer Science 514	*- Advanced Computer Graphics*
Computer Science 525	*- Image Understanding II: Scene Analysis*
Electrical Engineering 575	*- Signal and Image Processing*
Electrical Engineering 466	*- Digital Signal Processing Systems (has prerequisites)*
Forestry 422	*- Forest Land Classification*
Forestry 435	*- same as Computer Science 435*
Forestry 442	*- Photo Interpretation of Forest Lands*
Forestry 443	*- Remote Sensing in Forestry and Agriculture*
Forestry 542	*- Advanced Studies in Photogrammetry*
Forestry 543	*- Selected Topics in Remote Sensing*
Geography 370	*- Air Photo Analysis*
Geography 372	*- Cartography*
Geography 470	*- Remote Sensing in Geographic Enquiry*
Geography 526	*- same as Oceanography 526*
Geological Sciences 305	*- Field Methods*
Oceanography 526	*- Satellite Remote Sensing: Application to Oceanography and Meteorology*
Soil Science 417	*- same as Forestry 422*
Soil Science 442	*- same as Forestry 442*
Soil Science 443	*- same as Forestry 443*

9.3 REPORT OF THE UNIVERSITY OF MANITOBA

The proposed establishment of an Institute on 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. Richard Gordon: Botany and Radiology

The following papers on image processing research were published during 1986:

- Dhawan, A.P., C. Buelloni,& R.Gordon (1986) Enhancement of mammographic features by optimal adaptive neighborhood image processing. IEEE Trans. Medical Imaging MI-5(1),8-15.
- Harauz,G.,R.Gordon& M.vanSteel (1986) Oblique sampling of projections for direct three dimensional reconstruction. Comput.Vis. Graphics, Image Processing
- Gordon,R. (1986) Geometric unwarping for detection of early breast cancer. 22nd National Conference on Breast Cancer, Boston, May 12-16.

In addition the following theses on imaging were supervised during 1986:

- Geometric unwarping for detection of early breast cancer, Third Generation Image Compression Techniques for Teleradiology (X.Zhou, Electrical engin.)
- Neuroscopy: three dimensional computed tomography of nevi and melanomas in situ by transillumination. (A.Dhawan, Electrical Engin.)
- MAGPET: High Resolution Positron Tomography using Magnetic Fields (D.Rickey, Physics).

Dr. Gordon's current research as provided by grants from the National Cancer Institute of Canada and the Academic Development Fund, U. of Manitoba are, respectively: 3-D Digital Subtraction Mamography via Geometric Unwarping for Detection of Early Breast Cancer; and Focus-Free Digital Imaging for Microscopy, Photography and Robotic Vision.

Dr. Wooil Moon: Geophysics - Geological Sciences

The following papers on image processing research were published during 1986:

Ushah, R., Moon,W. and Singh, V. (1986) Hilbert Transform for Potential field data: Proceedings for the 55th SEG conference, 81-87.

Moon, W., Carswell,A., Tang,R. and Dillston, C. (1986) Radon transform wavefield separation for USP data, Geophysics, 51, 940-47.

Current research includes:

- Integrated geophysical imaging (with J. Morrish, A. Ushah) A theoretical framework for optimal integration of 3-D data volume is being developed. The information spectra being investigated range from LANDSAT optical bands to much longer wavelength geophysical data sets. (Funded by NSERC)
- Integrated geophysical imaging experiment of Sudbury Basin (with E. Kublick [U. of Manitoba]; B.Krause, E. Berrer [INCO7] Following the high resolution seismic survey (reflection and refraction) an integrated imaging experiment is in progress to reconstruct the geological structure of a selected portion of the Sudbury basin. (Funded by NSERC University-Industry program)

Faculty Research in Remote Sensing

Dr. John Stewart: Botany

Previous research (1984 and 1985) in conjunction with the Manitoba Remote Sensing Centre (MRSC) demonstrated that a relatively simple image processing technique produced about 75% of the information required to map the peat and non-peat categories at the 1:250,000 scale. A current sabbatical leave is being used to upgrade skills in using Landsat 4 and 5 Thematic Mapper (TM) and SPOT imagery data and ground truth verification procedures in peatland inventory. The increased resolution of the TM and SPOT imagery along with supervised classification procedures provided by the ARIES II image analysis system will provide improved classification of Manitoba peatlands. (Funded by MEM,MRSC and NSERC).

Dr. Wooil Moon: Geophysics-Geological Sciences

The following papers on remote sensing research were published during 1986:

Moon, W. and Tang, R. (1986). Ocean bottom friction coefficient from SEASAT-ALT data. Geophysical Journal (Royal Astronomical Society), 86, 797-830.

Moon, W. and Ushah, A. (1986). Integration of potential field data using 2-D Hilbert transform. European Space Agency Special Paper, SP-254, 1555-1562.

Moon, W, Tang, R. and Cloe, B.(1986). Application of Satellite Altimeter data in Global Geodynamics, European Space Agency Special Paper, SP-254,1555-1562.

Ushah, A., Moon, W. and Singh, V. (1986). Application of 2-D Hilbert Transform for potential field data interpretation. Proceedings for the 55th SEG Conference, 81-87.

Dr. Moon is currently (1986-87) on sabbatical and during 1986 delivered a number of papers, nationally and internationally, on geophysical imaging and remote sensing. He has been selected for the Canadian Scientific Investigation Team, along with two other Canadian university faculties, to work with the ERS-1 satellite. His involvement is with the radar altimeter system during the post launch, commissioning period. Following the commissioning period, Wooil and his graduate students will apply the results on the presently on-going Global Geodynamic research.

Dr. Micha Pazner: Geography

Dr. Pazner joined the Geography Department in September, 1986 as a specialist in computer cartography; the application of Artificial Intelligence in geographic problem solving; and in Geographic Information Systems. His Ph.D. dissertation (1986, Univ. of California, Santa Barbara) was titled: "Geographic Knowledge Base Design and Implementation"

Among his current interests are:
- to develop and apply 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. Other interests in remote sensing involve the development of Geographic Information Systems for microcomputer useage and image processing, classification and pattern recognition in remote sensing.

Dr. Larry Stene: Geography

Dr. Stene's research involves the utilization of LANDSAT, hydrometric, and hydrologic data to investigate the possible reasons for large-scale river bank erosion and the possibility of developing a predictive model of such erosion for the Jamuna River, Bangladesh. The project, jointly sponsored by the International Development Research Centre (IDRC) and the Universities of Manitoba and Jahangirnagar, Savar, Bangladesh, will culminate in 1987.

Short Term Goals:

1. External Funding for the U. of Manitoba Institute on Imaging and Remote Sensing will continue to be sought in 1987.
2. Collaborative research projects among university departments, MRSC and the private sector will be encouraged.

List of Active Group Members

R. Gordon - Botany and Radiology
D. Hall - Geological Sciences
M. Hamid - Electrical Engineering
T. Henley - Natural Resources Institute
W. Moon - Geological Sciences
M. Pazner - Geography
L. Stene - Geography
J. Stewart - Botany
M. Vaisey-Genser - Assoc. Vice-Pres.Research

9.4 RAPPORT DE L'UNIVERSITÉ DE SHERBROOKE

Centre d'applications et de recherches en télédétection (CARTEL) avec la collaboration de l'Université Laval

Introduction

L'enseignement de la télédétection à l'Université de Sherbrooke relève du département de géographie de la Faculté des Lettres et Sciences humaines, tandis que le volet recherche relève du Centre d'applications et de recherches en télédétection (CARTEL) de la même faculté. Les étudiants gradués participent ainsi, pendant la durée de leur études, au développement de la recherche par l'intermédiaire de cette association recherche-enseignement.

Le département de géographie est responsable de tous les aspects reliés à la formation. Il compte plusieurs professeurs spécialistes de la télédétection ou encore, dont certains aspects de la recherche font appel à cette discipline. C'est ainsi que certains professeurs spécialisés en géographie du tiers-monde ou en géographie urbaine par exemple, utilisent la télédétection comme outil de travail dans le cadre de leurs recherches.

Le Centre d'applications et de recherches en télédétection (CARTEL) regroupe les professeurs du département de géographie qui enseignent en télédétection, certains professeurs dont la spécialité première n'est pas la télédétection mais qui utilisent la télédétection, des attachés de recherche, des assistants de recheches et des chercheurs associés qui travaillent dans les secteurs privé ou public.

Le CARTEL est, à l'heure actuelle, un des plus importants centres de recherche universitaire en télédétection au Canada, tant par le nombre de chercheurs qui y sont rattachés que par la diversité et la qualité de ses réalisations. Fondé en 1985, le Centre remplace le laboratoire de télédétection du département de géographie qui existait depuis 1972. En 1985, le laboratoire obtenait un statut de Centre dans l'Université, avec une participation de l'Université Laval au niveau du conseil d'orientation.

Le Centre a été sélectionné en 1985-86 pour une subvention de 1,309,000$, répartie sur 5 ans, par le programme des Actions structurantes du Ministère de l'enseignement supérieur de la science et de la technologie du Québec. Cette subvention a permis d'engager 3 attachés de recherches (Dr. A Condal, Dr. N. O'Neill et Dr. H. Granberg), d'accorder 12 bourses d'étudiants, d'assurer 2 postes de professionnels et d'améliorer l'équipement de traitement d'images, en passant au système ARIES III de Dipix, avec un Microvax II comme ordinateur de calcul.

Les équipements

Le Centre possède un système de traitement d'images DIPIX ARIES-III basé sur Microvax II avec les périphériques suivants: une caméra de numérisation EIKONIX, une imprimate à jet d'encre ACT-II, une table de numérisation ALTEK GENTIAN et une imprimante photo IMAPRO. On y retrouve deux stations de travail. En plus des logiciels ARIES, le CARTEL possède des logiciels qu'y ont été développés au Centre même.
De plus, le Centre possède un laboratoire mobile de spectroradiométrie qui est utilisé essentiellement pour des mesures radiométriques ou météorologiques lors de survols. Cette station est équipée de radiomètres (Barnes PRT-5 & 10, Exotech, SPOT Cimel et radiomètres à bilan), de télé-thermomètres et de sondes à thermistors. Les données sont enregistrées de façon analogue ou digitale.

Activités de recherche

Colloques:
Au cours de l'année, divers chercheurs ont participé à des colloques ou symposium importants dont le 10ième Symposium canadien sur la télédétection à Edmonton (5 communications) et le 20ième Symposium de l'ERIM à Nairobi (3 communications). De plus, le directeur du Centre participait en fin d'année au colloque Spot/PEPS à Toulouse, où l'on a fait le point sur SPOT et divers aspects du programme PEPS.

Etudes côtières et marines:
Sept (7) projets de recherche ont été complétés ou amorçés avec le MAPAQ (Pêches maritimes), Parcs Canada, le Groupe-Conseil Roche, Pêches & Océans Canada et d'autres sur la télédétection de la végétation marine, des courants de surface, de la dérive des larves de crustacés et de l'environnement côtier.

Etudes de l'atmosphère par télédétection satellite et mesures au sol:
Plusieurs projets de recherche ont été entrepris dans le domaine de la modélisation du rayonnement solaire réfléchi par l'atmosphère et la terre dans le visible et le proche infrarouge: des applications ont portées sur le développement de méthodes de corrections atmosphériques et sur l'étude de séries chronologiques d'image Landsat. Enfin des projets de recherche ont également été poursuivi dans les domaines de la télédétection radar des ressources renouvelables, de l'évolution urbaine et des propriétés thermiques de la surface terrestres.

Exposition pan-canadienne sur la télédétection:
Le CARTEL est le promoteur, avec le Musée du Séminaire de Sherbrooke, d'une exposition sur la télédétection qui se tiendra à l'été 87 à Sherbrooke et qui deviendra itinérante à travers le Canada de 1987 à 1989.

Implications internationales:
Le CARTEL a été impliqué dans trois projets de formation: un projet sous l'égide du CRDI, et qui comportait un volet formation, a porté sur la télédétection de l'utilisation du sol en République Dominicaine , tandis que le Centre en collaboration avec la firme DIGIM-Lavalin a participé à un programme de formation en traitement d'images pour des spécialistes thailandais issus de diverses disciplines. Enfin, le Centre recevait un stagiaire du département des sciences du sol de l'Institut Agronomique Hassan II du Maroc pour un stage de formation de longue durée.

Programme France-Québec:
Dans le cadre de la coopération France-Québec en enseignement supérieur et recherche en matière de télédétection, le MESST sanctionnait en fin d'année un programme d'échange entre le CARTEL et le CRPE (Centre de recherches en Physique de l'Environnement (Paris VII). Le programme d'une durée de trois ans comprend des stages et des missions et implique des échanges possibles, par le biais d'ententes préalables, avec des laboratoires associés tels que l'INRA (Avignon) et le LERTS (Toulouse) et des organismes tels que DIGIM et Agriculture Canada. Le CARTEL participe aussi, conjointement avec le CRCS (Centre de recherches sur les communications de Sherbrooke) à un programme France-Québec avec l'Ecole nationale supérieure des télécommunications de Brest.

Programme PEPS:
Une équipe de chercheurs du CARTEL a été sélectionnée au terme d'un concours international pour participer au programme préliminaire d'évaluation de SPOT (PEPS). Une autre équipe participe à une équipe PEPS de l'IFREMER.

Les chercheurs membres du CARTEL

Bonn, Ferdinand J., Ph.D. (Strasbourg): Application des données de télédétection (en particulier les thermographies) à l'étude des sols, de la végétation et du microclimat.

Brochu, Richard, M.Sc (Sherbrooke): Radiométrie, traitement d'images et application de la télédétection au milieu urbain.

Cavayas, François, Ph.D. (Laval): Professeur au département de géographie de l'Université de Montréal, spécialisé en corrections radiométriques d'images et en traitement numérique.

Condal, Alfonso, Ph.D. (British Columbia): Attaché de recherche au département des sciences géodésiques et télédétection de l'Université Laval, spécialisé en physique atmosphérique.

Dubois, Jean-Marie, Ph.D. (Ottawa): Télé-interprétation des ressources naturelles, en particulier des littoraux de région froide et des dépôts meubles quaternaires.

Granberg, Hardy B., Ph.D. (McGill): Couvert nival en relation avec l'hydrologie et climatologie du pergelisol (bilan radiatif).

Gwyn, Q. Hugh J., Ph.D. (London): Application de la télédétection aux sciences de la terre , principalement des images radar aux dépôts meubles.

Morin, Denis, Ph.D. (Laval): Application de la télédétection aux études urbaines.

O'Neill, Norman T., Ph.D. (York): Physique de la télédétection et du rayonnement.

Royer, Alain, Ph.D. (Grenoble): Corrections atmosphériques, physique de la télédétection.

Les chercheurs associés au Centre

Belsher, Thomas, Ph.D. (Aix-Marseilles): Océanographe et chercheur à l'IFREMER, applications de la télédétection à l'étude de l'environnement et de l'aménagement du littoral.

Brown, Ronald J., Ph.D. (Manitoba): Chercheur au Centre canadien de télédétection, membre de l'équipe Radarsat, applications du radar.

Fortin, Jean-Pierre, Ph.D. (Montpellier): Professeur à l'Institut national de la recherche scientifique (INRS-Eau), applications de la télédétection à l'hydrologie et à la météorologie.

Paquette, Romain, Ph.D. (McGill): Professeur au département de géographie de l'Université de Sherbrooke et spécialiste du tiers-monde.

Pesant, Alain, M.Sc. (Laval): Chercheur à la station de recherches de Lennoxville (Agriculture Canada), spécialiste de la physique des sols.

Rochon, Guy, M.Sc.A. (Laval): Président de DIGIM Inc. et de Photosur Inc. est professeur associé à l'Université de Sherbrooke et chercheur associé au Centre.

Thomson, Keith, Ph.D. (Toronto): Professeur au département des sciences géodésiques et de télédétection de l'Université Laval, spécialisé dans le utilisations du radar.

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Charbonneau, L., D. Morin, A. Royer (1987): Interprétation et analyse du paysage urbain de l'agglomération de Montréal à l'aide des données Landsat. *Revue Photo-Interprétation*, 9p. (Accepté pour publication)

Bégin, D., Q.H.J. Gwyn et F. Bonn (1987): Radiometric correction of SAR images: a new algorithm, *International Journal of Remote Sensing*. (Accepté pour publication)

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Carignan, M. et J.M.M. Dubois (1986): L'image multidate: un outil potentiel pour la gestion du territoire agricole (Québec, Canada). *Photo-Interprétation. (Soumis)*

Grenier, M., E. Lambert, J.M.M. Dubois et A. Lavoie (1986): La télédétection des macrophytes marins. *Photo-Interprétation. (Soumis)*

Lavoie, A. E. Lambert, J.M.M. Dubois et L. Gendron (1986): Télé-interprétation des laminaires des côtes du Québec et évaluation de biomasse. *Photo-Interprétation. (Soumis)*

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Girard, C. (1987): Effet de la structure géométrique du couvert forestier sur la réponse radar. Thèse de M.Sc., Département de géographie, Université de Sherbrooke, 59p.

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Fournier, L., A. Royer et F. Bonn (1986): Surface albedo variations due to land-use changes since 1973 in the Wertern Dominican Republic, *20th International Symposium on Remote Sensing of Environment*, Nairobi (Kenya), December 4-10, 1986. (Accepté)

Diakité, M., M. Yergeau et F. Bonn (1986): The utility of Landsat TM imagery in the Inland Delta cartography of Mali, *20th International Symposium on Remote Sensing of Environment*, Nairobi (Kenya), December 4-10, 1986. (Accepté)

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Lavoie, A., J.M. Dubois, J. Lacroix, A. Royer et M, Carignan (1986): Télédétection de la circulation des eaux de surface dans le nord du Golfe du Saint-Laurent: application à la dérive des larves de poissons et de crustacés, *Rapport présenté à Pêches et Océans Canada*, Direction de la recherche sur les pêches, Québec, contrat OSD85-00249, 97p.

Gratton, D. (1986): Évaluation des données TM de Landsat en glaciologie: rapport final, *Recherche effectuée pour le compte de l'Institut National de Recherche en Hydrologie (Environnement Canada)*, Contrat KW504-5-0220, 55p.

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9.5 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 of the Faculty of Environmental Studies, and in the Departments of Systems Design Engineering and Civil Engineering in the Faculty of Engineering. A remote sensing project has been undertaken in the Department of Earth Sciences of the Faculty of Science; and in the Pattern Analysis and Machine Intelligence Laboratory of the Department of Systems Engineering there are projects of direct interest to remote sensing.

There is no coordinating body within the University to oversee remote sensing activities. However, there is considerable contact and cooperation between the different groups. As demonstrated in this report, there are joint research projects between the different groups, students take remote sensing courses across campus, faculty participate on student advisory committees, and research equipment is shared when appropriate.

RESEARCH FACILITIES

1. **Department of Geography**

Equipment used for research in remote sensing is located in the Mapping, Analysis and Design Area of the Faculty of Environmental Studies. In Figure 1, a diagrammatic layout of the facility is presented. The equipment was provided by an Ontario Board of Industrial Leadership and Development (BILD) Grant to R. Newkirk and E. LeDrew in 1982 and University of Waterloo/Digital Equipment Corporation (WATDEC) Grants to E. LeDrew and P. Howarth in 1985 and 1986. The facility allows not only standard digital analysis using the Dipix ARIES III system, but also developmental work using the other VAX-based equipment. A system, known as the Mapping, Analysis and Design Geographic Information (MADGI) System, for input and output of data, and moving files between systems is being developed. Eventually, it is planned that MADGI will be linked into the computer cartography facilities, including a CalComp digitising table.

2. **Department of Systems Design Engineering**

M.E. Jernigan operates an image processing and vision modelling lab. with a DEC GPX-11 with MicroVAX II workstation for software development. It is planned to connect the facility to the Engineering VAX 11/780 computers.

3. **Department of Civil Engineering**

J. Sykes has a MASSCOMP Image Analysis System with PCI software, while S.I. Solomon operates a DEC Professional microcomputer.

4. **Department of Earth Sciences**

The department has an IBM PC-AT microcomputer with digitizing board for analysis of video images and features on aerial photographs. For more detailed analysis, H. George has made use of facilities in the Faculty of Environmental Studies.

RESEARCH PROJECTS

Cooperation between different faculties and departments is demonstrated by several joint research projects. These are described below. Also listed separately, are international research projects and individual research projects being undertaken by faculty members and their graduate students.

In each case, the title of the project is listed, followed by the period of time over which the project will run. The agency (or agencies) providing financial support are indicated, with the amount of funding for the year 1986-87 (or 1985-86 if the project terminated in 1986). Faculty and students, including their departmental affiliations, are recorded, and a brief description is given for each project.

Cooperative Projects

1. Image Analysis of Sea Ice and Ocean Radar Data (1985-88).
Support: Natural Sciences and Engineering Research Council of Canada, Strategic Grant (1986-87: $84,443).
Faculty: M.E. Jernigan (Systems Design Engineering), E. LeDrew and P.J. Howarth (Geography) and J. Sykes (Civil Engineering).
Students: P. Arora, D. Hudson and G. McLean (Systems Design Engineering), D.D. Johnson and D. Lantz (Geography), and R. Soulis (Civil Engineering).
Analysis algorithms and procedures for identification of sea ice type from airborne imagery and the mapping of movement of sea ice are being developed. The objective is the establishment of a real-time analysis system that will be used in navigation.

2. Climatic and Hydrologic Monitoring using Satellite Imagery of the South Saskatchewan River Basin (1985-87).
Support: Royal Canadian Geographic Society, Major Competitive Grant (1986-87: $25,000).

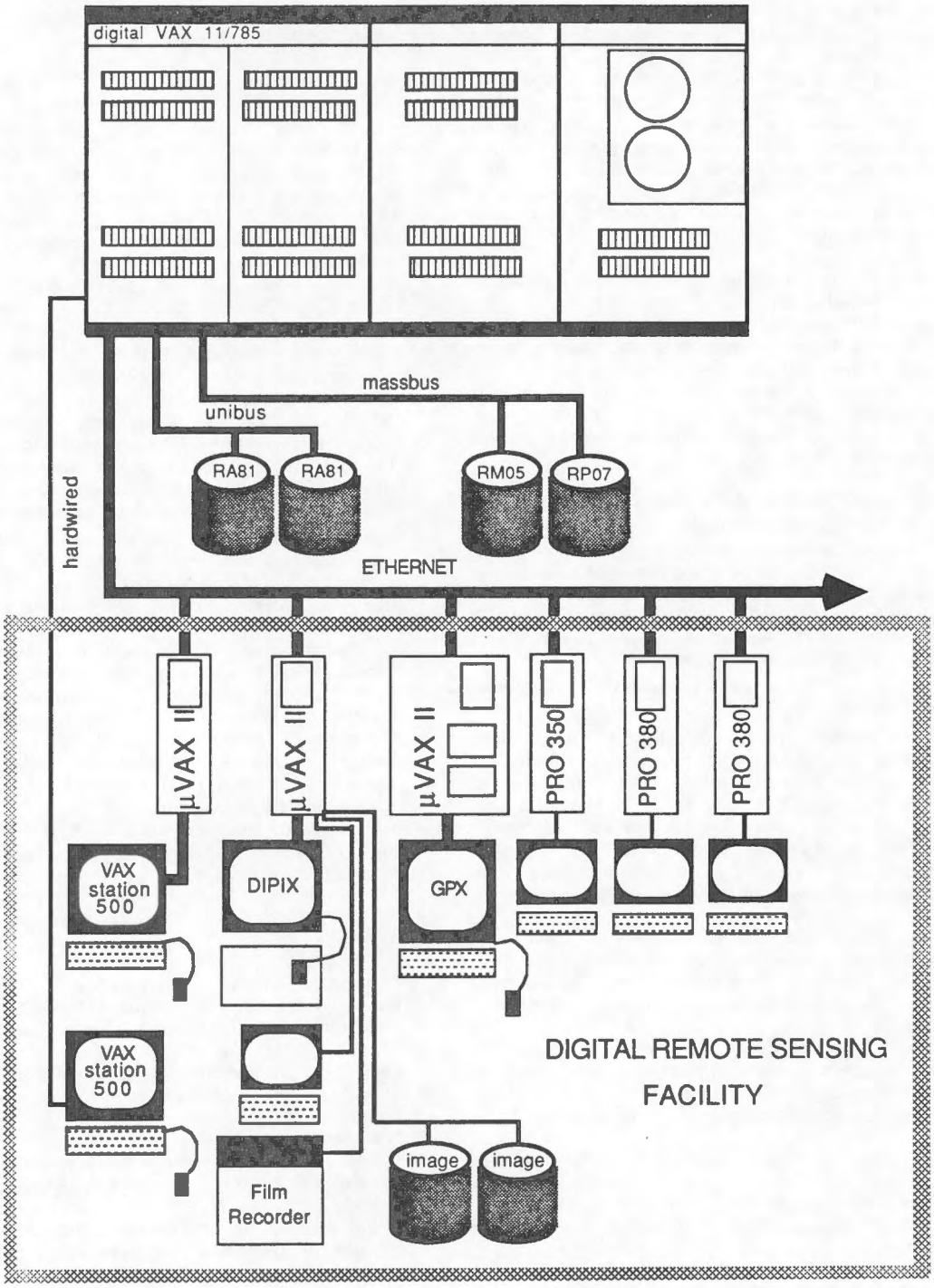

Figure 1. The digital remote sensing facility in the Faculty of Environmental Studies at the University of Waterloo.

Faculty: P.J. Howarth, E. LeDrew and J. Gardner (Geography).
Students: D. Gratton, B. Russon and L. Sargent (Geography).
The long-term objective is to assess the use of satellite imagery in monitoring climatic variability. Vegetation stress in the Palliser Triangle, spring and summer snow cover and glacier margin fluctuations in the Rocky Mountains are being studied with satellite data. Temperature, precipitation and streamflow records are also being analysed.

3. Exploration for Buried Granular Aggregates by Remote Sensing Techniques (1985-87).
Support: Ontario Geoscience Research Fund.
Faculty: H. George and M.B. Dusseault (Earth Sciences), and A. Kesik (Geography).
The study involves the determination of anomalous radiant temperature patterns on thermal infrared imagery which may be caused by the presence of buried gravel.

4. An Evaluation of SPOT Imagery for Detecting Residential Expansion on the Rural-Urban Fringe of Toronto, Canada (1985-87).
Support: SPOT Image (free imagery) and the Natural Sciences and Engineering Research Council of Canada (1986-87: $17,033).
Faculty: P.J. Howarth (Geography) and L.R.G. Martin (Urban and Regional Planning).
Students: G.H. Holder and D.D. Johnson (Geography).

The objectives are to develop a method for detecting, classifying and quantifying residential expansion at the edge of the built city, and to assess the method on the basis of the time and costs incurred and the levels of accuracy obtained relative to the more conventional methods of acquiring data, including air photointerpretation and Landsat image analysis.

5. Towards a Comparative Analysis of Rural Land Use in the Montreal and Toronto Regions (1986).
Support: Ministry of Colleges and Universities, Ontario-Quebec Exchange Project (1986-87: $2,000).
Faculty: E. LeDrew and C. Bryant (Geography).
A series of exchange workshops focussing on methodologies for studying rural land use change, with particular emphasis on remote sensing.

6. Land Use Change Analysis with Multiresolution Data (1985-88).
Support: Commonwealth Scholarship and Social Sciences and Humanities Research Council of Canada.
Faculty: E. LeDrew and C. Bryant (Geography).
Students: T. Fung and Q. Zhang (Geography).
The effects of integrating remotely sensed data of different resolutions for change detection are being investigated. The emphasis is on combining Landsat MSS and TM data from different dates for studies in the Waterloo/Hamilton area.

International Projects

In this section, research activities are presented which involve faculty and/or students from other countries and projects in which data from outside Canada are being analysed.

7. Resource Mapping of the Sokoto-Rima Basin, Northeastern Nigeria (1985-1988).
Support: International Development Research Centre, Information Sciences/Cooperative Programs (1986-87: $116,320).
Faculty: R.A. Bullock, P.J. Howarth and A. Kesik (Geography), P.O. Adeniyi and I. Adalemo (Geography, University of Lagos).
Students: P.G. Pilon (Geography), A Ajayi and A. Omojola (Geography, University of Lagos).
Landsat MSS imagery is being used to study the effects on agriculture and the environment of the construction of dams and irrigation schemes on the Sokoto and Rima rivers. Imagery from before and after construction of the dams shows the influence of changes in flow regime and the changing patterns of agriculture in the area.

8. Remote Sensing Research and Training with Digital Image Processing - China (1985-1987).
Support: International Development Research Centre, Information Sciences/Cooperative Programs (1986-87: $15,000).
Faculty: P.J. Howarth (Geography).
Students: J. Wang (Geography) and F. Wang (Urban and Regional Planning).
Two students from the People's Republic of China are undertaking Ph.D. studies in the Faculty of Environmental Studies.

9. Application of Remote Sensing to the Investigation of Water Resources of Africa (1985-88).
Support: Natural Sciences and Engineering Research Council of Canada (1986-87: $22,000) and North Atlantic Treaty Organisation (1986-87: $7,000).
Faculty: S.I. Solomon (Civil Engineering).
Students: A. Pietoniro and W. Wishart (Civil Engineering)
The water resources of Africa will play a significant role in attempts to make this continent self sufficient in food production. The project will provide inputs to an FAO study for assessing the irrigation potential of Africa. Topics to be studied include the relationship between parameters of a hydrologic model and basin characteristics estimated from remote sensing, and the estimation of precipitation and runoff in ungauged river basins in Africa using ground truth combined with remotely sensed data.

Individual Projects

Research projects being undertaken by individual faculty members and the graduate students they are supervising are summarised in this section.

10. Landsat and Airborne Digital Data for Studying the Physical Environment (1986-88).
Support: Natural Sciences and Engineering Research Council of Canada, Operating Grant (1986-87: $17,033).
Faculty: P.J. Howarth (Geography).

Students: D.D. Johnson, P. Treitz and C. Wagner (Geography).
A series of studies is being undertaken to determine the capabilities of high spatial and spectral resolution MEIS imagery for providing environmental information. The studies involve classification of coniferous forest species, the detection of increased concentrations of minerals in the soil through geobotanical sensing and an evaluation of imagery of different spatial resolutions for mapping land cover/use on the urban/rural fringe.

11. Investigation of the Role of Surface Characteristics in Climate Processes Using Remotely Sensed Imagery (1986-89).
Support: Natural Sciences and Engineering Research Council of Canada, Operating Grant (1986-87: $17,400).
Faculty: E. LeDrew (Geography).
Students: C. Duguay and D.D. Johnson (Geography).
The aim of the study is to investigate the potential of Landsat 5 TM imagery combined with radiative transfer formulations for mapping the monthly net radiation in alpine environments. Methodologies for extracting surface albedo and thermal emission will be investigated. Use will be made of digital elevation data.

GRADUATE STUDENTS

Theses Completed in 1986

Listed in this section are the titles of theses presented and defended by graduate students during the past year. The degree for which they were studying, the department and the name of the supervisor are also appended.

Johnson, D.D. "The Effects of Spatial Resolution on the Information Content of MEIS II Data: A Case Study from an Area in the Southern Ontario Urban-Rural Fringe". M.A., Geography (Howarth).

McLean, G. "Hierarchial Edge Detection and Contextural Filtering". MASc, Systems Design Engineering (Jernigan).

Pilon, P.G. "Detecting Changes in a Semi-Arid Environment Using Landsat Multispectral Scanner Data: A Study of the Bakalori Irrigation Scheme, Nigeria". M.A., Geography (Howarth and Bullock).

Treitz, P.M. "The Capabilities of Two Airborne Multispectral Sensors for Identifying Coniferous Forest Species". M.A., Geography (Howarth).

Wagner, C.L. "The Use of Airborne Digital Data to Detect Mineral-Stressed Vegetation at Natal Lake, Northern Ontario". M.A., Geography (Howarth).

Walford, A. "Texture Analysis Based on a Model of the Visual Cortex". MASc, Systems Design Engineering (Jernigan).

Wright, G. "Feature Selection for Texture Coding". MASc, Systems Design Engineering (Jernigan).

Zhang, Q. "Land-Use Change Detection in the Kitchener-Waterloo-Guelph Region. M.A., Geography (LeDrew).

Current Graduate Student Topics - Ph.D. Level

Duguay, C. "Net Radiation Mapping of Mountainous Terrain Using Digital Terrain Data and Landsat 5 TM". Ph.D., Geography (LeDrew).

Fung, T. "Land Use Change Analysis with Multiresolution Remotely Sensed Data". Ph.D., Geography (LeDrew).

Goertz, H. "Contribution of Remotely Sensed Data to Improving the Accuracy of Hydrologic Estimates". Ph.D., Civil Engineering (Solomon).

Gratton, D. "Remote Sensing Inputs to Environmental Hazard Mapping in Mountainous Environments". Ph.D., Geography (Howarth).

Holder, G.H. "Spatial Resolution Considerations for Mapping Land Use at the Urban/Rural Fringe Using Remotely Sensed Data". Ph.D., Geography (Howarth).

Johnson, D.D. "Use of Satellite Imagery in Studies of Air-Sea Interaction along the Seasonal Sea Ice Zone of the Arctic". Ph.D., Geography (LeDrew).

Lantz, D. "Ice Classification and Movement Studies Using Sequential Radar Images". Ph.D., Geography (Howarth).

McLean, G. "Contrast Invariant Image Processing". Ph.D., Systems Design Engineering (Jernigan).

Moloney, C. "Nonlinear Processing of Images in Multiplicative Noise". Ph.D., Systems Design Engineering (Jernigan).

Montrivade, T. "Application of Remote Sensing in Estimation of Hydroelectric Potential in Sparsely Gauged Areas". Ph.D., Civil Engineering (Solomon).

Wang, F. "Towards the Development of an Expert System for Change Detection Using Remote Sensing Data". Ph.D., Urban and Regional Planning (Newkirk).

Wang, J. "Methodology for Automatic Linear Feature Detection from Remotely Sensed Data and its Application in Geologic Interpretation". Ph.D., Geography (Howarth).

Zhang, Q. "Land Use Change Patterns and the Impact on Agricultural Policy". Ph.D., Geography (LeDrew).

Graduate Student Topics - Master's Level

Arora, P. "Texture Segmentation". M.A.Sc., Systems Design Engineering (Jernigan).

Cooper, T. "Use of Remotely Sensed Data for Improving Hydrological Forecasts". M.A.Sc., Civil Engineering (Solomon).

Hudson, D. "Texture Analysis with Adaptive Filters". M.A.Sc., Systems Design Engineering (Jernigan).

MacLennan, M. "The Application of Fractal Concepts to Multispectral Digital Imagery: An Empirical Investigation with Application to Natural Land Cover Mapping". M.A., Geography (Howarth).

Pietoniro, A. "Improvements of Precipitation Estimation from Remotely Sensed Data in Africa, Using Changes in Land Surface Reflectance". M.A.Sc., Civil Engineering (Solomon).

Piwowar, J. "Raster to Vector Conversion Efficiencies for Geographic Information Systems". M.A., Geography (LeDrew).

Sawanapon, C. "Comparison of Hydrologic Model Validation Results Using Parameters Estimated by Simple Interpolation and with the Help of Interpolation" M.A.Sc., Civil Engineering (Solomon).

Tao, T. "Use of Robotics in Hydrometric Operations". M.A.Sc., Civil Engineering (Solomon).

PUBLICATIONS

Bullock, R.A., P.O. Adeniyi, I. Adalemo, P. Howarth, A. Kesik, B. Ajayi, A. Omojola and P. Pilon, 1986. Resource mapping of the Sokoto-Rima basin, Nigeria. Proceedings of the Badagry Meeting, International Archives of Photogrammetry and Remote Sensing, Volume 26, Part VI, 16 pp. (In press).

Cooper, T. and S.I. Solomon, 1986. Higher education in remote sensing and the global issue of water resources assessment and use. International Symposium, Visions of Higher Education - Transnational Dialogues, Transformations, Zurich, Switzerland.

George, H., M.B. Dusseault, A. Kesik and E.V. Sado, 19867. Evaluation of MEIS II multispectral imagery for surficial geologic mapping in the Chatam area, southwestern Ontario. Proceedings of the 10th Canadian Symposium on Remote Sensing, pp. 141-151.

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Howarth, P.J. and C.S.L. Ommanney, 1986. The use of Landsat digital data for glacier inventories. Annals of Glaciology, Vol. 8, pp. 90-92.

Howarth, P.J., 1986. An overview of satellite imagery and its use in planning. Plan Canada, Vol. 26, No. 7, pp. 172-179.

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Howarth, P.J., 1986. Review. Atlas of North America: Space age portrait of a continent, National Geographic, Washington, DC. Canadian Geographic, Vol. 106, No. 4, p. 79.

Howarth, P.J., 1986. Report of the Ontario Association of Remote Sensing (1985). Minutes of the Annual Meeting of the Canadian Advisory Committee on Remote Sensing, Canada Centre for Remote Sensing, Ottawa, pp. 126-127.

Howarth, P., D. Johnson, R. Suffling, P. Treitz and C. Wagner, 1986. An evaluation of the MEIS II airborne sensor for environmental studies (Abstract). Program and Abstracts of the 1986 Annual General Meeting of the Canadian Association of Geographers, Calgary, Alberta, June 1986, pp. 95-96.

Howarth, P., J. Gardner, E. LeDrew, L. Sargent and B. Russon, 1986. Satellite imagery for developing measures of climatic variability from snow cover and vegetation mapping (Abstract). Program and Abstracts of the 1986 Annual General Meeting of the Canadian Association of Geographers, Calgary, Alberta, June 1986, pp. 112-113.

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Kesik, A.B., H. George and M.B. Dusseault, 1986. Application of MEIS II multispectral airborne data and CIR photography for the mapping of surficial geology and geomorphology in the Chatam area, southwestern Ontario, Canada. Proceedings of the 7th International Symposium on Remote Sensing for Resources Development and Environmental Management, ISPRS Commission VII, Enschede, Netherlands, August 1986 (In press).

Kesik, A., 1986. Operational applications of satellite imagery in Ontario, Canada. Proceedings of Seminare Euro-Carto V, Comite Francais de Cartographie, Paris, Fasc. No. 109-110.

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LeDrew, E., P. Howarth, J. Gardner and B. Russon, 1986. Indices of climatological and hydrological variability derived from satellite imagery for the South Saskatchewan River basin. Proceedings of the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta. Canadian Aeronautics and Space Institute, May 1986, pp. 545-557.

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Martin, L.R.G., 1986. Change detection in the urban fringe employing Landsat satellite imagery. Plan Canada, Vol. 26, No. 7, pp.182-190.

McLean, G. and M.E. Jernigan, 1986. Contextual filters for image processing. Proceedings of the 1986 International Conference on Systems, Man and Cybernetics, pp. 525-529.

Pietroniro, A. and S.I. Solomon, 1986. The application of remote sensing to annual precipitation-runoff relationships for the Sudano-Sahelian zone of West Africa. Proceedings of the 20th International Symposium on Remote Sensing of Environment (In press).

Treitz, P.M., P.J. Howarth and D.G. Leckie, 1986. The effect of spatial resolution of MEIS data on classifying coniferous forest species (Abstract). Proceedings of the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta. Canadian Aeronautics and Space Institute, pp. 807-808.

Wagner, C.L., P.J. Howarth and V.H. Singhroy, 1986. The use of airborne digital data to detect mineral-stressed vegetation at Natal Lake, northern Ontario (Abstract). Proceedings of the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta. Canadian Aeronautics and Space Institute, May 1986, p. 809.

Wang, J.F. and P.J. Howarth, 1986. A methodology for automated extraction of drainage networks from satellite imagery. Proceedings of the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta. Canadian Aeronautics and Space Institute, May 1986, pp. 811-817.

Wright, G. and M.E. Jernigan, 1986. Texture discriminants from spatial channels. Proceedings of the 1986 International Symposium on Systems, Man and Cybernetics, pp. 519-524.

PRESENTATIONS

Bryant, C., E. LeDrew and Q. Zhang, "Detecting land-use changes in the Kitchener-Waterloo area using digital Landsat data", presented at the Universite de Montreal et Universite de Waterloo Exchange Workshop, Universite de Montreal, Montreal, Quebec, December 1986.

Howarth, P., D. Johnson, R. Suffling, P. Treitz and C. Wagner, "An evaluation of the MEIS II airborne sensor for environmental studies", presented at the 1986 Annual General Meeting of the Canadian Association of Geographers, Calgary, Alberta, June 1986.

Howarth, P., J. Gardner, E. LeDrew, L. Sargent and B. Russon, "Satellite imagery for developing measures of climatic variability from snow cover and vegetation mapping", presented at the 1986 Annual General Meeting of the Canadian Association of Geographers, Calgary, Alberta, June 1986.

Howarth, P.J., D. Johnson, L.R.G. Martin and G. Holder, "SPOT and other high resolution data for studying the urban-rural fringe", presented to the Ontario Association of Remote Sensing, Toronto, December 1986.

Johnson, D.D. and P.J. Howarth, "Effects of spatial resolution on MEIS data: A case study from the Toronto rural-urban fringe", presented at the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta, May 1986.

Kesik, A., "Operational applications of satellite iamgery in Ontario, Canada", presented to Euro-Carto V, Paris, May 1986.

LeDrew, E.F., "Satellite image analysis", presented at the Digital Campus-Wide Seminar, University of Waterloo, April 1986.

LeDrew, E.F., "Global environmental monitoring and the ISLSCP Program", presented to the Canadian Advisory Committee on Remote Sensing, Arnprior, April 1986.

LeDrew, E., P. Howarth, J. Gardner and B. Russon, "Indices of climatological and hydrological variability derived from satellite imagery for the South Saskatchewan River basin", presented at the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta, May 1986.

LeDrew, E.F. and C. Duguay, "Radiation modelling in a high relief environment using a digital terrain model and Landsat TM imagery", presented at the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta, May 1986.

LeDrew, E.F., "Remote sensing as a diagnostic science", presented to the University of Waterloo/University of Montreal Exchange Seminar on Agricultural and Rural Land Use Change Research, Waterloo, Ontario, June 1986.

LeDrew, E.F. and T. Fung, "Application of the tasseled cap transformation in land use change detection in the Kitchener-Waterloo-Guelph area", presented at CAGONT '86, Ottawa, Ontario, October 1986.

LeDrew, E.F., "Strategy for including remotely sensed data in environmental analysis", presented at a Workshop on Recent Research Trends and Interpretation Programs, University of Waterloo, Waterloo, Ontario, November 1986.

Makhdoom, M.T.A. and S.I. Solomon, "Forecast of hurricane characteristics from GOES imagery", presented at the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta, May 1986.

McLean, G. and M.E. Jernigan, "Contextual filters for image processing", presented at the 1986 IEEE Conference on Systems, Man and Cybernetics, Atlanta, Georgia, October 1986.

Pietroniro, A. and S.I. Solomon, "The application of remote sensing to annual precipitation-runoff relationships for the Sudano-Sahelian zone of West Africa", presented at the International Symposium on Remote Sensing of Environment, Kenya, December 1986.

Suffling, R. and P.J. Howarth, "Tests of methods of large-scale vegetation mapping at Presqu'ile Provincial Park", presented at the Renewable Resources Research Seminar '85, Ontario Ministry of Natural Resources, Toronto, January 1986.

Treitz, P.M., P.J. Howarth and D.G. Leckie, "The effect of spatial resolution of MEIS data on classifying coniferous forest species", presented at the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta, May 1986.

Wagner, C.L., P.J. Howarth and V.H. Singhroy, "The use of airborne digital data to detect mineral-stressed vegetation at Natal Lake, northern Ontario", presented at the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta, May 1986.

Wang, J.F. and P.J. Howarth, "A methodology for automated extraction of drainage networks from satellite imagery", presented at the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta, May 1986.

Wright, G. and M.E. Jernigan, "Texture discriminants from spatial frequency channels", presented at the 1986 IEEE Conference on Systems, Man and Cybernetics, Atlanta, Georgia, October 1986.

9.6 REPORT OF THE NOVA SCOTIA COLLEGE OF GEOGRAPHIC SCIENCES

Background

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. Cooperative projects, culminating in a thesis report, were completed and submitted to our library and are available for public use. The titles of these reports are listed in Table II, Minutes of the Annual Meeting of CACRS (1986, p. 155). 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.

Revision of the Curriculum

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. Options specified in the attached list of courses (Table 1) provide an opportunity for students to follow the desired specialization. It is anticipated that the number of options will increase in the future.

Cooperative Projects

The titles of cooperative projects arranged for this year are listed in Table III The subject of these studies varies 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.

International Student Training

The College has offered courses in digital image processing and geographical information systems to several international students. A student from Thailand completed a course pertaining to the above subjects and their application 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. Both investigations focused on the processing of Landsat data in conjunction with other types of conventional data and are pertinent to the countries of origin of the students.

Faculty Research

Dr. M. S. Akhavi continues supervising geologic research projects conducted at the College. 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, Canada for consideration by M. S. Akhavi, J. F. Wightman and W. P. Jones.

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

Other Activities

1) Participation and presentation of a poster/paper display related to our remote sensing activities at the Nova Scotia Department of Mines and Energy 10th Annual Oper House and Review of Activities, November 19-20, 1986.

2) The College is cooperating with other Universities in the Atlantic region to coordinate research and training. A proposal has been formulated through the Education Sub-Committee of the Maritime Remote Sensing Committee to set up a program of Radar Data Applications Research and Development to operate in the region.

TABLE I

THE OUTLINE OF CURRICULUM
OF REMOTE SENSING COURSES AT COGS

First Semester		Hours
RS 100	Principles of Photo Interpretation and Remote Sensing	160
GIS 101	Introduction to Computers	150
RS 102	Applications of Aerial Photography in Earth Resources Investigations	160
RS 103	Drafting and Graphic Arts	100
GIS 103	FORTRAN Programming	
	or	
GIS 104	Applications of GIS	150
RS 108	Cooperative Project	80
	Total Semester Hours	800
Second Semester		
RS 200	Remote Sensing from Space and Airborne Platforms	120
RS 201	Photographic Sensitometry and Photographic Systems	120
RS 202	Introduction to Geophysical Systems	
	or	
SCP 202	Scientific Applications	130
RS 203	Microwave Sensing	110
RS 204	Introduction to Image Processing and Enhancement	120
RS 208	Cooperative Project	200
	Total Semester Hours	800
Third Semester		
RS 301	Terrain Analysis	180
RS 302	Remote Sensing for Resource Management and Environmental Monitoring	160
RS 303	Advanced Digital Image Analysis	160
RS 308	Cooperative Project	300
	Total Semester Hours	800
	Total Program Hours	2400

TABLE II

NAMES, ACADEMIC CREDENTIALS, COOPERATIVE PROJECTS & EXTERNAL AGENCIES
Remote Sensing Students College of Geographic Sciences 1985 - 1986

NAME	COOPERATIVE PROJECT TOPIC	EXTERNAL AGENCY
G. Bourns BSc Physical Geography University of Calgary	Assessing Potential Risk to Erosion on Prince Edward Island Utilizing Remote Sensing Techniques	Lands Directorate Atlantic Region Jaques Whitford Associates Agriculture Canada
P. Brown BA Sc Geography Canberra College of Advanced Education	Development of Techniques to Maximize the Information Content of Ships from Radar Imagery	RADARSAT Canpolar Consultants Ltd.
D. Cameron BSc Geology St. Francis Xavier University	A Geocoded Database Integrating LANDSAT and Airborne Radio-Metric Imagery, for the Delineation of Mineral Occurences in the Western Musquodoboit Area, Nova Scotia	GSC/EMR
G. Cameron BSc Geology St. Mary's University	Hydrogeologic Investigations Utilizing Digitally Enhanced LANDSAT Data to Locate Shallow Groundwater Resources in the Vermilion, Alberta Region	Alberta Remote Sensing Center Alberta Research Council
L. Dobbin BSc Geology Dalhousie University	Application of Remote Sensing Techniques for the Detection of Vegetative Base Metal Mineral-ization Stress, Gays River, Nova Scotia	Kidd Creek Mines Ltd.
R. Faulkner BA Geography University of Victoria	Description and Display of Ship Targets and Ocean Backgrounds in Selected SEASAT SAR Digital Image Subscenes	RADARSAT
T. Goodwin BSc Geology Acadia University	Application of Remote Sensing Techniques for Mineral Explor-ation North Western New Brunswick	Noranda Exploration Co.Ltd.
B. Harmeson BSc Geology Brock University	An application of a Digital Geocoded Database Pertaining to Gold Localization, Guysborough County, Nova Scotia	GSC/EMR RADARSAT
C. Henry Environmental Technology University College of Cape Breton	Marsh Species Map of Chezzet-cook Inlet Using Colour Photographs, Airborne MSS and MEIS Digital Imagery, and a Pre-Vegetation map as Train-ing Base	Nova Scotia Department of Transportation Pat Lane Associates

TABLE II - CONTINUED

NAME	COOPERATIVE PROJECT TOPIC	EXTERNAL AGENCY
K. Herman BA Physical Geography University of Ottawa	Enhancement and Classification of X and L Band Synthetic Aperture Radar Imagery from Winter Beaufort Sea Ice	CCRS RADARSAT
W. Jones BSc Biology & Geology St. Francis Xavier University	Geological and Geobotanical Investigations of the Liscomb Pluton, Nova Scotia, Utilizing Remote Sensing Techniques	EMR/RADARSAT
W. McNeil BSc Geology St. Francis Xavier University	The Application of Airborne Digital Radiometric and LANDSAT Data for Delineation of Igneous Phases and Mineral Exploration, Eastern Musquodoboit Batholith Area, Halifax County, Nova Scotia	GSC/EMR
J. Mulvie BA Geography Carleton University	Detectability of Iceberg Targets from STAR-1 and Convair 580 Image Data Over the Hibernia Area Offshore, Newfoundland, Canada	RADARSAT CANPOLAR Consultants Ltd.
S. Trampé BSc Geography McMaster University	ARIES Program to Compensate for Antenna Beam Pattern Effects on Radar Imagery	

TABLE III

NAMES, ACADEMIC CREDENTIALS, COOPERATIVE PROJECTS & EXTERNAL AGENCIES
Remote Sensing Students College of Geographic Sciences 1986 - 1987

NAME	COOPERATIVE PROJECT TOPIC	EXTERNAL AGENCY
J. Alvi BA Geography University of Saskatchewan	Integration of SAR, TM and GIS for Landsacpe Investigations	
J. T. Barbeau Forest Technician Northern Alberta Institute of Technology	Application of Landsat Thematic Mapper data for updating Forest Cover changes in the Red Earth Creek area of Alberta	Alberta Department of the Environment Alberta Department of Forestry, Wildlife and Lands
R. Bishop BSc Geology Acadia University (2 years)	The Application of Remote Sensing Techniques for Mineral Exploration in the East Dalhousie Area of the South Mountain Batholith, Nova Scotia	Nova Scotia Department of Mines & Energy
M. Cassidy Diploma in Renewable Resource Technology	Assessing High Resolution MEISS II Data on Conifer Regrowth	Petawawa National Forestry Institute
E. Cloney BSc Forestry University of New Brunswick	Forest Cover Classification in Annapolis County, Nova Scotia using Landsat TM Data	Nova Scotia Department of Lands & Forests
W. Jealous BSc Geology University of Regina	Detection of Groundwater Discharge Areas and Soil Moisture Anomalies in South Saskatchewan Utilizing Landsat TM Data	Saskatchewan Research Council
R. E. MacDougall BSc Geology Acadia University	Geological Mapping and Mineral Exploration of the New Ross Area, South Mountain Batholith	Nova Scotia Department of Mines & Energy
K. I. March BSc Biology Dalhousie University	Suspended Sediment Measurement from Nova Scotian Landsat TM Imagery using the Chromaticity Technique	CCRS - Applications Technology Division
L. Peskett BSc Biology St. Mary's University	Biophysical Update of the Seaside Adjunct using MEIS II Imagery; An Accuracy Assessment	Environment Canada Parks Atlantic Region
S. M. Shupe BSc Geology Dalhousie University	Geologic Mapping and Mineral Exploration in the West Halifax Area of the South Mountain Batholith, Nova Scotia	Nova Scotia Department of Mines & Energy

TABLE III - CONTINUED

NAME	COOPERATIVE PROJECT TOPIC	EXTERNAL AGENCY
D. Wall BA Geography Bishops University	Mapping Agricultural Areas at High Risk to Erosion, Wilmot River Watershed, P.E.I. using Remote Sensing and Geographic Information Systems	Environment Canada Lands Directorate
B. Watson BSc Geology University of Waterloo	The Creation of a Digital Terrain Model to Explore the Advantages of a 3-Dimensional Perspective for Interpretation of Remote Sensing Imagery	Memorial University Geography Department
K. I. Yurach BSc Geography University of Saskatchewan	An Evaluation of Landsat Thematic Mapper Imagery for Assessing Agricultural Acreages in the Melfort Area of Saskatchewan for Tax Assessment Purposes	Saskatchewan Research Council Agriculture Canada

TABLE IV

PARTIAL LIST OF REMOTE SENSING PUBLICATIONS
Completed at COGS, 85-86

S. D. Melvin and M. S. Akhavi, 1985, Multisensor Remote Sensing as an Exploration Tool in the Cobequid Mountains Area, Nova Scotia, proc. ERIM's 4th Thematic Mapping Conference "Remote Sensing for Exploration Geology", San Francisco, California, April 1-4, 1985, pp. 265-270.

M. S. Akhavi and E. Wedler, 1985, Superposition of Map and Image Data to assist Geological Exploration and Surveying, proc. The Canadian Institute of Surveying (CIS), 85 Symposium, Edmonton, Alberta

E. Wedler, 1985, Azimuthal Smear Study of Ocean Targets from the CV-580 X- and C-band SAR Digital Imagery, Contract Report to Canpolar Consultants Ltd. 20 pp.

M. S. Akhavi and T. R. Mallinson, 1985, Groundwater and Surface Water Relationships Detected by Remote Sensing Data, proc. The 1st Atlantic Canada Symposium on Remote Sensing and Geographic Information Systems, NSLSI, August 16-17, 1985, pp. 79-85.

M. S. Akhavi, 1985, The Detection of Vegetative Stress Utilizing Colour Infrared and Thermal Imagery, Annapolis River Marshlands, Nova Scotia. proc. The 1st Atlantic Canada Symposium on Remote Sensing and Geographic Information Systems, NSLSI, August 16-17, 1985, pp. 109-109D.

B. MacPherson and E. Wedler, 1985, Filter Edge Detection Technique for Geological Lineament Mapping, In: First Atlantic Canada Symposium on Remote Sensing and Geographic Information Systems, Lawrencetown, Nova Scotia August 16-17, 1985.

M. S. Akhavi and R. Pollock, 1985, Interpretive Analysis of Landsat Data for Groundwater Development in West-Central Iran, A Case Study, In press: Geosat Selected Case Histories of the Successful Applications of Remote Sensing in Geology.

M. S. Akhavi, 1985, Geocoded Database Investigations Utilizing Remote Sensing Techniques: Guysborough Area, Nova Scotia (Abst.) proc. Atlantic Geoscience Society, 1985 Symposium.

E. Wedler, 1985, Summary of Environmental and Resource Mapping at Scots Bay and Blomidon Peninsula, Nova Scotia, Canada, In: First Atlantic Canada Symposium on Remote Sensing and Geographic Information Systems, Lawrencetown, Nova Scotia, August 16-17, 1985.

M. S. Akhavi and E. Wedler, 1985, Applications of a GIS Analysis System Transfer for Digital Landsat Signature Extraction and Image Classification/ Enhancement in Exploration Geology, Project 318, EMR Research agreement Progress Summary, pp. 131-132.

M. S. Akhavi, 1985, Application of a Geocoded Database for Geological Investigation and Exploration, proc. 4th ERIM Thematic Conference: "Remote Sensing for Exploration Geology", San Francisco, California April 1-4, 1985, pp. 271-277.

TABLE IV - CONTINUED

K. D. Kalicharran and M. S. Akhavi, 1986, Analysis of Airborne Infrared Data for Interpretive Geological Mapping of the Brookfield Area, Nova Scotia, proc. 10th Canadian Symposium on Remote Sensing, Edmonton, pp. 19-26.

T. R. McInnis and M. S. Akhavi, 1986, Integration of Geophysical and Landsat Digital Data for Geologic Investigation and Exploration, proc. 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta, Map 5-8, 1986, pp. 11-17.

10.0 PROGRESS REPORT ON ACTION TAKEN BY CCRS AS A RESULT OF THE 1986 CACRS RECOMMENDATIONS

(refer to Section 3.0, pages 7-17, of CACRS 1985 Report for complete list of recommendations and action statements)

3.1.3 Pointing policy for SPOT

CCRS has not yet implemented a specific pointing policy for SPOT. At present, data are acquired for the archive in an interim configuration (off-nadir and PLA), except where there is a specific request for a special acquisition. CCRS must provide programming requests to CNES at least 14 days in advance of the pass; any external conflicts are then resolved and Canadian requests are confirmed by CNES during the next 12 days. The satellite program is frozen 1 day in advance of the pass and can only be changed in cases of emergency. CCRS continues to program the satellite in the user requested configuration until it has been confirmed that the specified scenes have been acquired.

CCRS will not program the satellite for special configurations unless there is an assured client; thus, the requestor is obliged to purchase products from any acceptable scenes so acquired.

CCRS will request that the PEPS Working Group of CACRS consider and recommend the preferred satellite configuration (pointing and modes) for recording into the archive.

3.1.4 Assessment of the airborne program

While the need for an unbiased evaluation of the cost/benefit of the airborne program is recognized, there is no doubt that the budget has been cut and that major changes in the mode of operations are indicated. The purpose of such an evaluation exercise might therefore be not to effect a reassessment of the budget, but rather to help promote the new industrial involvement in the operation of the Falcon and the DC-3. CCRS is asking the private sector to assume responsibility for the collection of data for all tasks previously classed as external, co-op, and lease. The electro-optical sensors, and the Convair with the microwave sensor package, will be made available to the private sector so that qualified companies can take advantage of this opportunity.

3.2.1 Availability of IRIS C-band SAR

The new C-band SAR has been installed in the Convair and its commissioning is proceeding well. At the request of the RADARSAT Office, data have already been collected for agricultural applications in Quebec.

In mid-March 1987, the CV-580 successfully collected C-band SAR data for the LIMEX/LEWEX projects. Canada is participating in this large international experiment over the Labrador Sea as part of the RADARSAT/Radar Data Development Program.

Note that IRIS is used to designate the MDA standard SAR product line (INTERA's Star 2 uses an IRIS); the research SAR developed by MDA for CCRS is known as C-SAR (at C-band) and X-SAR at X-band.

3.2.2 Postponement of European flights to 1987

The flights to Europe did not take place in the Fall of 1986 as had been proposed. The ESA project was reduced significantly in scope with only small projects being flown by European radars in 1986. Although there has been another small proposal to fly C-SAR for ESA in the Fall of 1987, it is uncertain whether this will be supported by CCRS. These small projects are precursors to a very large agricultural and land use project called MAESTRO which will be sponsored jointly by ESA and the JRC/EEC in 1988.

CCRS has agreed that the CV-580 may be used for a commercial project in Europe for six weeks beginning mid-August 1987.

3.3.1 Use of ground microwave system for snow cover

It had been planned to acquire C-IRIS data over the ground-truthed test area in the winter of 1986/87 for the Prairie Snow Experiment, however, the

necessary funds could not be obtained by any group. Because of budget restraints, CCRS is prepared to loan the ground microwave system to the University of Saskatchewan for such an experiment, but funding for the operation of the system will have to be arranged by the university.

3.3.3 Determination of elevations and contours over Arctic icefields

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.

3.4.3 NOAA Imagery

All AVHRR data received by CCRS is stored and archived at PASS. Although data is not catalogued, the order desk maintains a file of photographic prints of each image received back to 1980. Prior to 1980, the data exist on micro-film and has been archived.

3.8.1 Ice studies

CCRS is entering in an ice application program through the RDDP in cooperation with the Atmospheric Environment Service.

3.10.1 Ocean applications

Ocean applications will be addressed through the RDDP in cooperation with the Department of Fisheries and Oceans.

3.10.4 Ocean data management system

Studies are being undertaken under the RDDP.

3.11.2 Establishment of subcommittee on GIS

The Chairperson of CACRS will establish such a subcommittee with the specific objectives to report on the rapid recent developments in the micro-based geographic information systems/remote sensing applications for agricultural land use decision making, and to explore the development of the "best systems" for local governments (townships and county levels) for Canadians and/or developing countries.

3.12.2 Agricultural Data Set - Description and list of publications

A general description of the Melfort data-set and a list of recent related CCRS publications is available to interested parties. The contact is Dr. R. Brown (Applications Division) at 1547 Merivale Road, Ottawa, Ontario, K1A 0E4.

3.12.3 CCRS Software

A list of available CCRS Software will be compiled and published, along with conditions of access.

3.12.5 Use of compact disks for data storage

Optical recording is being evaluated by CCRS in many areas: CD-ROM, CD-WOM, 5 1/4" optical disk, large format optical disks. CCRS is following the new technological developments in Canada and abroad, and is aware of the potential of the optical disk as a low cost, convenient medium for storing large volumes of data, with access through a low cost reader. The question of data format is being addressed by various working groups and committees, in particular the LANDSAT Technical Working Group and the Committee for Earth Observation Satellites (CEOS), in order to provide a common format which will be both industry compatible and suitable for various data sets, and which also will be used internationally.

3.12.6 (Similar to 3.12.5)

The Image Analysis Data Base Format Sub working group of the IASAI is presently assessing the impact of new storage technologies, in particular optical disks. CCRS has three projects which have a major emphasis on microcomputer-based image analysis systems, using off-the-shelf components. These systems will be used to assess the micro-based technology.

3.13.2 Funding of Rangeland Publication

This matter has been discussed between the Chairperson of the Rangeland Subcommittee and the Director, Applications Technology Division. In addition to support in kind, a modest amount of seed money could be contributed by CCRS. The suggestion of the CACRS Executive (October '86) regarding a resource contract person to write the proposed publication will be brought to the attention of the chairperson of the Rangeland Subcommittee, in charge of the publication.

3.16.3 Publicity for rangeland applications

CCRS encourages the Rangeland Subcommittee to contribute to the professional publications and events cited in the recommendation, and the User Asistance and Marketing Unit will be glad to assist and advise as requested.

3.17.1(b) Comparison of several methodologies in demonstration projects

Demonstration projects carried out under the Technology Enhancement Program have utilized data from a wide variety of sources (airborne and satellite) and have involved the use of various analysis techniques (visual, analog, and digital). Any single project, however, normally does employ only one particular data source and analysis method, since most of the co-operating agencies are unwilling to commit the additional time and resources required for a comparison of different alternatives. The approach to be used is decided through consultation between the principal investigator, the TEP staff specialist, and other experts in the field (where necessary) and is based on the user's requirements and available resources. Notwithstanding the above, TEP staff do encourage co-operating agencies to consider using more than one method wherever feasible, and will continue to do so in the future.

3.17.1(c) Assessment of utility of various TM bands

The combination of TM bands for forestry have been published in the CCRS Forestry brochure, and the combinations for agriculture and geology have also been established and will be published shortly.

3.17.2 Pricing policy for TM floppy diskettes

In order to ensure the availability of TM data in this format, CCRS sent out a Request for Proposals to private industry. A number of proposals were received and have been evaluated, and CCRS is negotiating with the private sector for licences to produce TM data on floppy diskettes.

3.17.4 Free TM scenes for universities

The library of CCT's which CCRS already provides for educational institutions at no cost beyond the cost of the tapes, has been enlarged to include several representative TM images, suitable for teaching purposes.

3.18.2 Training in use of radar data

CCRS will enter into a contract (following a call for proposals) with an educational institution, to produce a 3-4 day course, to be repeated 4 or 5 times across the country, at least once per region. The proposed course content would be approximately: 33-50% technical (sensor, processing and analysis techniques), and 50-66% applications (interpretation) oriented. Experts from within CCRS will assist in developing the course content and possibly by giving lectures on special topics.

11.0 PARTICIPANTS IN THE ANNUAL CACRS MEETING, CORNWALL, ONTARIO, APRIL 21-24, 1987

Ms. Lyn D. Arsenault
Cold Regions Remote Sensing
Box 526
Stittsville, Ontario
K0A 3G0

Mr. W.G. Best
Manitoba Centre for Remote Sensing
1007 Century Street,
Winnipeg, Manitoba
R3H 0W4

Mr. Michael Black
Department of Municipal
Affairs and Environment
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1

Dr Ferdinand Bonn
Laboratoire de télédétection
Département de géographie
Université de Sherbrooke
Sherbrooke, (Québec)
J1K 2R1

Mr. Cal D. Bricker
Alberta Remote Sensing Center
11th Floor, Oxbridge Place
9820 - 106th Street,
Edmonton, Alberta
T5K 2J2

Mme Dominique Bruger
Directrice
Service de la Cartographie
1995, boul. Charest ouest
Ste-Foy, Québec
G1N 4H9

Dr. Peter Crown
Department of Soil Science
University of Alberta
Edmonton, Alberta
T6G 2E3

Mr. Howard Edel
Marine Sciences Information Directorate
Dept. of Fisheries and Oceans
240 Sparks Street, 7th Floor W.,
Ottawa, Ontario
K1A 0E6

Mr. Dan Fenety
Agriculture Canada
Sir John Carling Bldg.
930 Carling Avenue
Ottawa, Ontario
K1A 0C5

M. Jean Gauthier
Direction des levés et de la
cartographie
Siège no. 516
615, rue Booth
Ottawa, Ontario
K1A 0E9

Mr. Ensley A. Godby
501 Wilbrod Street
Ottawa, Ontario
K1N 5R4

Dr. Barry Goodison
Canadian Climate Centre
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario
M3H 5T4

Mr. Frank Hegyi
B.C. Forest Service
Inventory Division
Legislative Buildings
Victoria, B.C.
V8W 3E7

Dr. Phil Howarth
Department of Geography
University of Waterloo
Waterloo, Ontario
N2L 3G1

Mr. Andrew Jano
Ontario Centre for Remote Sensing
Ministry of Natural Resources
880 Bay Street, 3rd Floor
Toronto, Ontario
M5S 1Z8

Mr. Jim Kerr
Advanced Technology Market
Development Division
External Affairs
Lester B. Pearson Bldg.
125 Sussex Drive
Ottawa, Ontario
K1A 0G2

Dr. Jaan Kruus
Data Acquisition Systems Branch
Environment Canada
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario
M3H 5T4

Mr. Don Leckie
Petawawa National Forestry Institute
Chalk River, Ontario
K0J 1J0

Dr. Ellsworth LeDrew
Faculty of Environmental Studies
University of Waterloo
Waterloo, Ontario
N2L 3G1

Mr. Ed Lewis
Ocean Science & Surveys
Department of Fisheries & Oceans
67 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Dr. Alex R. Mack
Soil Research Institute
Agriculture Canada
Sir John Carling Bldg.
Ottawa, Ontario
K1A 0C5

Mr. Steven Matthews
Habitat Management Section
Wildlife Management Division
Government of the Northwest Territories
Yellowknife, N.W.T.
X1A 2L9

Dr. Peter A. Murtha
Faculty of Forestry
University of British Columbia
2075 Wesbrook Mall
Vancouver, B.C.
V6T 1W5

Mr. George Nassiopoulos
Department of Renewable Resources
Government of the Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6

Mr. Lawrence Peters
New Brunswick Remote Sensing Committee
Department of Municipal Affairs and
Environment
P.O. Box 6000
Fredericton, N.B.
E3B 5H1

Mr. Rick Pierce
President
Ontario Association of Remote Sensing
Land Use and Environmental
Planning Department
Ontario Hydro
700 University Avenue H8B13
Toronto, Ontario
M5G 1X6

Mme Danielle Pilon
Ministère de l'Energie et des Ressources
Centre québécois de coordination de
la télédétection
1995, boul. Charest ouest
Ste-Foy (Québec)
G1N 4H9

Dr. Richard Protz
Department of Land Resources Science
University of Guelph
Guelph, Ontario
N1G 2W1

M. Guy Rochon
Département de photogrammétrie
Université Laval
C.P. 10047 - Pavillon Casault
Ste-Foy (Québec)
G1K 7P4

Mr. Vernon Singhroy
Ontario Centre for Remote Sensing
Ministry of Natural Resources
3rd Floor
880 Bay Street
Toronto, Ontario
M5S 1Z8

Mr. Ian Sneddon
Chief, Technical Program Division
Policy and Planning Development
Indian and Northern Affairs Canada
Terrasses de la Chaudière
10 Wellington Street, North Tower
Hull, Quebec
K1A 0H4

Dr. Larry P. Stene
Department of Geography
University of Manitoba
Winnipeg, Manitoba
R3T 2N2

Mr. Jean Thie
Director, Land Resources and Data Systems
Branch
Canada Lands Directorate
Environment Canada
20th Floor, Place Vincent Massey
Hull, Québec
K1A 0E7

Dr. Keith Thomson
Président
Association Québecoise de Télédétection
C.P. 12047
Ste-Foy (Québec)
G1V 4C6

Mr. Michael Trant
Agriculture/Natural Resources Division
Resources, Technology & Services
Statistics Branch
Statistics Canada
Main Building, Room 2106
Tunney's Pasture
Ottawa, Ontario
K1A 0T6

Mr. Randy Trenholm
Chief, Resources Inventories Sector
Natural Resources Division
Canadian International Development Agency
7th Floor
200 Promenade de Portage
Hull, Quebec
K1A 0G4

Mr. Jeff Whiting
Saskatchewan Research Council
30 Campus Drive
Saskatoon, Saskatchewan
S7N 0X1

Mr. John Wightman
Vice-Principal
Nova Scotia Land Survey Institute
Lawrencetown
Annapolis County, Nova Scotia
B0S 1M0

CCRS/CCT PERSONNEL

Mailing Address/adresse postale:

Canada Centre for Remote Sensing
Centre canadien de télédétection
2464 Sheffield Road
2464 chemin Sheffield
Ottawa, Ontario
K1A 0Y7

Mr. Ralph C. Baker
Acting Director General

Mlle Monique Bernier
Scientifique
Division des applications

Mme Carole Boucher
Agent de liaison, p.i.
Planification et evaluation de la
technologie

Dr. Ron Brown
Scientist
Applications Technology Division

Mrs. Jean Game
User Liaison Officer
User Assistance & Marketing Unit
Applications Technology Division

Mlle Diane Gareau
Secretaire
Division des applications

Dr. David G. Goodenough
Head, Methodology Section
Digital Methods Division

M. Florian E. Guertin
Directeur, Division des méthodes

M. Bob Hamelin
Conducteur/messager
Division de l'administration

M. Jean-Claude Henein
Directeur, Division des applications

Mr. Doug Heyland
Head, Technology Enhancement Office
Applications Technology Division

Dr. Ed Langham
Project Development Manager
RADARSAT Project Office

Ms. Jenny Murphy
Head, Systems Section
Digital Methods Division

Dr. Robert O'Neil
A/Director, Data Acquisition Division

Dr. Surrendra Parashar
Radar Applications Co-ordinator
RADARSAT Project Office

Mr. Ian Press
Head, Satellite Operations Centre
Data Acquisition Division

Dr. Robert A. Ryerson
Head, User Assistance and Marketing Unit

M. Marcel Saint-Pierre
Economist
Bureau du projet RADARSAT

Mr. Edryd Shaw
Director, RADARSAT Project

Ms. Pat Stewart
Secretary
Director General's Office

Dr. Susan Till
A/Head, Sensor Section
Data Acquisition Division

Mr. A. Leslie Whitney
CACRS Secretariat
Planning and Technology Assessment

Mme Carolle Yelle
Secretariat du CCCT
Planification et évaluation de
la technologie

12.0 TABLE OF ACRONYMS USED IN THIS REPORT

ACDI:	Agence canadienne de développement international
ACFAS:	Association canadienne française pour l'avancement de la science
ACMIR:	Alberta Centre for Machine Intelligence and Robotics
AERIE:	Airborne Equipment for Remote Imaging of the Environment (B.C. Research)
AES:	Atmospheric Environment Service (Canada)
AFS:	Alberta Forest Service
AI:	Artificial Intelligence
AIMCC:	Association of Ice Monitoring Contractors of Canada
AIMR:	Airborne Imaging Microwave Radiometer
AIR:	Airborne V + IR Data Processing System (CCRS)
ALICE:	Airborne Linescan Image Processor (Knudsen Engineering)
AMI:	Advanced Microwave Imager
APP:	ARIES Pixel Processor
APT:	Automatic Picture Transmission
AQT:	Association québécoise de télédétection
ARD:	Atmospheric Research Directorate (AES)
ARIES:	Applied Resource Image Exploitation System (DIPIX)
ARSC:	Alberta Remote Sensing Center
ASTM:	American Society for Testing and Materials
ATD:	Application Technology Division (CCRS)
AVHRR:	Advanced Very High Resolution Radiometer (TIROS-N, NOAA-A to G)
BILD:	Board of Industrial Leadership and Development (Ontario)
BIO:	Bedford Institute of Oceanography
C-SHARP:	Synthetic Aperture Radar System (CCRS)
CACRS:	Canadian Advisory Committee on Remote Sensing
CARTEL:	Centre d'applications et de recherches en télédétection (Université de Sherbrooke)
CASI:	Canadian Aeronautics and Space Institute
CASP:	Canadian Atlantic Storms Program
C-CORE:	Centre for Cold Ocean Research Engineering (Newfoundland)
CCC:	Canadian Climate Centre (AES)
CCRS:	Canada Centre for Remote Sensing
CCT:	Centre canadien de télédétection
CCTs:	Computer Compatible Tapes
CD-ROM:	Compact Disk Technology
CDA:	Canadian Department of Agriculture (now Agriculture Canada)
CEOS:	Committee for Earth Observation Satellites (formerley IEOSC)
CFL:	Centre de foresterie des Laurentides
CFS:	Canadian Forestry Service
CHS:	Canadian Hydrographic Service
CIAR:	Canadian Institute for Advanced Research
CIAS:	CCRS Image Analysis System
CIDA:	Canadian International Development Agency
CIMMER:	Centre for Mining and Mineral Exploration, Laurentian University
CIR:	Colour Infrared
CIR:	Colour Image Recorder (CCRS)
CIS:	Crop Information System
CNES:	Centre national d'études spatiales (France)

COGS: College of Geographic Sciences (Nova Scotia)

CQCT: Centre québécois de coordination de la télédétection

CRSS: Canadian Remote Sensing Society

CRSTI: Canadian Remote Sensing Training Institute

CSD: Central Services Directorate (AES)

CV: Convair (CCRS aircraft)

CWB: Canadian Wheat Board

CZCS: Coastal Zone Colour Scanner (NIMBUS 7, NOSS)

DAD: Data Accquisition Division (CCRS)

DCPs: Data Collection Platforms

DCS: Data Collection System (LANDSAT, TIROS-N, SMS/GOES, NOAA)

DDT: Department of Development and Tourism (Newfoundland)

DEM: Digital Elevation Model

DFO: Department of Fisheries and Oceans (now Fisheries and Oceans Canada)

DICS: Digital Image Correction System (CCRS)

DMD: Digital Methods Divison (CCRS)

DMSP: Defense Meteorological Satellite Program (USAF/NOAA/USN) (previously called DAPP)

DPCM: Differential Pulse Code Modulation

DREP: Defence Research Establishment Pacific (Canada)

DSS: Department of Supply and Services

DTM: Digital Terrain Model

EDC: EROS Data Center

ELDO: European Launcher Development Organization

EMR: Department of Energy, Mines and Resources

EOSAT: Earth Observation Satellite Corporation

ERBE: Earth Radiation Budget Experiment

EROS: Earth Resources Observations System (U.S. Department of Interior)

ERS: ESA Remote Sensing Satellite

ERS: European Resources Satellites (ESA)

ESA: European Space Agency (previously ELDO and ESRO)

ESRF: Environmental Studies Revolving Funds (a program of Indian and Northern Affairs Canada)

FAO: Food and Agricultural Organization (U.N.)

FIDEX: Floating Ice Detection Experiment (CCRS)

FIRMS: Forest Information Resource Management Systems (B.C.)

FLI: Fluorescence Line Imager (Institute of Ocean Sciences)

GAAP: (LANDSAT) Geological Analysis Aid Package (CCRS)

GBR: Ground-Based Radiometer

GIMMS: Global Inventory, Monitoring and Modelling Studies (U.S. NASA)

GIS: Geographic Information System

GMS: Geostationary Meteorological Satellite

GOES: Geostationary Operational Environmental Satellite (NOAA)

GPS: Global Positioning System

GRGS: Groupe de recherche de géodésie spatiale (France)

GS: Geodetic Survey Satellite (Japan)

GSAR: Generalized Synthetic Aperture Radar

GSFC: Goddard Space Flight Center (U.S. NASA)

GSS: Gatineau Satellite Station (Canada)

HCMM: Heat Capacity Mapping Mission Satellite (an Application Explorer Mission)

HDDT: High Density Digital Tape

HF: High Frequency

HRPT: High Resolution Picture Transmission (with NOAA 2 to G & TIROS-N)

HRV: High Resolution Visible

IACRS: Interagency Committee on Remote Sensing (Canada)

IAI: International Artificial Intelligence

IASAI: Image Analysis System and Artificial Intelligence (a CACRS Working Group)

IACP: Interdepartmental Committee on Aerial Photography

IDRC: International Development and Research Centre

IFOV: Instantaneous Field of View

IGARSS: International Geographic and Remote Sensing Society

IGBP: International Geosphere-Biosphere Programme

IGN: Institut géographique national

IISS: Image Inventory Search & Summary (CCRS)

INRS: Institut national de la recherche scientifique

IOS: Institute of Ocean Sciences (Canada)

IPTASC: Interprovincial/Territorial Advisory Subcommittee (CACRS)

IR: Infrared

IRIS: Integrated Radar Imaging System (SAR developed by MDA for CCRS)

ISLSCP: International Satellite Land-Surface Climatology Project

ISPRS: International Society for Photogrammetry and Remote Sensing

ISS: Ice Status System (AES)

IUGS: International Union of Geological Sciences

IWD: Inland Waters Directorate, AES

JPL: Jet Propulsion Laboratory

JRC/EEC: Joint Research Centre of the European Economic Community

LANDSAT: Land Satellite (previously called ERTS)

LDIAS: LANDSAT Digital Image Analysis System (CCRS)

LEWES: Labrador Extreme Waves Experiments

LFC: Large Format Camera (on space shuttle)

LGSOWG: LANDSAT Ground Station Operations Working Group

LIMEX: Labrador Ice Margin Experiment (C-CORE, Canada)

LLL(TV): Low-Light-Level Television

LORAN-C: Long Range Aid to Navigation (used for aerial surveys)

LRIS: Land Resources Information System (U.S. Army)

LSP: Large-scale Photo (camera)

MADGI: Mapping Analysis and Design Geographic Information (VAX-based system)

MAESTRO: An agriculture experiment sponsored by JRC/EEC

MAID: Maid-housekeeping Data Acquisition System (a CCRS airborne program)

MAPAQ: Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec

MCBIAS: Micro-computer Based Image Analysis System (CCRS)

MDA: MacDonald, Dettwiler and Associates (Canada)

MEIS: Multispectral Electro-Optical Imaging Spectrometer (CCRS-AOPS)

MER: Ministère de l'Énergie et des Ressources (Québec)

METSIS: Meteorological Satellite Information System (TELESAT Canada/SPAR Aerospace)

MICROGAP: PC-Based Image Analysis Software for Geological Applications (CCRS)

MIPS: MSS Image Processing System (for LANDSAT) (U.S. NOAA)

MLA: Multispectral Linear Array

MOMS: Modular Opto-Electronic, Multispectral Scanner (W. Germany)

MOS: Marine (or Maritime) Observation Satellite (Japan)

MOSAICS: Multi-Observation Satellite Image Correction System (MDA for CCRS)

MOSST: Ministry of State for Science and Technology

MOU: Memorandum of Understanding

MPB: Mountain Pine Beetle

MRMS: Maritime Resource Management Service

MRS: Multidiscipline Refurbishable Satellite (U.K.)

MRSC: Manitoba Remote Sensing Center

MRSC: Maritime Remote Sensing Committee

MSS: Multispectral Scanner

MTEP: Maritime Technology Enhancement Program

MUN: Memorial University of Newfoundland

MUNCL: Memorial University of Newfoundland Cartographic Laboratory

NACSM: National Advisory Committee on Surveys and Mapping

NAPL: National Airphoto Library (Canada)

NASA: National Aeronautics and Space Administration (USA)

NFS: National Farm Survey (Statistics Canada)

NHRC: National Hydrology Research Centre

NOAA: National Oceanic and Atmospheric Administration (U.S. Department of Commerce)

NoFC: Northern Forestry Centre

NORDA: Naval Ocean Research & Development Activity (U.S. NAVY)

NORDCO: Newfoundland Ocean Research and Development Corporation

N-ROSS: Navy Remote Ocean Sensing System (U.S. Navy proposed satellite - 1988)

NRC: National Research Council

NRCC: National Research Council of Canada

NSERC: Natural Sciences and Engineering Research Council

NSRSC: Nova Scotia Remote Sensing Committee

OARS: Ontario Association for Remote Sensing

OCRS: Ontario Centre for Remote Sensing

OERD: Office of Energy Research and Development

OSS(A): Office of Space Science Application (U.S. NASA)

PASS: Prince Albert Satellite Station (Canada)

PC: Personal Computer

PDA: Prospecters and Developers Association

PEPS: Programme d'évaluation préliminaire de SPOT

PFRA: Prairie Farm Rehabilitation Association

PFRC: Pacific Forest Research Centre (Canada)

PILP: Programme for Industry/Laboratory Projects (National Research Council)

PIPOR: Programme for International Polar Oceans Research (ESA)

PLA: Panchromatic Linear Array

PMI: Programmable Multispectral Imager (Moniteq Ltd.)

PNFI: Petawawa National Forestry Institute (Canada)

PUIS: Programme d'utilisation des images SPOT (Québec)

PWC: Pacific Weather Centre (AES)

QCR: Quick Colour Recorder

RADARSAT: Radar Satellite (Canada)

RBV: Return Beam Vidicon (ERTS or LANDSAT 1 to 3)

RDDP: Radar Data Development Program (CCRS)

REAP: Regional Environment Assessment Program (a GIS in South Dakota)

REAP: Resource Evaluation and Planning (Alberta Government)

RESORS: Remote Sensing On-line Retrieval System (CCRS)

RFP: Request for Proposals

RPO: RADARSAT Project Office (CCRS)

SAGE II: Stratospheric Aerosol and Gas Experiment II (ERBS)

SANIL: Système d'analyse des images LANDSAT (Université de Sherbrooke)

SAR: Synthetic Aperture Radar

SC: Statistics Canada

SCANIQ: Système conjoint d'analyse numérique d'images de Québec (similar to ARIES)

SDL: Satellite Data Laboratory (AES)

SEASAT: Sea Satellite

SHARP: Synthetic Aperture Radar Processing System (CCRS)

SICORP: SPOT Image Corporation

SIR: Spaceborne Imaging Radar

SLAR: Side Looking Airborne Radar

SME: Solar Mesospheric Explorer (USA)

SMMR: Scanning Multichannel (or Multifrequency) Microwave Radiometer (on SEASAT, NIMBUS-G, LOCSS, and NOSS)

SPAS: Shuttle Pallet Satellite (ESA)

SPOT: Satellite pour l'observation de la Terre

SPRR: Saskatchewan Parks and Renewable Resources

SRC: Saskatchewan Research Council

SSM/I: Special Sensor Microwave Imager (DMSP) (U.S. Air Force)

SST: Sea Surface Temperature

STAR: Sea Ice and Terrain Assessment Radar (ERIM and INTERA)

STEP: Saskatchewan Technology Enhancement Program

TEO: Technology Enhancement Office (CCRS)

TEP: Technology Enhancement Program (CCRS)

TM: Thematic Mapper (on LANDSAT-4, 5)

TMTS: Thematic Mapper Transcription System (CCRS)

TOVS: TIROS Operational Vertical Sounder (on TIROS-N, NOAA 6)

TRIAD: Timesharing Research Image Analysis and Display (CCRS)

TSS: Time-Sharing System (CCRS)

UCAR: University Corporation for Atmospheric Research

UNIDSK: Device-independent Disk File Format

UQAC: Université du Québec à Chicoutimi

URSI: Union Radio Scientific International

USGS: U.S. Geological Survey (U.S. Department of Interior)

UTM: Universal Transverse Mercator Projection System

VAS: VISSR Atmospheric Sounder (GOES-4 to 8)

VIR: Visible and Infrared

VISSR: Visible and Infrared SPIN-SCAN Radiometer (SMS, GOES, GMS)

WG:	Working Group
WMO:	World Meteorological Organization
WORM:	Write Once and Read Many
WSD:	Weather Services Directorate (AES)
YTG:	Yukon Territorial Government

CACRS 1987 CCT

(Written late at night during the meeting)

GOODBYE CACRS (OR KISS MY GIS)
(to the tune of Old MacDonald)

THE MINISTER HAD AN IDEA,
ON C - A - C - R - S
WITH AN EDICT HERE
AND A MANDATE THERE
A YEA VOTE HERE, A NAY VOTE THERE
E - I - E - I - O

LES "BROWN" WHITNEY PREPARED A PLAN,
C - A - C - R - S
WITH A COUNCIL HERE
AND A COMMITTEE THERE
ALL HE REALLY WANTS IS OUR BLESS

AND IN THIS COUNCIL HE HAD SOME INDUSTRY
INDUSTRY HERE, APPLICATIONS THERE
SUBCOMMITTEE HERE, WORKING GROUP THERE
C - A - C - R - S

OUR IPTASC GROUP IS NOT INTACT
THE NEWFIE TOOK ANOTHER TACK
E - I - E - I - O
WITH A HAS BEEN HERE, A BEEN HAD THERE
SEEK TERMS OF REFERENCE HERE, NEW MEMBER THERE
A - I - A - I - O

BUT ON THE COUNCIL, NO UNI. REP
DOMINATION HERE, PROCRASTINATION THERE
INDUSTRY HERE, COUNCIL THERE
C - A - C - R - S

SIR LARRY MORLEY, FIRST D.G.
STARTS C - A - C - R - S
NO BUREAUCRACY, LIFE WAS FREE
TWAS C - A - C - R - S
VISIONARY HERE, SCIENCE COUNCIL THERE
HERE A PROF, THERE A BOFF
AND FINALLY WORD OF CRESS

AULDE LEE GODBY HAD IT NEXT
OUR C - C - R - S
MADE LIFETIME MEMBER FOR A DAY
SCUBA DIVING NEXT
WITH A FRANCES HERE, AND JOAN R. THERE
ARNPRIOR HERE AND CORNWALL THERE
THAT'S C - C - R - S

PERE BESCOND ONCE HAD A THOUGHT
E - I - E - I - O
AND IN THAT THOUGHT HE HAD A SPOT
E - I - E - I - O
HERE A SCOT, THERE A SPOT
BUT GOOD KANUCK DATA, THERE WAS NOT

ALL THE VENDORS HAD A GIS
L - D - I - A - S
AND WITH FERDINAND BONN, THEY COULDN'T MISS
I - A - S - A - I
HERE A MILLION, THERE A MILLION
WHERE IS MARCEL MASSE'S TRILLION
C - A - C - R - S

(to the tune of the Volga Boatmen)

WE THOUGHT THAT BAKER
COULD BE OUR MAKER
SENSED WE THAT HE WAS
THE UNDERTAKER

WE WANTED ACTION, PARTICIPATION
WE LANDED ACTORS, SENSUAL CONTRACTORS
NO AUTOMATION, JUST CONSTIPATION.
WHERE DO WE GO NOW FROM HERE?

(to the tune of Goodbye Ladies)

GOODBYE CACRS
OH, GOODBYE NACRS
BUT LIKE PHOENIX FROM ASHES
HELLO ANOTHER CACRS